Hôpitaux Universitaires Genève

STATE OF THE ART IN ROBOTIC SURGERY

Overview of Automation and Surgical Gesture Assistance Technologies

2nd EDITION — 2024

Hôpitaux Universitaires Genève

Hôpitaux Universitaires Genève
Biomedical and Equipment Service
www.hug.ch/service-biomedical-equipements

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CONTRIBUTORS

Hôpitaux Universitaires de Genève
Biomedical and Equipment Service

Hervé Jacquemoud
Department Manager

Karim Rghioui
Engineer, Project Manager

Magali Jacquemin
Engineering Intern

With the collaboration of the Department of Surgery and all the surgeons at the HUG

www.hug.ch/service-biomedical-equipements

With the support of the members of the Swiss Foundation for Innovation and Training in Surgery (SFITS)

SWISS FOUNDATION FOR INNOVATION AND TRAINING IN SURGERY

www.sfits.ch

INTRODUCTION

In 2020 and 2021, the Biomedical and Equipment Department of the Geneva University Hospitals (HUG) set up a working group dedicated to technological monitoring of surgical assistance and automation solutions. This was prompted by the emergence of numerous robotic systems in various surgical specialties, along with the need to identify what the industry had to offer upstream of any acquisition project (initial introduction or renewal).

To this end, the HUG carried out a meticulous inventory of automation technologies and surgical assistance technologies, resulting in the creation of an initial freely accessible, state-of-the-art structured guide (2022 version).

Following the success of this inaugural edition. we decided to produce a second version of the guide to update the robot description sheets and introduce the new robotic platforms that have emerged meanwhile. Additionally, several new features have been incorporated compared to the previous version:

- Three guidance sheets designed to raise awareness about various aspects related to the implementation of a complex system within a healthcare facility. These encompass IT considerations, reprocessing of reusable robotic instruments, and aspects of surgical training. Other topics such as maintenance, environment, equipment surroundings, and installation will also be taken into account.
- The data sheets for each robot have been revised with new sections to provide as much relevant information as possible.

- A new chapter on platforms in the process of development, clinical trial or registration phases, i.e. not yet on the market. This is particularly relevant given the common occurrence of extensive advertising and marketing campaigns for these platforms before mandatory steps for use on human beings, such as technical adjustments, tests, and regulatory acceptance.
- Finally, the publication of a dual French/English version of this guide to ensure the widest possible access.

This guide comprehensively reviews the range of systems currently on the market or in development, aiming to offer a global and neutral overview of the solutions. It is intended to be as exhaustive, independent and impartial as possible, without seeking to be a medical or technical comparison of the equipment.

The integration of these high-tech robotic systems into the complex hospital environment necessitates a global, methodological, and structured approach. While considering the subjectivity and irrationality inherent to all strategic decisions, the results are often specific to each establishment and their ability to manage their patients with these highly effective technologies. We therefore aim for this guide to be freely accessible and beneficial to all professionals involved in the acquisition and use of those surgical technologies (including board and management, surgeons, operating room teams, biomedical engineers, technicians, sterilization teams, surgical training structures).

Hervé Jacquemoud
Karim Rghioui
Magali Jacquemin

STANDARD DATA SHEET STRUCTURE

All datasheets are designed and presented uniformly.
Solutions are categorised by brand, surgical field, and control type.

TS Telesurgery system | **CM** Co-manipulator | **GA** Guidance assistant

The sheets furnish essential information about robotic platforms, including a concise presentation of the solution, surgical indications, the link to the manufacturer's website, as well as references to relevant studies and publications.

Company logo

Company name
Website
E-mail
Country

Robot photo

NAME OF THE ROBOT

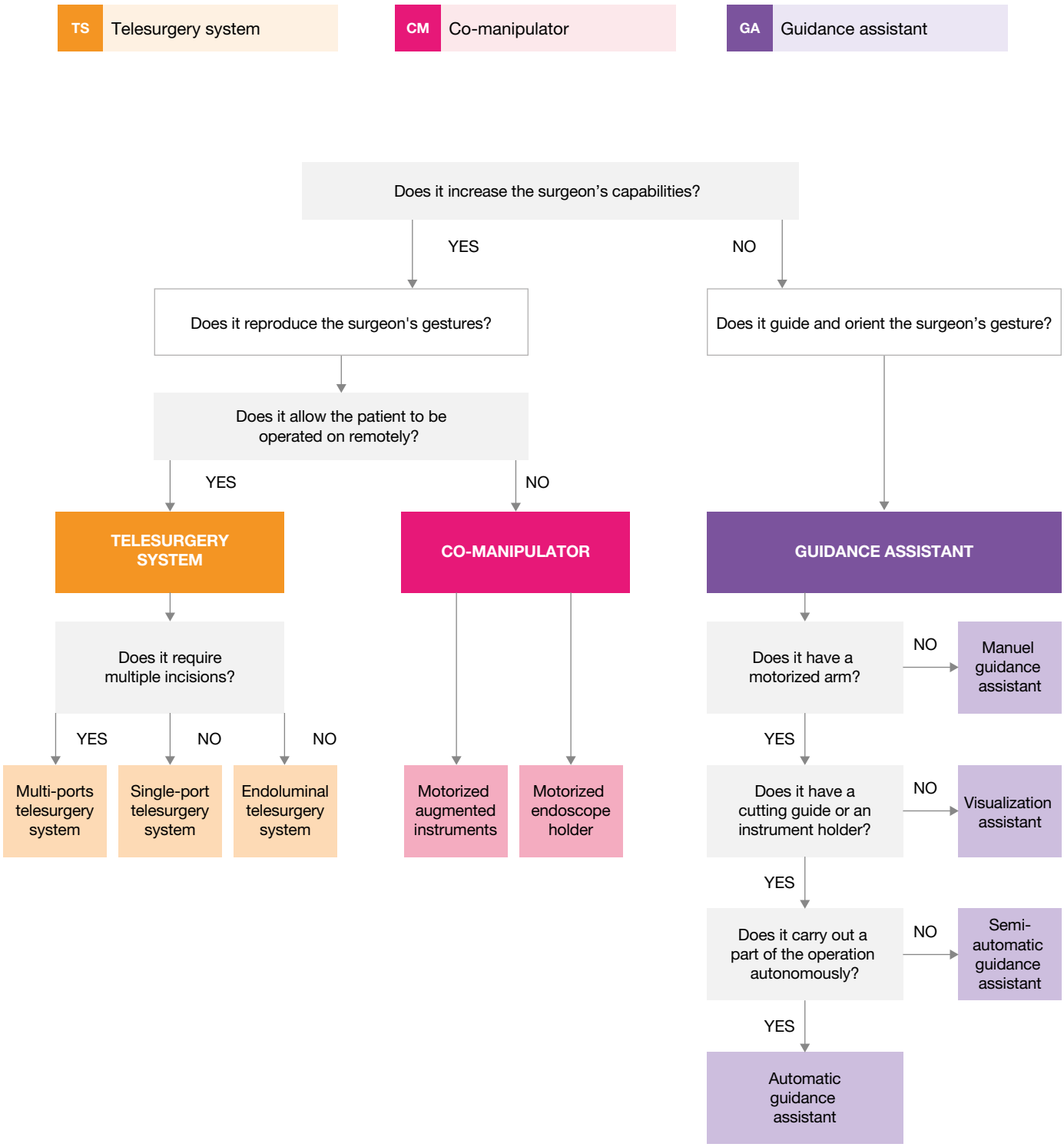
Field of application	Surgical specialties classification
TS **CM** **GA**	Control type
Conception-configuration **Conception-features** **Conception-technical specificities**	Further details are provided about configurations, features, and any technical specificities
Instruments	
Therapeutic indications	
Height / weight / age limits	This section specifies known limitations related to patients' age or morphology
Regulatory aspects	This section provides information about systems certification (EC, FDA, others)
Publications / studies	
Number of studies	

To facilitate reading/understanding of the Publications/Studies section, we have placed their types in front of them:

Meta-Analysis	**MA**	Systematic Review	**SR**
Randomised Controlled Trial	**RCT**	Case Report	**CR**
Review	**R**	Preliminary Experiment	**PE**

CLASSIFICATION METHODOLOGY

Classification Method for a Surgical Robot Based on the Type of Assistance Provided to the Surgeon



GUIDANCE SHEETS

IT

These days, IT ecosystems have become particularly dense in healthcare establishments, whether through applications linked to the various professions (medical, administrative and support functions) or those integrated into the many connected medical devices that make up the technical platform in situ or used outside the walls (telemedicine, grouping of establishments). These devices, including surgical robots, need to be connected to the healthcare establishment's IT network to exchange patient data (demographic data, diagnostic or therapeutic data and images) or technical parameters (remote maintenance) securely.

The question is whether the robot is (or needs to be) connected to the network and whether it needs to exchange information with applications in the hospital information system (HIS) or other third-party devices to perform the surgery.

Robots must be integrated in such a way as to be of profound use. In addition, the IT operation of the robots will have to be controlled throughout their operational life in the establishment. It will therefore be necessary to investigate several IT issues before implementing robotic surgical solutions in the operating theater, which incorporate software and applications such as:

- Architecture studies and determination of data flows
- Locating the data acquired by the robot (internal, external)
- Prospecting and developing the market or implementing solutions (development strategy, master plans)
- The emergence and potential added value of new technologies (external or on-board AI)
- Supplier relations in terms of support and guidance
- Data security when data is exchanged between institutions or establishments (encryption, hosting), or with the supplier (cloud)
- Definition of the communication mode (Wi-Fi, Ethernet, USB, etc.)

IT data in a hospital is sensitive, whether it is patient or hospital data. It is therefore essential to control and secure not only the exchanges between the various pieces of equipment but also the storage solutions. IT security is therefore essential when integrating a robot into a fleet of equipment. Depending on the different system configurations, this integration will be straightforward in this non-standardized market.

Institutions are thus faced with challenges depending on the software architectures used to operate the robots. Key points to be studied are:

- The durability and security of archiving data (IT security policy)
- The hospital infrastructure strategy (redundancy, backup, network protection, etc.), and therefore, the security of computer networks with segmentation of the network of highly critical equipment (own sub-network and port limitation)
- Archiving and securing data flows
- Securing and updating operating systems (obsolescence, security patches, antivirus/firewall [communication port], limiting services and applications, criticality of applications) according to the supplier's constraints and the availability required in a hospital environment
- The integration objective:
  - Patient identification [ADT], surgical imaging, quality of regulation, surgical planning, or follow-up of instructions
  - User identification: Active Directory, remote account [SAML], presence of remote guidance (flow encryption), remote maintenance, security, and access history

With the contribution of Cyrill Gonin: biomedical IT project manager - HUG

REPROCESSING OF REUSABLE ROBOTIC INSTRUMENTS

Surgical instruments are medical devices that perform actions such as dissection, palpation, grasping, visualization, energy delivery, suturing, sawing, or screwing during surgery. Robotic surgical platforms use these instruments as end-effectors to guide, assist or reproduce surgical gestures during the operation.

These devices fall into two categories: reusable (multiple-use) and single-use instruments. Single-use instruments only allow one usage and must be disposed of via an appropriate waste channel once used on a patient. Multi-use instruments, on the other hand, can be re-used after sterilization, depending on the recommendations and limits (number of cycles) defined by the manufacturers.

These two categories of instruments have specific constraints and will generate variable direct and indirect costs that need to be considered. In addition, there are organizational and environmental impacts that will be specific to each robotic surgery platform and the staff involved.

Before acquiring a surgical robot, it is therefore necessary to consider the reprocessing processes to implement for each of the associated reusable instruments (washing and disinfection, use of ultrasound, functionality checks, packaging, type of sterilization as well as the various manual steps required, where applicable).

Sterilization is a process designed to render a product free of viable micro-organisms. The manual and/or automated washing and disinfection steps determine the sterilization procedure.

There are different sterilization processes (set temperature level and type of sterilizing agent) which must be used on a case-by-case basis depending on the properties of the materials making up the instruments (thermolabile or thermostable) or their geometry, and always in accordance with the manufacturer's recommendations. Depending on the method and equipment used, the cost of reprocessing may be significantly higher than for standard reprocessing (vH2o2 low-temperature sterilization vs. conventional steam sterilization).

It is therefore essential to know the reprocessing method required for each reusable instrument, to be able to anticipate, if necessary, investments linked to specific washing-disinfection or sterilization equipment or accessories, and to make the most of the associated operating costs (maintenance, consumables, qualifications). It is also vital to use chemicals that are compatible with the instruments and validated by their manufacturer.

Training of sterilization personnel and the quantification of manual interventions required during reprocessing must also be considered. The overall reprocessing time for reusable instruments, the number of sets or instruments needed to rotate between cases, and the scheduling of procedures all need to be appropriate to ensure optimum use of the surgical robot.

The **Swiss Good Practices for MD reprocessing** reference document, published in 2022 by the Swiss Society of Hospital Sterilization (SSSH/SGSV/SSSO) and Swissmedic, along with the presentation of current reprocessing processes and equipment in the **State of the Art in Sterilization** study (AFIB/SSSH/SGSV/SSSO 2022) will give our readers a detailed picture of the requirements and equipment in this field.

With the contribution of
Hervé Ney, Sterilization Expert
President of the Swiss Society
of Hospital Sterilization
SSSH/SGSV/SSSO

SURGICAL TRAINING

Teaching surgery used to be easy. "See one, do one, teach one" was Halsted's (1852-1922) adage, and for most of the 19th and 20th centuries, this approach was fitting. At the time, masters were even paid by their students for providing "teaching" expertise.

Surgery used to be a low-tech field, only requiring tools and instruments that were straight out of the forge or the manufacture, without any need for accreditation nor bureaucratic approval processes. Anyone interested in learning about surgery could do so via means of observation and then be trained – in the best-case scenario under the supervisory eye of a mentor – before rapidly becoming become a solo operator.

A single surgeon could master a wide range of surgeries – a dream for current administrators – even if some were better at carrying amputations and others at treating hernias or fistulas. Success and word of mouth helped develop the practice. All of this made sense from an economic standpoint, while this kind of educational system allowed hospitals not to invest much in future surgeons' training.

Later, things started to evolve as new techniques emerged. Anaesthesiology enabled deep exploration of the human body. In 1895, Roentgen´s discovery of X-Rays revolutionised the fields of physics and medicine, making it possible to see through the human body. Despite the limited means of communication, by the end of the century, all hospitals were equipped with these technologies. Blood transfusions and antibiotic discoveries followed, leading to increasingly complex procedures. CT scans, MRIs, ultrasonography, and isotopes revolutionised diagnostic processes: these days, third-year medical students are able to diagnose illnesses that former experienced professors and practitioners could only guess at. Nevertheless, until the 1980s, Halsted´s principles stood the test of time. Later, endoscopy was discovered and represented a step forward for all areas of surgery. New skills were needed to master these techniques, at first essentially diagnostic, but rapidly becoming interventional as instrumentation developed.

Finally, robotic surgical assistance technologies (or "cobots") invaded operating theaters. In more recent years, artificial intelligence – viewed by some as a threat and by others as a universal remedy – has been on the verge of saturating our activities on all fronts. We bravely entered the 21st century only to find that technology had not only disrupted practices, but also that society was evolving. Work ethics have also evolved, as individual needs steadily grow to prevail over societal needs. Nowadays, working hours have shrunk while leisure and free time have become priorities. Furthermore, the weight of economics, administration as well as regulation are creating an ever-increasing burden on medical practice. Our surgical and interventional professions have quickly had to face that although health has no price tag, it does have a cost.

The same applies to education. While a learner can watch a skilled endoscopic operator for hours, without practice they may not necessarily assimilate the art of triangulation or 3D perception from a flat screen. These skills need to be taught proactively and, above all, practiced on increasingly realistic simulation systems. Complex and delicate procedures such as microsurgery or endovascular interventional catheterisation need to be learnt and performed on appropriately prepared teaching materials or specimens. Highly complex surgical procedures must be planned and performed on anatomical specimens or models before being directly applied to patients. New skills require training, rehearsal, development, assessment, and practice.

Training processes must be carried out in partnership with engineers and developers of the new technologies.

For most professions, training and practice are inextricably linked. Who would travel on a commercial flight flown by a pilot who has not completed flight simulator training? And who would attend a play or concert where performers have not rehearsed their act?

Keenly aware of teaching issues, the University Hospitals of Geneva have set up a foundation special-ized in organizing surgical and interventional training sessions: the Swiss Foundation for Innovation and Training in Surgery (SFITS), which innovates in the field of interventional techniques.

Pr Pierre J. Hoffmeyer
Chairman of SFITS

Dre Jelena Godjevac
Director of SFITS

Fully equipped wet labs

Simulators

Flat panels

3D and 4k screens

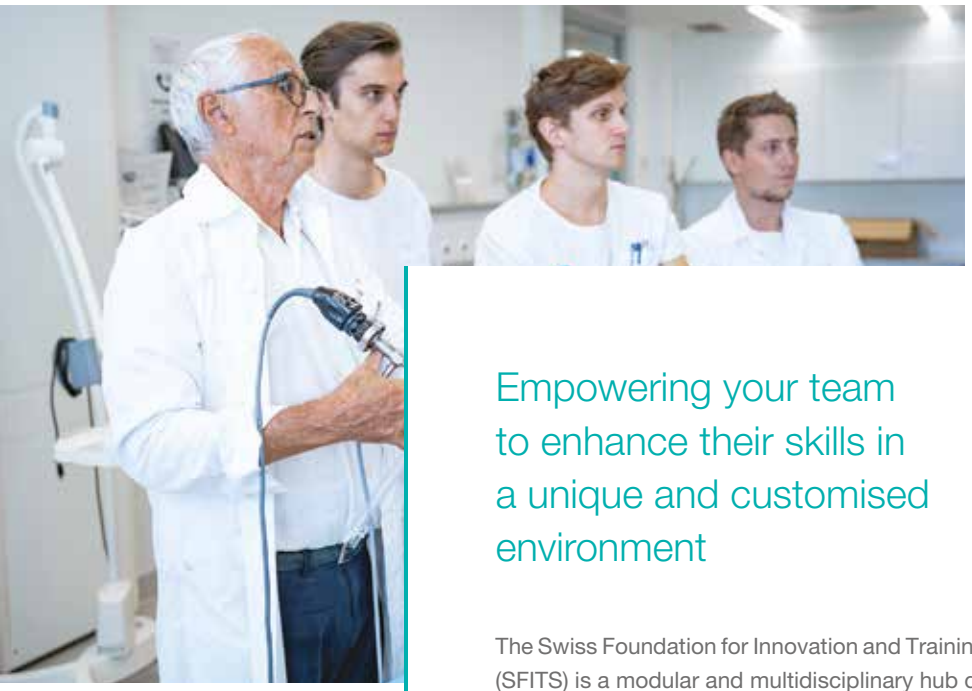
X-ray scopes

Video studio

The foundation is located within the hospital's campus, in a versatile 1,860 m^2 modular space spread over two floors. It includes fully equipped wet labs (operating tables, microscopes, scalpels, instruments, arthroscopy, and laparoscopy towers), simulators, flat panels, 3D and 4k screens, X-ray scopes, a video studio, an auditorium, and meeting rooms. The foundation has developed unparalleled expertise in teaching and standardizing training models, through appropriate configurations and anatomical models.

THE SFITS, WHERE THE FUTURE OF SURGICAL EDUCATION HAPPENS

SWISS FOUNDATION FOR INNOVATION AND TRAINING IN SURGERY



Empowering your team to enhance their skills in a unique and customised environment

The Swiss Foundation for Innovation and Training in Surgery (SFITS) is a modular and multidisciplinary hub dedicated to surgical and interventional training.
Its infrastructure and equipment provide a secure and appropriate workplace, including a 50-seat auditorium and conference rooms equipped with a sophisticated audio-visual system for live broadcasts from operating theaters, hybrid events, and educational video recordings.
Specialised in operational, audio-visual, biomedical, and educational fields, the team is versatile and highly skilled. The staff possesses cutting-edge knowledge required to master various processes and successfully complete training, research, and innovative projects.

50

seats in the auditorium

+ 700

face-to-face, online and blended events

More information on

www.sfits.ch

Conferences and symposia

Workshops on synthetic materials

Practical workshops on organic parts

Cadlabs on anatomical specimens

R&D and testing sessions

Live streams and hybrid events

Preparation for complex clinical procedures

As a centre of excellence, SFITS runs over 700 face-to-face, online, and blended events annually, catering to hospital healthcare professionals, medical associations, and the Medtech industry.

Its innovative environment enables users to implement specific surgical training courses and training on technologies surrounding automation and surgical assistance, whether on organic, synthetic, or anatomical teaching material.

Drawing on its experience in organizing robotic surgery courses, SFITS can assist in building customised training programs.

Contact us to discuss your training projects.

sfits@sfits.ch
+41 (0)22 322 91 00

SYSTEMS SUMMARY TABLE

COMPANY	PRODUCT	MICROSURGERY	PEDIATRICS	PLASTIC AND RECONSTRUCTIVE	OPHTALMOLOGY	CARDIOLOGY	NEUROSURGERY
AcuSurgical SAS	AcuSurgical				Future		
Aktormed GMBH	Solo Assist II					Achievable	
AOT	CARLO						
Asahi Intecc Co., Ltd	ANSUR						
Asensus Surgical (TransEnterix)	Senhance		Achievable				
Avateramedical GMBH	Avatera		Future				
B. Braun	Aesculap Aeos	Achievable					Achievable
BHS Technologies	RoboticScope						Achievable
Biobot Surgical Pte Ltd	iSR'obot Monalisa v1 + v2						
Brainlab	Cirq						Achievable
CAScination AG	HEARO						
CMR Surgical	Versius		Future				
Collin Medical	RobOtol						
Corin Group	OMNIBotics						
Curexo	Cuvis-Joint						

Achievable applications Future applications

SPINE	ORTHOPEDICS	THORACIC – ENDOCRINE	ENT	VISCERAL	UROLOGY	GYNECOLOGY	TYPE OF CONTROL	SYSTEM	PAGE
							TS	Multi-ports	28
							CM	Motorized endoscope holder	29
							GA	Automatic	30
							CM	Motorized augmented instruments	31
							TS	Multi-ports	32
							TS	Multi-ports	34
							GA	Visualization assistant	35
							GA	Visualization assistant	36
							GA	Semi-automatic	37
							GA	Semi-automatic	38
							GA	Automatic	40
							TS	Multi-ports	41
							GA	Semi-automatic	42
							GA	Semi-automatic	43
							GA	Semi-automatic	44

TS Telesurgery system CM Co-manipulator GA Guidance assistant

COMPANY	PRODUCT	MICROSURGERY	PEDIATRICS	PLASTIC AND RECONSTRUCTIVE	OPHTALMOLOGY	CARDIOLOGY	NEUROSURGERY
Curexo	Cuvis-Spine						
Cyber Surgery	Alaya						
DEX Surgical	DEX						
Distalmotion	Dexter						
eCential Robotics	CoBot						
EDAP TMS SA	Focal One						
Edge Medical	MP1000						
Elmed Medical System	Avicenna Roboflex						
EndoControl	JAIMY Advance		■				
EndoControl	Viky		■				
EndoQuest Robotics (Columbris MX)	Columbris ELS						
EndoQuest Robotics (Columbris MX)	Columbris SP						
Fortimedix Surgical B.V.	SymphonX Surgical Platform						
FreeHand LDT	FreeHand V1.2					■	
Globus Medical Inc.	Excelsius GPS						■

■ Achievable applications ■ Future applications

SPINE	ORTHOPEDICS	THORACIC – ENDOCRINE	ENT	VISCERAL	UROLOGY	GYNECOLOGY	TYPE OF CONTROL	SYSTEM	PAGE
■							GA	Semi-automatic	45
■							GA	Semi-automatic	46
		■		■	■	■	CM	Motorized augmented instruments	47
				■	■	■	TS	Multi-ports	48
■	■						GA	Semi-automatic	50
					■		GA	Semi-automatic	51
		■		■	■	■	TS	Multi-ports	52
					■		TS	Endoluminal	53
				■	■	■	CM	Motorized augmented instruments	54
		■		■	■	■	CM	Motorized endoscope holder	55
			■	■			TS	Endoluminal	56
				■	■	■	TS	Single-port	57
				■	■	■	CM	Motorized augmented instruments	58
■		■		■	■	■	CM	Motorized endoscope holder	59
■							GA	Semi-automatic	60

TS Telesurgery system CM Co-manipulator GA Guidance assistant

COMPANY	PRODUCT	MICROSURGERY	PEDIATRICS	PLASTIC AND RECONSTRUCTIVE	OPHTALMOLOGY	CARDIOLOGY	NEUROSURGERY
Hangzhou Jianjia Medical Technology Co., Ltd	Arthrobot						
Harbin Sagebot Intelligent Medical Equipment Co., Ltd/ Kangduo	Kangduo						
HIWIN Healthcare	MTG-H100						
Human Xtensions	HandX		■				
Hurwa	HURWA Surgical Robot						
Interventional Systems	Micromate		■				■
Intuitive Surgical	Da Vinci SP						
Intuitive Surgical	Da Vinci X						
Intuitive Surgical	Da Vinci Xi		■			■	
Intuitive Surgical	Ion						
J&J Auris Health	Monarch						
J&J DePuy Synthes	Velys						
J&J Tinavi	TiRobot						■
Karl Storz	ARTip Cruise & Vitom 2D/3D	■	■	■		■	■
Keranova	FemtoMatrix				■		

■ Achievable applications ■ Future applications

SPINE	ORTHOPEDICS	THORACIC – ENDOCRINE	ENT	VISCERAL	UROLOGY	GYNECOLOGY	TYPE OF CONTROL	SYSTEM	PAGE
	■						GA	Semi-automatic	61
		■		■	■	■	TS	Multi-ports	62
		■		■	■	■	CM	Motorized endoscope holder	63
		■		■	■	■	CM	Motorized augmented instruments	64
	■						GA	Semi-automatic	65
■	■	■		■	■		GA	Semi-automatic	66
		■	■	■	■	■	TS	Single-port	67
				■	■	■	TS	Multi-ports	69
		■	■	■	■	■	TS	Multi-ports	70
		■					TS	Endoluminal	72
		■			■		TS	Endoluminal	73
	■						GA	Semi-automatic	74
■	■						GA	Semi-automatic	75
■		■	■		■	■	GA	Visualization assistant	76
							GA	Automatic	77

TS Telesurgery system CM Co-manipulator GA Guidance assistant

COMPANY	PRODUCT	MICROSURGERY	PEDIATRICS	PLASTIC AND RECONSTRUCTIVE	OPHTALMOLOGY	CARDIOLOGY	NEUROSURGERY
Ku Leuven	Mynutia				■		
Levita Magnetics	MARS						
Levita Magnetics	Levita Magnetic Surgical System						
Medicaroid Corporation	Hinotori					■	
Medrobotics Corporation	Flex						
Medtronic	Hugo RAS		■			■	
Medtronic	Mazor X Stealth Station						
Medtronic	Stealth Autoguide						■
Meere Company	Revo-i						
MicroPort	Honghu (SkyWalker platform) R.One (Joint Venture),						
MicroPort	Toumai						
Microsure	MUSA	■	■	■			
MMI	Symani	■	■	■	■		■
Momentis Surgical (Memic)	Anovo (Hominis)						
Moon Surgical	Maestro						

■ Achievable applications ■ Future applications

SPINE	ORTHOPEDICS	THORACIC – ENDOCRINE	ENT	VISCERAL	UROLOGY	GYNECOLOGY	TYPE OF CONTROL	SYSTEM	PAGE
							GA	Semi-automatic	78
							CM	Motorized augmented instruments	79
							CM	Motorized augmented instruments	80
							TS	Multi-ports	81
							TS	Endoluminal	82
							TS	Multi-ports	83
							GA	Semi-automatic	84
							GA	Semi-automatic	85
							TS	Multi-ports	86
							GA	Semi-automatic	88
							TS	Multi-ports	89
							TS	Multi-ports	90
							TS	Multi-ports	91
							TS	Endoluminal	92
							CM	Motorized augmented instruments	93

TS Telesurgery system CM Co-manipulator GA Guidance assistant

COMPANY	PRODUCT	MICROSURGERY	PEDIATRICS	PLASTIC AND RECONSTRUCTIVE	OPHTALMOLOGY	CARDIOLOGY	NEUROSURGERY
Neocis	Yomi Dental Robot						
Noah Medical	Galaxy System						
NuVasive	Pulse						
Olympus	Orbeye	■	■	■			■
Perfint Healthcare Pvt Ltd	Maxio III						
Point Robotics	The Kinguide system						
Preceyes B.V.	Preceyes				■		
Procept BioRobotics	AquaBeam						
Quantum Surgical	Epione						
Renishaw	Neuromate						■
Rob Surgical	Bitrack						
Sinamed	Sinaflex		■			■	
Smith&Nephew	Navio FPS						
Soteria Medical	Soteria						
SSInnovations / Surgical Robotic Solutions	SSI Mantra					■	

■ Achievable applications ■ Future applications

SPINE	ORTHOPEDICS	THORACIC – ENDOCRINE	ENT	VISCERAL	UROLOGY	GYNECOLOGY	TYPE OF CONTROL	SYSTEM	PAGE
							GA	Semi-automatic	94
							TS	Endoluminal	95
							GA	Semi-automatic	96
							GA	Visualization assistant	97
							GA	Semi-automatic	98
							GA	Semi-automatic	99
							TS	Multi-ports	100
							TS	Endoluminal	101
							GA	Semi-automatic	102
							GA	Semi-automatic	103
							TS	Multi-ports	104
							TS	Multi-ports	105
							GA	Manuel	106
							TS	Endoluminal	107
							TS	Multi-ports	108

TS Telesurgery system CM Co-manipulator GA Guidance assistant

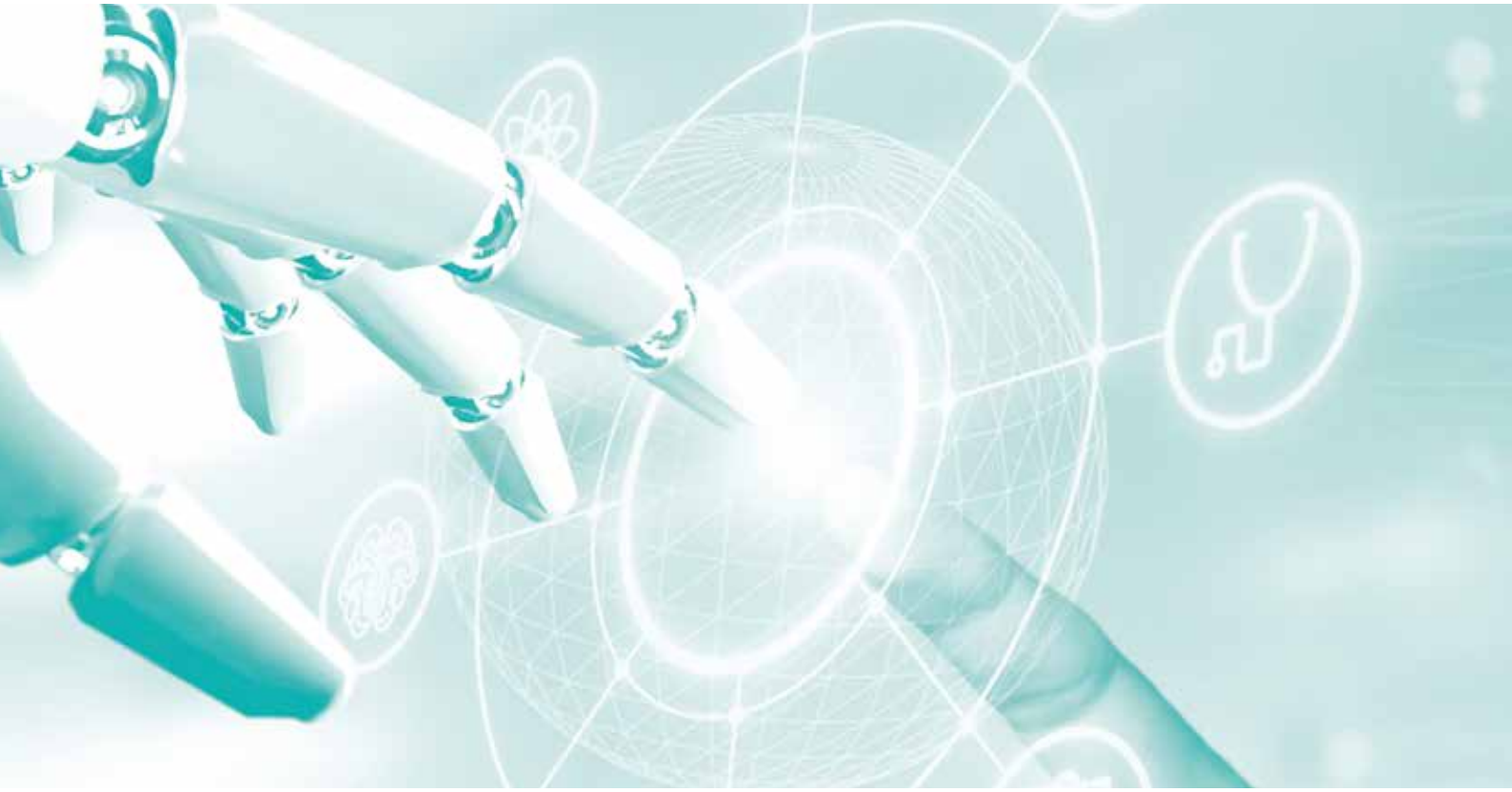
COMPANY	PRODUCT	MICROSURGERY	PEDIATRICS	PLASTIC AND RECONSTRUCTIVE	OPHTALMOLOGY	CARDIOLOGY	NEUROSURGERY
Styker	Mako						
Synaptive	Modus V		■				■
THINK Surgical	TMINI				■		
Think Surgical Inc.	Tsolution One						
Venus Concept (Restoration Robotics)	ARTAS iX			■			
Virtual Incision	MIRA						
WEGO	Microhand-S System						
Yuanhua Intelligent Technology / Yuanhua Technology	Yuanhua Surgical Robot						
Zimmer Biomet	Rosa Knee						
Zimmer Biomet	Rosa One						■

■ Achievable applications ■ Future applications

SPINE	ORTHOPEDICS	THORACIC – ENDOCRINE	ENT	VISCERAL	UROLOGY	GYNECOLOGY	TYPE OF CONTROL	SYSTEM	PAGE
							GA	Semi-automatic	109
							CM	Motorized endoscope holder	110
							GA	Semi-automatic	111
							GA	Automatic	112
							GA	Automatic	113
							TS	Single-port	114
							TS	Multi-ports	115
							GA	Semi-automatic	116
							GA	Semi-automatic	117
							GA	Semi-automatic	118

TS Telesurgery system CM Co-manipulator GA Guidance assistant

ROBOTIC PLATFORMS



AcuSurgical SAS
https://acusurgical.com/fr/accueil/
contact@acusurgical.com
France

ACUSURGICAL

Field of application	Ophthalmology
TS	Multi-port telesurgery system
Conception-configuration	This robot under development at LIRMM (UMR 5506 CNRS and University of Montpellier) and BiiGC (EA 2521, University and CHU of St-Etienne) will allow bi-manual surgery on a console with a system of 3D microscopy and augmented vision (real-time OCT imaging, preoperative images, etc.).
Conception-features	Instruments controlled with two joysticks
Conception-technical specificities	3D microscopy and augmented vision system

Therapeutic indications

Vitreoretinal surgery:
The teleoperated system targets routine surgery (vitrectomy, membrane peeling, endophotocoagulation) and some of the most complex procedures, such as intra/subretinal and intravascular injections.

Specify size/weight limit	No known indications
Regulatory aspects	CE in progress FDA in progress
Publications / studies	No academic articles found
Number of studies	0

AKTORmed™ ROBOTIC SURGERY

Aktormed GMBH
https://aktormed.info/en/products/soloassist-en
info@aktormed.com
Germany

SOLOASSIST II

Field of application	Cardiology Thoracic-endocrine Visceral Urology Gynecology
CM	Co-manipulator: motorized endoscope holder
Conception-configuration	Robotic arm
Conception-features	Joystick or voice-controlled (speaker independent - no speech training required) Manual positioning
Conception-technical specificities	Speech/motion latency less than 200 ms Accuracy - recognition rate over 95%

Therapeutic indications

Thoracoscopic procedures

Gynecology:
- Tubal Ligation
- Hysterectomy
- Cystectomy
- Ovarectomy

Urology:
- Nephrectomy
- Vasectomy
- Adrenalectomy
- Prostatectomy

Cardiology procedures

Visceral:
- Cholecystectomy
- Appendectomy
- Gastroenterological procedures
- Fundoplicatio
- Gastric Banding

Specify size/weight limit	No known indications
Regulatory aspects	CE / FDA 2018

Publications / studies

1. Ohmura Y, Suzuki H, Kotani K, Teramoto A. Laparoscopic inguinal hernia repair with a joystick-guided robotic scope holder (Soloassist II®): retrospective comparative study with human assistant. Langenbecks Arch Surg. 2019 Jun;404(4):495-503. doi: 10.1007/s00423-019-01793-y. Epub 2019 May 25. PMID: 31129765.
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3. Park JO, Kim MR, Park YJ, Kim MS, Sun DI. Transoral endoscopic thyroid surgery using robotic scope holder: Our initial experiences. J Minim Access Surg. 2020 Jul-Sep;16(3):235-238. doi: 10.4103/jmas.JMAS_12_19. PMID: 31031326; PMCID: PMC7440021.
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5. Ohmura Y, Nakagawa M, Suzuki H, Kotani K, Teramoto A. Feasibility and Usefulness of a Joystick-Guided Robotic Scope Holder (Soloassist) in Laparoscopic Surgery. January 31, 2018. Visc Med 2018;34:37–44 DOI: 10.1159/000485524.

Number of studies	5

AOT
https://aot.swiss/carlo/
info@aot.swiss
Switzerland

CARLO

Field of application	Orthopedics
GA	Guidance assistant: automatic
Conception-configuration	Cold, robot-guided laser ablation.
Conception-features	The system is rounded off with complex 3D planning, navigation and control software and hardware. It slots seamlessly into the operating room and works autonomously, but provides the surgeon with full control of the procedure at all times. Cutting bone up to 20 mm and working on improving the cutting ability to over 50 mm.
Therapeutic indications	Osteotomies
Height / weight / age limits	No known indications
Regulatory aspects	CE in progress FDA in progress

Publications / studies

1. Ureel M, Augello M, Holzinger D, Wilken T, Berg BI, Zeilhofer HF, Millesi G, Juergens P, Mueller AA. Cold Ablation Robot-Guided Laser Osteotome (CARLO®): From Bench to Bedside. J Clin Med. 2021 Jan 24;10(3):450. doi: 10.3390/jcm10030450. PMID: 33498921.
2. Holzinger D, Ureel M, Wilken T, Müller AA, Schicho K, Millesi G, Juergens P. First-in-man application of a cold ablation robot guided laser osteotome in midface osteotomies. J Craniomaxillofac Surg. 2021 Jul;49(7):531-537. doi: 10.1016/j.jcms.2021.01.007. Epub 2021 Jan 17. PMID: 33994295.

ASAHI INTECC
Medical Components

Asahi Intecc Co., Ltd
http://www.asahi-intecc.co.jp/en/
https://ssl.asahi-intecc.com/
Japan

ANSUR

Field of application	Gynecology
CM	Co-manipulator: motorized augmented instruments
Conception-configuration	ANSUR is a co-working-style assistant robot for laparoscopic surgeries. ANSUR takes the role of scopist & assistant surgeon as your reliable partner. ANSUR has 3 robotic arms (one for holding the endoscope and the other two for holding the dedicated ANSUR grasping forceps). Of the three arms, surgeon can select and use the required number of robotic arms according to the procedure. There is no separate console.
Conception-features	ANSUR is compatible with the endoscope/imaging system already installed in the facility. An articulated instrument connecting dedicated ANSUR grasping forceps. Requires some accessories and a sterile cover for using ANSUR.
Conception-technical specificities	While continuing to stand by the patient as usual during laparoscopic surgery, surgeons can control ANSUR using sensors attached to their device. It is expected to minimize surgeons per procedure but form a first-class team for laparoscopic surgeries.
Therapeutic indications	Wide range of laparoscopic surgeries (except for thoracic and cardiac surgery)
Height / weight / age limits	No known indications
Regulatory aspects	Japanese Ministry of Health 2023
Publications / studies	No academic articles found

Asensus Surgical (TransEnterix)
https://asensus.com
USA

SENHANCE

Field of application	Pediatrics Thoracic-endocrine Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	The platform includes 3 to 4 independent robotic manipulator arms and a control console with haptic feedback. Two handles with movement inversion, 3D visualization and force feedback reproduce the movements performed during a standard laparoscopy. In addition, an eye tracking system and an algorithm calculate the rotation and pivoting of each manipulator arm to minimize tissue trauma and bruising. Surgical instruments connect to it via magnets. Transenterix offers a range of 22 instruments, with a diameter of 3 to 10mm, which can be sterilized without limiting the number of uses. Enables Digital laparoscopy. The Senhance Surgical System is digitizing laparoscopy by integrating advanced technology—robotic precision, haptic sensing, eye-tracking camera control, and improved ergonomics—with skilled laparoscopists while focusing on responsible economics. The open-platform architecture allows for compatibility with 3DHD and fluorescence vision systems along with other existing hospital investments in laparoscopy. The system comprises 3 to 4 independent modular, portable robotic arms, a cockpit console and the Intelligent Surgical Unit, the digital engine behind Asensus Augment Intelligence.
Conception-features	The intelligent Surgical Unit is the world's first AI system to be FDA cleared and CE Marked for use in robotic surgery. Asensus Augment Intelligence is providing digital tools to help surgeons make informed decisions, navigate challenging anatomy, and reduce variability that impact outcomes. In combination with the surgical system (5mm articulating instruments, 7 degrees of freedom), these novel digital capabilities are designed to provide clinicians with new data and insights to enhance real-time decision making. The surgeon is works at an open console, freely communication with the OR Team at the table site.
Conception-technical specificities	Eye-tracking camera control allows surgeons to continuously control camera with their eyes. Haptic sensing transmits forces sensed by the robotic instruments to the surgeon's hands during critical tasks e.g. suturing. 3mm instruments on a robotic platform and 5mm articulation instruments allows 7 degrees of freedom. 2D and 3DHD visualization provides additional intelligence regarding depth and spatial relation of organs. Open-platform architecture allows use and integration of existing OR technologies to maximize benefit from investments and support surgeon preference. Standard reusable instruments keep costs similar to traditional laparoscopic instruments. MIS/laparoscopic access and thus immediate change to manual laparoscopic method if desired.

Instruments

Asensus Senhance offers a wide range (70+) of enabling instruments, straight and articulating from 3 to 10mm in diameter, single use and sterilizable/reusable with no limit on the number of uses or surgical time. Combining articulation and haptics enables improved access to critical structures by providing real time feedback and control. The Articulating instruments build on laparoscopic skills allowing the surgeon to stay focused on the surgical site and complete complex procedural steps end-to-end from the surgeon cockpit enabling more control and efficiency. Furthermore, the system provides Ultrasonic Advanced Energy for fast and precise tissue dissection and vessel seating.
Adopt commercial laparoscopic trocars.

Therapeutic indications

Urology:
Approved for minimal invasive abdominal surgery in urological
- Radical prostatectomy
- Partial or segmental ureterectomy
- Other ureteral interventions
- Partial nephrectomy
- Radical cystectomy
- Renal lumpectomy

Gynecology:
Approved for minimal invasive abdominal surgery in gynecological
- Radical hysterectomy
- Vaginal hysterectomy
- Colposacropxy

Visceral:
Approved for minimal invasive abdominal surgery in general-, visceral-, colorectal
- Cholecystectomy
- Gastrectomy
- Anterior rectal resection

Thoracic:
Approved for minimal invasive abdominal surgery parts of thoracic- surgery.
- Pulmonary lobectomy
- Thymectomy

Specify size/weight limit

CE: Above 10 Kg.
It has been shown (in inanimate models) that even in small volumes of 90 ml (2.9 x cm x 6.3 cm x 4.9 cm box rims), intracorporeal suturing and manipulation appears feasible with this system.
The first pediatric robotic procedures were performed in the Department of Pediatric Surgery at Maastricht University Medical Center +.

Regulatory aspects

CE 2006.
FDA 2017 general surgery; gynecology. Pediatric surgery expected in 2023.
CE-mark: general surgery; gynecology; pediatric surgery.
MHLW PMDA Japan: urology; gynecology; general surgery; thoracic surgery
Roszdravnadzor—Russia: yes, not specified.
Taiwan: yes, not specified.

Publications / studies

1. Samalavicius NE, Janusonis V, Siaulys R, Jasėnas M, Deduchovas O, Venckus R, Ezerskiene V, Paskeviciute R, Klimaviciute G. Robotic surgery using Senhance® robotic platform: single center experience with first 100 cases. J Robot Surg. 2020 Apr;14(2):371-376. doi: 10.1007/s11701-019-01000-6. Epub 2019 Jul 12. PMID: 31301021.
2. Melling N, Barr J, Schmitz R, Polonski A, Miro J, Ghadban T, Wodack K, Izbicki J, Zani S, Perez D. Robotic cholecystectomy: first experience with the new Senhance robotic system. J Robot Surg. 2019 Jun;13(3):495-500. doi: 10.1007/s11701-018-0877-3. Epub 2018 Sep 27. PMID: 30264180.
3. Bergholz R, Botden S, Verweij J, Tytgat S, Van Gemert W, Boettcher M, Ehlert H, Reinshagen K, Gidaro S. Evaluation of a new robotic-assisted laparoscopic surgical system for procedures in small cavities. J Robot Surg. 2020 Feb;14(1):191-197. doi: 10.1007/s11701-019-00961-y. Epub 2019 Apr 16. PMID: 30993523.
4. Schmitz R, Willeke F, Darwich I, Kloeckner-Lang SM, Saelzer H, Labenz J, Borkenstein DP, Zani S. Robotic-Assisted Nissen Fundoplication with the Senhance® Surgical System: Technical Aspects and Early Results. Surg Technol Int. 2019 Nov 10;35:113-119. PMID: 31687787.
5. Stephan D, Darwich I, Willeke F. First Clinical Use of 5 mm Articulating Instruments with the Senhance® Robotic System. Surg Technol Int. 2020 Nov 28;37:63-67. PMID: 32926398.
6. Darwich I, Stephan D, Klöckner-Lang M, Scheidt M, Friedberg R, Willeke F. A roadmap for robotic-assisted sigmoid resection in diverticular disease using a Senhance™ Surgical Robotic System: results and technical aspects. J Robot Surg. 2020 Apr;14(2):297-304. doi: 10.1007/s11701-019-00980-9. Epub 2019 Jun 3. PMID: 31161448; PMCID: PMC7125057.
7. DeBeche-Adams T, Eubanks WS, de la Fuente SG. Early experience with the Senhance®-laparoscopic/robotic platform in the US. J Robot Surg. 2019 Apr;13(2):357-359. doi: 10.1007/s11701-018-0893-3. Epub 2018 Nov 13. PMID: 30426353.
8. Schmitz R, Willeke F, Barr J, Scheidt M, Saelzer H, Darwich I, Zani S, Stephan D. Robotic Inguinal Hernia Repair (TAPP) First Experience with the New Senhance Robotic System. Surg Technol Int. 2019 May 15;34:243-249. PMID: 30716159.
9. Panico G, Campagna G, Vacca L, Caramazza D, Pizzacalla S, Rumolo V, Scambia G, Ercoli A. The Senhance ® assisted laparoscopy in urogynecology: case report of sacral colpopexy with subtotal hysterectomy with bilateral salpingo-oophorectomy for pelvic organ prolapse *: * Video Article, to see the video use this link: https://qrco.de/bbdi3G. Facts Views Vis Obgyn. 2020 Oct 8;12(3):245-248. PMID: 33123699; PMCID: PMC7580262.

Number of studies

90+

Avateramedical GMBH
https://www.avatera.eu/en/home
info@avateramedical.com
Germany

AVATERA

Field of application	Pediatrics Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	The system is composed of an open control unit and a surgical robotic unit with three arms and an endoscope arm. The system does not require a viewing column.
Conception-features	Arms with 7 degrees of freedom equipped with three surgical instruments and the endoscopic arm.
Conception-technical specificities	QXGA display resolution, high color fidelity and more than full HD resolution for surgeon.
Instruments	Disposables. The system offers various sterile and single-use instruments. Arms equipped with three 5mm surgical instruments and the endoscopic arm 10mm. Metzenbaum scissors (bipolar). Atraumatic grasper. Maryland dissector (bipolar). Needle holder.

Therapeutic indications

Urology:
- Radical prostatectomy
- Partial or segmental ureterectomy
- Other ureteral interventions
- Partial nephrectomy
- Radical cystectomy
- Renal lumpectomy

Gynecology:
- Radical hysterectomy
- Vaginal hysterectomy
- Colposacropxy

Specify size/weight limit	No known indications
Regulatory aspects	CE 2019 / FDA pending

Publications / studies

1. R: Rassweiler JJ, Autorino R, Klein J, Mottrie A, Goezen AS, Stolzenburg JU, Rha KH, Schurr M, Kaouk J, Patel V, Dasgupta P, Liatsikos E. Future of robotic surgery in urology. BJU Int. 2017 Dec;120(6):822-841. doi: 10.1111/bju.13851. Epub 2017 Apr 22. PMID: 28319324.
2. Koukourikis P, Rha KH. Robotic surgical systems in urology: What is currently available? Investig Clin Urol. 2021 Jan;62(1):14-22. doi: 10.4111/icu.20200387. PMID: 33381927; PMCID: PMC7801159.
3. Brodie, Andrew & Vasdev, Nikhil. (2018). The future of robotic surgery. Annals of The Royal College of Surgeons of England. 100. 10.1308/rcsann.supp2.4.
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5. R: Salkowski M, Checcucci E, Chow AK, Rogers CC, Adbollah F, Liatsikos E, Dasgupta P, Guimaraes GC, Rassweiler J, Mottrie A, Breda A, Crivellaro S, Kaouk J, Porpiglia F, Autorino R. New multiport robotic surgical systems: a comprehensive literature review of clinical outcomes in urology. Ther Adv Urol. 2023 Jun 5;15:17562872231177781. doi: 10.1177/17562872231177781. eCollection 2023 Jan-Dec. PMID: 37325289 Free PMC article.
6. ES: Peteinaris A, Kallidonis P, Tsaturyan A, Pagonis K, Faitatziadis S, Gkeka K, Vagionis A, Natsos A, Obaidat M, Anaplioti E, Tatanis V, Vrettos T, Liatsikos E. The feasibility of robot-assisted radical cystectomy: an experimental study. World J Urol. 2023 Feb;41(2):477-482. doi: 10.1007/s00345-022-04266-y. Epub 2022 Dec 29. PMID: 36577927.
7. SR: Gkeka K, Tsaturyan A, Faitatziadis S, Peteinaris A, Anaplioti E, Pagonis K, Vagionis A, Tatanis V, Vrettos T, Kallidonis P, Liatsikos E. Robot-Assisted Radical Nephrectomy Using the Novel Avatera Robotic Surgical System: A Feasibility Study in a Porcine Model. J Endourol. 2023 Mar;37(3):273-278. doi: 10.1089/end.2022.0596. Epub 2022 Dec 1. PMID: 36274228.
8. SR: Franz J, Gratzke C, Miernik A. [Minimally Invasive Therapy: What Is The Status In 2021 - What's Coming, What's Going?]. Aktuelle Urol. 2022 Jun;53(3):231-239. doi: 10.1055/a-1702-8150. Epub 2022 Mar 1. PMID: 35231939.

Number of studies	10+

B. Braun

https://www.bbraun.com/en/products-and-therapies/neurosurgery/aesculap-aeos.html?cid=sea:int-en-search-nb-aesculap-product-aesculapaeos-generic:ga:microscope%20neurosurgery:b&gclid=cj0kcqjw7pkfbhduarisafuomdbmvtqwgbeyqban-4lnovpnnqc8np0encncork8kedh8z3ovcmzgkxiaatxmealw_wcb

info.bbmch@bbraun.com

Germany

AESCULAP AEOS

Field of application	Microsurgery Neurosurgery Spine ENT
GA	Guidance assistant: visualization assistant
Conception-configuration	The Aeos exoscope integrates digital microscopy, a fluorescence imaging system, a robotic arm all in a compact mobile cart.
Conception-features	Arms with 6 degrees of freedom and several means of remote control. Surgery head up.
Conception-technical specificities	Surgery in 4k3D vision, ICG fluorescence function and 5-ALA. 10x optical zoom. 500mm focal length.

Therapeutic indications

- Spine surgery
- Neurosurgery
- ENT
- Other microsurgical procedures under exoscopy

Specify size/weight limit	No known indications
Regulatory aspects	CE 2020 FDA 2021

Publications / studies

1. Steinhilber B, Conte L, Seibt R, Herlan S, Tatagiba M, Ebner FH. Musculoskeletal demands in microsurgery-an explorative study comparing the ergonomics of microscope and 3D exoscope. Neurosurg Rev. 2023 Jul 4;46(1):164. doi: 10.1007/s10143-023-02076-3. PMID: 37402848.
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3. Hafez A, Haeren R, Huhtakangas J, Nurminen V, Niemelä M, Lehecka M. 3D Exoscopes in Experimental Microanastomosis: A Comparison of Different Systems. Life (Basel). 2023 Feb 19;13(2):584. doi: 10.3390/life13020584. PMID: 36836941.
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5. Haeren R, Hafez A, Lehecka M. Visualization and Maneuverability Features of a Robotic Arm Three-Dimensional Exoscope and Operating Microscope for Clipping an Unruptured Intracranial Aneurysm: Video Comparison and Technical Evaluation. Oper Neurosurg (Hagerstown). 2022 Jan 1;22(1):28-34. doi: 10.1227/ONS.0000000000000060. PMID: 34982902.
6. Maurer S, Prinz V, Qasem LE, Lucia KE, Rösler J, Picht T, Konczalla J, Czabanka M. Evaluation of a Novel Three-Dimensional Robotic Digital Microscope (Aeos) in Neurosurgery. Cancers (Basel). 2021 Aug 25;13(17):4273. doi: 10.3390/cancers13174273. PMID: 34503083.

Number of studies	6+

BHS Technologies GmbH
https://www.bhs-technologies.com/
office@bhs-technologies.com
Austria

ROBOTICSCOPE

Field of application	Neurosurgery Spine ENT
GA	Guidance assistant: visualization assistant
Conception-configuration	Surgical Microscope based on the combination of Camera Head, one robot arm, a Base Unit and the Head-Mounted Display.
Conception-features	The Roboticscope uses a 6-axis robot arm to precisely maneuver a Camera Head over the surgical field. By pressing one single button footswitch, full microscope functionality, e.g. pan, orbiting around a fixed point, zoom, focus, working distance, light settings, lifting of eyepieces and plenty more functions, can be controlled completely hands-free with head gestures.
Conception-technical specificities	The System is a real-time, complete digital, robot-based 3D surgical microscope. The Head-Mounted Display holds two 4:3 micro displays (2x 1600 x 1200 px) matching human discernible visual acuity. The RoboticScope is controlled via the unique and completely intuitive user interface, with head gestures. Alternative options to maneuver the microscope are via the Touch Screen or the 3D-Joystick. Absolute magnification: 2,7 to 30,1 x. The 6-axis robotic arm realizes a precision of ± 0,003 MM. Accessories: DualView (to support 2 Head-Mounted Displays), ArcView (optical redirection system to extent viewing angles).
Instruments	The RoboticScope only uses additional sterile drapes and caps during surgeries.

Therapeutic indications

- Spine
- ENT procedures
- Microsurgical operations

Specify size/weight limit	No known indications
Regulatory aspects	CE 2020

Publications / studies

1. Battiston, Bruno & Artiaco, Stefano & Ciclamini, Davide. (2020). The RoboticScope can be a Useful Tool for Hand and Microsurgical Procedures during the COVID-19 Pandemic. Journal of Hand and Microsurgery. 10.1055/s-0040-1716667.
2. Schär, Merlin, Röösli, Christof, Huber, Alexander. Preliminary experience and feasibility test using a novel 3D virtual-reality microscope for otologic surgical procedures. 2021. doi: 10.1080/00016489.2020.1816658.
3. Boehm, Felix; Graesslin, Rene; Theodoraki, Marie-Nicole; Schild, Leon; Greve, Jens; Hoffmann, Thomas K.; Schuler, Patrick J. 2021. "Current Advances in Robotics for Head and Neck Surgery—A Systematic Review" Cancers 13, no. 6: 1398. https://doi.org/10.3390/cancers13061398
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Number of studies	10+

Biobot Surgical Pte Ltd
Robotic targeted prostate biopsy | iSR'obot Mona Lisa (biobotsurgical.com)
sales@biobotsurgical.com
Singapore

ISR'OBOT MONA LISA V1 + V2

Field of application	Urology
GA	Guidance assistant: semi-automatic
Conception-configuration	The key components of iSR'obot Mona Lisa 2.0 include a workstation, robotic navigation module and the disposables. The workstation comprises the mobile cart, touch screen monitor, control box, Urobiopsy,Urofusion, Urotherapy, Uroconnect and Uroreview software. The robotic navigation module comprises the robotic arm and the bed rail stabilizer or a floor stand stabilizer. The set of disposables comprises the probe sheath, robotic arm drape, plastic needle guide and biopsy paper. The workstation is connected to the ultrasound system via a standard cable and hardware connector and displays the 2D live image feed.
Conception-features	The robot arm serves to position both ultrasound probe and biopsy or therapy needle, in direction and depth, in order to perform a most precise transperineal biopsy and ablation to detect and treat prostate cancer.
Conception-technical specificities	Robotic biopsy needle positioning and navigation for an automated workflow. MRI-Ultrasound fusion capability for accurate lesion targeting. Minimal prostate distortion due to the unique probe sheath. Minimally-invasive procedure with innovative dual-cone technology with only two entry points. Auto-Adjust function to correct for the navigational inaccuracy caused by needle bevelling.
Instruments	System uses disposable kit. Each kit can be used for one patient.

Therapeutic indications
Intended to guide physicians in the planning and positioning of insertion tools, such as a third-party needle or a probe, during image-guided diagnostic and interventional procedures in conjunction with the guidance of transrectal ultrasound involving the prostate gland in a clinical setting. Examples of such procedures include, but are not limited to, image fusion for diagnostic clinical examinations and procedures, soft tissue biopsies, and soft tissue ablations.

Specify size/weight limit	No known indications
Regulatory aspects	Version 1: CE 2014 / FDA 2011 / HSA (Singapore) 2012 / TGA (Australia) 2014 / MDA (Malaysia) 2018 / TFDA (Taiwan) 2019 / TFDA (Thailand) 2021 / AMAR (Israel) 2022) Version 2: FDA 2021 / HSA (Singapore) May 2023 / AMAR (Israel) May 2023
Publications / studies	No academic articles found

BRAINLAB

Brainlab
www.brainlab.com
contact@brainlab.com
Germany

CIRQ ARM SYSTEM 1.4 / CIRQ ARM SYSTEM 2.0

Field of application	Neurosurgery Spine Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Cirq Robotic Alignment System is the composition of a mechatronic arm, Robotic Alignment Module, indication specific instruments and application software. The bionic design is inspired by the human arm which facilitates intuitive interaction, and efficient draping. It can be mounted directly on the OR table rail and manually moved to the optimal position for surgery. Cirq is a universal robotic platform for various tasks, as a positioning and holding device for spinal navigation during screw placement or for stereotactiv neurosurgery. The Cirq Arm positions attachable modules, which provide indication specific support. The system has ergonomic touch strips for releasing individual joints, and also seven LED rings that display the status of the articulation. The integrated communication interfaces allow for easy connection to network, power, and additional controllers on the base of the arm.
Conception-features	Cirq Arm: Seven degrees of freedom, Articulated arm with seven joints controlled by ergonomic touch strips, stabilization brace for added stability on the OR table. Cirq Robotic Alignment Module: Robotic Alignment to preplanned trajectories with four degrees for freedom. The alignment to preplanned trajectories happens based on the tracking information of an optical navigation camera. This offers live tracking of the instruments position throughout the workflow.
Conception-technical specificities	Brake buttons to lock and unlock the brakes, the opened brakes will remain open until ANY two buttons (from the same segment) are pressed – at which point all brakes will CLOSE. Emergency stop pressed to entered in failsafe mode. Input voltage: 100-240 V, Frequency: 50-60 Hz, Output values: 24 VDC/7.3 A, Maximum power consumption power supply: 175 W.
Instruments	Brainlab offers instrument bundles that are composed for specific use cases. These bundles contain reference arrays and pointers commonly used in optical navigation workflows, reusable Cirq specific instruments for instrument alignment and drilling as well as disposable instruments and drapes. There are specific bundles for passive and active instrument alignment in spinal surgery, cranial biopsies and stereotactiv EEG.

Therapeutic indications

- Cranial biopsy
- Placement of pedicle screws
- Minimally invasive or Percutaneous procedures

Spine:
- Cervical fractures
- Complex deformity
- Lumbar fusions

Specify size/weight limit	For pediatrics: spine/cranial

Regulatory aspects

CE 2019
FDA 2019
Spine (CE 2020 / FDA 2021)
Neurosurgery (CE 2020 / FDA 2021)
Orthopedics (CE 2020 / FDA 2021)

Publications / studies

1. Krieg SM, Meyer B. First experience with the jump-starting robotic assistance device Cirq. Neurosurg Focus. 2018 Jul;45(VideoSuppl1):V3. doi: 10.3171/2018.7.FocusVid.18108. PMID: 29963918.
2. Farah K, Meyer M, Prost S, Albader F, Dufour H, Blondel B, Fuentes S. Robotic Assistance for Minimally Invasive Cervical Pedicle Instrumentation: Report on Feasibility and Safety. World Neurosurg. 2021 Apr 5:S1878-8750(21)00521-0. doi: 10.1016/j.wneu.2021.03.150. Epub ahead of print. PMID: 33831617.
3. Khalsa SSS, Park P. Commentary: Cirq® Robotic Assistance for Minimally Invasive C1-C2 Posterior Instrumentation: Report on Feasibility and Safety. Oper Neurosurg (Hagerstown). 2020 Aug 3:opaa242. doi: 10.1093/ons/opaa242. Epub ahead of print. PMID: 32745168.
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8. Kaissar Farah, Mikael Meyer, Solene Prost, Faisal Albader, Henry Dufour, Benjamin Blondel, Stephane Fuentes, Robotic Assistance for Minimally Invasive Cervical Pedicle Instrumentation: Report on Feasibility and Safety, World Neurosurgery. 2021. ISSN 1878-8750. https://doi.org/10.1016/j.wneu.2021.03.150
9. van Baarsen KM, Woodley DEA, Slot KM, Woerdeman PA, Han KS, Hoving EW. Robotic alignment system Cirq (Brainlab) for navigated brain tumor biopsies in children. Childs Nerv Syst. 2023 Jul 12. doi: 10.1007/s00381-023-06060-6. Online ahead of print. PMID: 37436473.
10. Gabrovsky N, Ilkov P, Laleva M. Cirq® robotic assistance for thoracolumbar pedicle screw placement - feasibility, accuracy, and safety. Brain Spine. 2023 Jan 21;3:101717. doi: 10.1016/j.bas.2023.101717. eCollection 2023. PMID: 37383441.

Number of studies

10+

CASCINATION

CAScination AG
https://www.cascination.com/en/hearo
info@cascination.com
Switzerland

HEARO

Field of application	ENT
GA	Guidance assistant: automatic
Conception-configuration	Multi-sensor guided robot. Assistive otological next-generation surgical robot. Robot mount, headrest, patient marker, drill and drill mount with force/torque sensor.
Conception-features	The entire procedure is planned in 3D based on CT images by the surgeon preoperatively using the OTOPLAN software. 1.8mm tunnel milling with torque control and nerve monitoring.
Instruments	1.8mm tunnel milling
Therapeutic indications	Otology Cochlear implants
Height / weight / age limits	No known indications
Regulatory aspects	CE 2020

Publications / studies

1. [Anon.]. Medical Robotics (2). Biomedical Engineering / Biomedizinische Technik. 2020;65(s1): 63-67. https://doi.org/10.1515/bmt-2020-6014
2. Bom Braga, Gabriela O'Toole*; Schneider, Daniel*; Muller, Fabian*; Hermann, Jan*; Weber, Stefan*; Caversaccio, Marco† Feasibility of Pediatric Robotic Cochlear Implantation in Phantoms, Otology & Neurotology: February 2020 - Volume 41 - Issue 2 - p e192-e200 doi: 10.1097/MAO.0000000000002434.
3. Schneider, D., Stenin, I., Ansó, J. et al. Robotic cochlear implantation: feasibility of a multiport approach in an ex vivo model. Eur Arch Otorhinolaryngol 276, 1283–1289 (2019). https://doi.org/10.1007/s00405-019-05318-7
4. Heuninck E, Van de Heyning P, Van Rompaey V, Mertens G, Topsakal V. Audiological outcomes of robot-assisted cochlear implant surgery. Eur Arch Otorhinolaryngol. 2023 Apr 12. doi: 10.1007/s00405-023-07961-7. Online ahead of print. PMID: 37043021.
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Number of studies	10+

CMR Surgical
https://cmrsurgical.com/versius
info@cmrsurgical.com
UK

VERSIUS

Field of application	Pediatrics | Thoracic-endocrine | Visceral | Urology | Gynecology
TS	Multi-port telesurgery system
Conception-configuration	Platform composed of 4 modular arms mounted on trolleys (endoscopic camera and 3 surgical instruments) and a control console.
Conception-features	Ability to support a single arm and perform hybrid interventions.
Conception-technical specificities	3D HD
Instruments	It offers 6 articulated instruments 5mm in diameter. Reusables. Adopt commercial laparoscopic trocars. Wristed instruments.

Therapeutic indications

Urology:
- Radical prostatectomy
- Partial nephrectomy
- Pelvic lymph node dissection

Gynecology:
- Radical hysterectomy
- Vaginal hysterectomy

Visceral:
- Cholecystectomy
- Gastrectomy
- Anterior rectal resection

Specify size/weight limit	No known indications
Regulatory aspects	CE 2019: general surgery; urology; gynecology; thoracic surgery FDA pending Australian TGA: general surgery; urology; gynecology Anvisa Brazil: general surgery; urology; gynecology Other countries: India; Pakistan; Egypt

Publications / studies

1. Thomas BC, Slack M, Hussain M, Barber N, Pradhan A, Dinneen E, Stewart GD. Preclinical Evaluation of the Versius Surgical System, a New Robot-assisted Surgical Device for Use in Minimal Access Renal and Prostate Surgery. Eur Urol Focus. 2021 Mar;7(2):444-452. doi: 10.1016/j.euf.2020.01.011. Epub 2020 Mar 10. PMID: 32169362.
2. Morton J, Hardwick RH, Tilney HS, Gudgeon AM, Jah A, Stevens L, Marecik S, Slack M. Preclinical evaluation of the versius surgical system, a new robot-assisted surgical device for use in minimal access general and colorectal procedures. Surg Endosc. 2021 May;35(5):2169-2177. doi: 10.1007/s00464-020-07622-4. Epub 2020 May 13. PMID: 32405893; PMCID: PMC8057987.
3. Kelkar D, Borse MA, Godbole GP, Kurlekar U, Slack M. Interim safety analysis of the first-in-human clinical trial of the Versius surgical system, a new robot-assisted device for use in minimal access surgery. Surg Endosc. 2020 Sep 28. doi: 10.1007/s00464-020-08014-4. Epub ahead of print. PMID: 32989548.
4. Collins D, Paterson HM, Skipworth RJE, Speake D. Implementation of the Versius robotic surgical system for colorectal cancer surgery: First clinical experience. Colorectal Dis. 2021 May;23(5):1233-1238. doi: 10.1111/codi.15568. Epub 2021 Mar 6. PMID: 33544433.
5. Huddy JR, Crockett M, Nizar AS, Smith R, Malki M, Barber N, Tilney HS. Experiences of a "COVID protected" robotic surgical centre for colorectal and urological cancer in the COVID-19 pandemic. J Robot Surg. 2021 Feb 11:1–6. doi: 10.1007/s11701-021-01199-3. Epub ahead of print. PMID: 33570736; PMCID: PMC7877309.
6. Salkowski M, Checcucci E, Chow AK, Rogers CC, Adbollah F, Liatsikos E, Dasgupta P, Guimaraes GC, Rassweiler J, Mottrie A, Breda A, Crivellaro S, Kaouk J, Porpiglia F, Autorino R. New multiport robotic surgical systems: a comprehensive literature review of clinical outcomes in urology. Ther Adv Urol. 2023 Jun 5;15:17562872231177781. doi: 10.1177/17562872231177781. eCollection 2023 Jan-Dec. PMID: 37325289.
7. RS: Alkatout I, Salehiniya H, Allahqoli L. Assessment of the Versius Robotic Surgical System in Minimal Access Surgery: A Systematic Review. J Clin Med. 2022 Jun 28;11(13):3754. doi: 10.3390/jcm11133754.PMID: 35807035.
8. Brownlee EM, Slack M. The Role of the Versius Surgical Robotic System in the Paediatric Population. Children (Basel). 2022 May 30;9(6):805. doi: 10.3390/children9060805. PMID: 35740742.

Number of studies	40+

Collin
www.collinmedical.fr
info@collinmedical.fr
France

ROBOTOL

Field of application	ENT
GA	Guidance assistant: semi-automatic
Conception-configuration	Mobile tele-operating system. Used only with one arm for endoscope or instrument. Controlled by a space-mouse interface, the ROBOTOL is dedicated to ENT surgery, in particular EAR surgeries. The surgeon stays in the operating working space in interaction with the ROBOTOL.
Conception-features	- Arm for endoscope - 3 degrees of freedom + 3 on the kart - Arm for passive instrument - 3 degrees of freedom + 1 (4mm) + 3 on the kart - Arm for active instrument - 3 degrees of freedom + 1 (30mm) + 3 on the kart Instrument: MIDAC (active & et passive instruments range), Rigid Optics, Forcep... Speed adjustable between 10 mm/s and 0.1 mm/s. Linear resolution: 5µm. Angular resolution: 3°. Designed for evoluate and be connected to video kart or navigation system.
Conception-technical specificities	No Haptic feedback. No incision is requested, access by natural way or surgical opening. No electrosurgery. No fluorescence. Possibility to adapt a lot of tools.
Instruments	Reusable Instruments (>15)- No disposable only 2 sterile draps by surgery
Therapeutic indications	Cochlear implants / Ostospongiosis / Cholesteatoma / Tympanoplasty / middle and inner ear.
Height / weight / age limits	No limit of size or weight
Regulatory aspects	CE 2016 / FDA in progress

Publications / studies

1. R: Nguyen Y, Bernardeschi D, Sterkers O. Potential of Robot-Based Surgery for Otosclerosis Surgery. Otolaryngol Clin North Am. 2018 Apr;51(2):475-485. doi: 10.1016/j.otc.2017.11.016. PMID: 29502730.
2. Jia H, Pan JX, Li Y, Zhang ZH, Tan HY, Wang ZY, Wu H. [Preliminary application of robot-assisted electrode insertion in cochlear implantation]. Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi. 2020 Oct 7;55(10):952-956. Chinese. doi: 10.3760/cma.j.cn115330-20200228-00141. PMID: 33036510.
3. Vittoria S, Lahlou G, Torres R, Daoudi H, Mosnier I, Mazalaigue S, Ferrary E, Nguyen Y, Sterkers O. Robot-based assistance in mi degrés de libertée ear surgery and cochlear implantation: first clinical report. Eur Arch Otorhinolaryngol. 2021 Jan;278(1):77-85. doi: 10.1007/s00405-020-06070-z. Epub 2020 May 26. PMID: 32458123.
4. Kazmitcheff G, Nguyen Y, Miroir M, Péan F, Ferrary E, Cotin S, Sterkers O, Duriez C. Mi degrés de libertée-ear microsurgery simulation to improve new robotic procedures. Biomed Res Int. 2014;2014:891742. doi: 10.1155/2014/891742. Epub 2014 Jul 23. PMID: 25157373; PMCID: PMC4135140.
5. Daoudi H, Lahlou G, Torres R, Sterkers O, Lefeuvre V, Ferrary E, Mosnier I, Nguyen Y. Robot-assisted Cochlear Implant Electrode Array Insertion in Adults: A Comparative Study With Manual Insertion. Otol Neurotol. 2021 Apr 1;42(4):e438-e444. doi: 10.1097/MAO.0000000000003002. PMID: 33306661.
6. Barriat S, Peigneux N, Duran U, Camby S, Lefebvre PP. The Use of a Robot to Insert an Electrode Array of Cochlear Implants in the Cochlea: A Feasibility Study and Preliminary Results. Audiol Neurootol. 2021 Apr 26:1-7. doi: 10.1159/000513509. Epub ahead of print. PMID: 33902040.
7. R: De Seta D, Daoudi H, Torres R, Ferrary E, Sterkers O, Nguyen Y. Robotics, automation, active electrode arrays, and new devices for cochlear implantation: A contemporary review. Hear Res. 2022 Feb;414:108425. doi: 10.1016/j.heares.2021.108425. Epub 2021 Dec 25. PMID: 34979455.
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9. Gawęcki W, Balcerowiak A, Podlawska P, Borowska P, Gibasiewicz R, Szyfter W, Wierzbicka M. Robot-Assisted Electrode Insertion in Cochlear Implantation Controlled by Intraoperative Electrocochleography-A Pilot Study. J Clin Med. 2022 Nov 29;11(23):7045. doi: 10.3390/jcm11237045. PMID: 36498620.

Number of studies	1 PHRC - 10 center

Corin Group
https://www.coringroup.com/healthcare-professionals/solutions/omnibotics/
info@coringroup.com
UK

OMNIBOTICS

Field of application	Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Platform with navigation integrated into a control unit. The latter controls two robotic instruments: - A ligament tensor, the BalanceBot™ - A robotic cutting guide, the OMNIBot™, which is attached to the patient's femur intraoperatively OMNIBotics® provides a dynamic measurement of ligament balance for the installation of total knee prostheses.
Therapeutic indications	**Total knee prosthesis:** - Femoral cuts (distal, posterior and chanfreins) - Installation of total knee prosthesis
Specify size/weight limit	No known indications
Regulatory aspects	CE 2019 FDA 2020

Publications / studies

1. Shalhoub S, Lawrence JM, Keggi JM, Randall AL, DeClaire JH, Plaskos C. Imageless, robotic-assisted total knee arthroplasty combined with a robotic tensioning system can help predict and achieve accurate postoperative ligament balance. Arthroplast Today. 2019 Aug 13;5(3):334-340. doi: 10.1016/j.artd.2019.07.003. PMID: 31516978; PMCID: PMC6728592.
2. Kayani B, Konan S, Ayuob A, Onochie E, Al-Jabri T, Haddad FS. Robotic technology in total knee arthroplasty: a systematic review. EFORT Open Rev. 2019 Oct 1;4(10):611-617. doi: 10.1302/2058-5241.4.190022. PMID: 31754467; PMCID: PMC6836078.
3. Shatrov, J., Parker, D. Computer and robotic – assisted total knee arthroplasty: a review of outcomes. J EXP ORTOP 7, 70 (2020). https://doi.org/10.1186/s40634-020-00278-y
4. R: Shatrov J, Murphy GT, Duong J, Fritsch B. Robotic-assisted total knee arthroplasty with the OMNIBot platform: a review of the principles of use and outcomes. Arch Orthop Trauma Surg. 2021 Dec;141(12):2087-2096. doi: 10.1007/s00402-021-04173-8. Epub 2021 Oct 15.PMID: 34652515.
5. Blum CL, Lepkowsky E, Hussein A, Wakelin EA, Plaskos C, Koenig JA. Patient expectations and satisfaction in robotic-assisted total knee arthroplasty: a prospective two-year outcome study. Arch Orthop Trauma Surg. 2021 Dec;141(12):2155-2164. doi: 10.1007/s00402-021-04067-9. Epub 2021 Jul 20. PMID: 34283279.

Number of studies	10+

Curexo
http://www.curexo.com/english/?phpsessid=0779c9f63527a2a9828f59d8e6755c50
info@curexo.com
South Korea

CUVIS - JOINT

Field of application	Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Main console, robotic arm and planner for prosthetic surgery.
Conception-features	Planning via 2D C-arm or 3D CT imaging and navigation system. 6 axis articulated robot. System monitor, optical tracking system. Operating software, main controller, milling tool, irrigation. Surgical planning software. Fully automated cutting.
Conception-technical specificities	Robot cutting: max 50mm/s Repeat precision < 0.5mm / positioning accuracy < 1 mm
Therapeutic indications	Total hip prosthesis. Total knee prosthesis.
Height / weight / age limits	No known indications
Regulatory aspects	MFDS 2020 CE 2021 FDA 2021

Publications / studies

1. Vadalà G, De Salvatore S, Ambrosio L, Russo F, Papalia R, Denaro V. Robotic Spine Surgery and Augmented Reality Systems: A State of the Art. Neurospine. 2020 Mar;17(1):88-100. doi: 10.14245/ns.2040060.030. Epub 2020 Mar 31. PMID: 32252158; PMCID: PMC7136092.
2. Kim, H.C., Jeon, H., An, S.B., Kim, H., Hwang, S., Cha, Y., Moon, S., Shin, D.A., Ha, Y., Kim, K.N., Yoon, D.H. and Yi, S. (2021), Novel C-arm based planning spine surgery robot proved in a porcine model and quantitative accuracy assessment methodology. Int J Med Robot, 17: e2182. https://doi.org/10.1002/rcs.2182
3. Vadalà, Gianluca & De Salvatore, Sergio & Ambrosio, Luca & Russo, Fabrizio & Papalia, Rocco & Denaro, Vincenzo. (2020). Robotic Spine Surgery and Augmented Reality Systems: A State of the Art. Neurospine. 17. 88-100. doi: 10.14245/ns.2040060.030.
4. Mohamad Bydon, Selby G. Chen, Matthew D. Neal, Chandan Krishna, Aaron J. Biedermann, Travis C. Paul, Yagiz U. Yolcu, Anshit Goyal, Bernard R. Bendok, Alfredo Quinones-Hinojosa, Robert J. Spinner, Fredric B. Meyer. Initiation of a Robotic Program in Spinal Surgery: Experience at a Three-Site Medical Center. Mayo Clinic Proceedings. Volume 96. Issue 5. 2021. Pages 1193-1202. ISSN 0025-6196. https://doi.org/10.1016/j.mayocp.2020.07.034
5. Lee H.J., Park K.K., Park Y.B., Choi S.W., Kim B.O., Kim S.H. Accuracy of Advanced Active Robot for Total Knee Arthroplasty: A Cadaveric Study. J Knee Surg. 2023 Jan 13. doi: 10.1055/s-0042-1760391. PMID: 36638805 DOI: 10.1055/s-0042-1760391.

Number of studies	6+

Curexo
http://www.curexo.com/english/?phpsessid=0779c9f63527a2a9828f59d8e6755c50
info@curexo.com
South Korea

CUVIS - SPINE

Field of application	Spine
GA	Guidance assistant: semi-automatic
Conception-configuration	System with a robotic arm for placing pedicle screws.
Conception-features	Planning via 2D C-arm or 3D CT imaging and navigation system.
Therapeutic indications	- Pedicle Screw Insertion - Spinal stenosis - Degenerative spondylolisthesis
Specify size/weight limit	No known indications
Regulatory aspects	MFDS 2020 CE 2021 FDA 2021

Publications / studies

1. Vadalà G, De Salvatore S, Ambrosio L, Russo F, Papalia R, Denaro V. Robotic Spine Surgery and Augmented Reality Systems: A State of the Art. Neurospine. 2020 Mar;17(1):88-100. doi: 10.14245/ns.2040060.030. Epub 2020 Mar 31. PMID: 32252158; PMCID: PMC7136092.
2. Kim, H.C., Jeon, H., An, S.B., Kim, H., Hwang, S., Cha, Y., Moon, S., Shin, D.A., Ha, Y., Kim, K.N., Yoon, D.H. and Yi, S. (2021), Novel C-arm based planning spine surgery robot proved in a porcine model and quantitative accuracy assessment methodology. Int J Med Robot, 17: e2182. https://doi.org/10.1002/rcs.2182
3. Vadalà, Gianluca & De Salvatore, Sergio & Ambrosio, Luca & Russo, Fabrizio & Papalia, Rocco & Denaro, Vincenzo. (2020). Robotic Spine Surgery and Augmented Reality Systems: A State of the Art. Neurospine. 17. 88-100. doi: 10.14245/ns.2040060.030.
4. Mohamad Bydon, Selby G. Chen, Matthew D. Neal, Chandan Krishna, Aaron J. Biedermann, Travis C. Paul, Yagiz U. Yolcu, Anshit Goyal, Bernard R. Bendok, Alfredo Quinones-Hinojosa, Robert J. Spinner, Fredric B. Meyer. Initiation of a Robotic Program in Spinal Surgery: Experience at a Three-Site Medical Center. Mayo Clinic Proceedings. Volume 96. Issue 5. 2021. Pages 1193-1202. ISSN 0025-6196. https://doi.org/10.1016/j.mayocp.2020.07.034.

Number of studies	5+

CYBER SURGERY

Cyber Surgery
https://cyber-surgery.com/
info@cyber-surgery.com
Spain

ALAYA

Field of application	Spine
GA	Guidance assistant: semi-automatic
Conception-configuration	Cyber Surgery's Robotic Assistant has been designed for minimally invasive and open spinal fusion surgeries, indicating the trajectory in which the surgeon shall introduce the required surgical instruments for the surgery.
Conception-features	The robotic arm has six degrees of freedom which positions the tool guide in the screw insertion trajectories.
Conception-technical specificities	This Robotic Assistant avoids the use of optical navigation by means of haptic navigation, leading to greater accuracy of the whole system.
Instruments	All the surgical instrumentation components are reusable except the fiducial and the plastic covers for the robotic arm and the touchable screen.
Height / weight / age limits	No known indications
Regulatory aspects	CE in progress FDA in progress

Publications / studies

1. Benito, R., Bertelsen, Á., de Ramos, V. et al. Fast and versatile platform for pedicle screw insertion planning. Int J CARS 18, 1151–1157 (2023). https://doi.org/10.1007/s11548-023-02940-z
2. Amarillo, A., Sanchez, E., Caceres, J. et al. Collaborative Human–Robot Interaction Interface: Development for a Spinal Surgery Robotic Assistant. Int J of Soc Robotics 13, 1473–1484 (2021). https://doi.org/10.1007/s12369-020-00733-x
3. A. Amarillo, J. Oñativia and E. Sanchez, "RoboTracker: Collaborative robotic assistant device with electromechanical patient tracking for spinal surgery," 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), Madrid, Spain, 2018, pp. 1312-1317, doi: 10.1109/IROS.2018.8594467.
4. XXXV Congreso anual de la Sociedad Española de Ingeniería Biomédica: Libro de actas / coord. por Raimon Camps Salat, 2017, ISBN 978-84-9082-797-0, pages 273-278.

Number of studies	4

Dex Surgical

DEX Surgical
https://www.dex-surgical.com/
France

DEX

Field of application	Thoracic-endocrine Visceral Urology Gynecology
CM	Co-manipulator: motorized augmented instruments
Conception-configuration	This co-manipulator is fully autoclavable.
Conception-features	7 degrees of freedom Unlimited rotation Haptic feedback Compatible with all ESU for monopolar cautery
Conception-technical specificities	Portable and space-saving (600g)
Instruments	Tools (monopolar scissors, monopolar Maryland forceps, monopolar hook electrode) Reusable and completely steam sterilizable 132°C/134°C
Therapeutic indications	The DEX device laparoscopic instruments have applications in a variety of minimally invasive procedures to facilitate grasping, mobilization, dissection, suturing, transsection and electro-cauterization of tissues.
Height / weight / age limits	No known indications
Regulatory aspects	CE 2013 FDA 2021
Publications / studies	No academic articles found
Number of studies	

Distalmotion

Distalmotion Ltd
https://www.distalmotion.com/
info@distalmotion.com
Switzerland

DEXTER®

Field of application	Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	The Dexter System™ consists of 3 components – a surgeon console, 2 patient carts, and an endoscope arm. The surgeon console is optimized for ergonomic comfort — the surgeon can sit or stand. Here, the surgeon controls the movement of the instruments and the endoscope arm using two handle grips, a foot-operated clutch pedal, and an endoscope foot pedal. The surgeon can use clutching on all articulated micro-movements to enhance control of instrument maneuvering. Each patient cart holds one robotic arm, and each arm guides one robotic instrument. The wheelbase and handlebars enable easy maneuvers. During surgery the robotic arms are draped and remain sterile throughout. Inserting and removing robotic instruments is quick and easy. The arms are easy to move into the desired position and leave space for the team to operate at the patient bed. The endoscope arm holds and controls the laparoscope and is compatible with all 3D laparoscopes. It can be controlled from the surgeon console when operating robotically or manually when operating laparoscopically. It can be fitted on the patient bed or to a dedicated Dexter endoscope cart.
Conception-features	Fully articulated instruments are sterile and single-use, with full articulation up to 75°. Dexter arms and instruments offer 7° of freedom.
Conception-technical specificities	Dexter's open technology platform enables the use of any 3D laparoscope, including fluorescence and 4K imaging modalities. Portfolio includes both monopolar and bipolar instruments which can be connected to standard RF generators.
Instruments	Dexter instruments are single-use, with no requirement for reprocessing. Instruments include: - Needle holder - Bipolar Johann Grasper - Bipolar Maryland dissector - Monopolar scissors - Monopolar hook With laparoscopic workflows and setup, the surgeons can use their existing laparoscopy instruments (vessel sealing, stapler, forklifts, etc.) during the procedure.

Therapeutic indications

Urology:	Gynecology:	Visceral:
- Radical prostatectomy - Partial nephrectomy	- Radical hysterectomy - Vaginal hysterectomy	- Cholecystectomy - Gastrectomy - Anterior rectal resection

Specify size/weight limit	No known indications

Regulatory aspects	CE 2020 FDA pending

Publications / studies

1. Robotic MIS With Dexter - https://clinicaltrials.gov/ct2/show/NCT05537727
2. Robotic Minimally Invasive Inguinal Hernia Repair With Dexter (RAS-Ahead) - https://clinicaltrials.gov/ct2/show/NCT05873582?term=Dexter&draw=2&rank=1
Chandrasekaran, K., Parameswaran, S., Annamraju, S., Chandra, S., Manickam, R., and Thondiyath, A. (January 18, 2021). "A Practical Approach to the Design and Development of Tele-Operated Surgical Robots for Resource Constrained Environments—A Case Study." ASME. J. Med. Devices. March 2021; 15(1): 011105. https://doi.org/10.1115/1.4049393

Manuscripts:

1. Böhlen D, Gerber R. First Ever Radical Prostatectomy Performed with the New Dexter Robotic System™. Eur. Urol. 2023;83(5):479-480. doi:10.1016/j.eururo.2023.02.004.
2. Thillou D, Robin H, Ricolleau C, et al. Robot-assisted Radical Prostatectomy with the Dexter Robotic System: Initial Experience and Insights into On-demand Robotics. [published online ahead of print, 2023 Jun 5]. Eur. Urol. 2023; S0302-2838(23)02880-4. doi:10.1016/j.eururo.2023.05.034.

Abstracts:

1. Robin H, Hugues G, Forgues A, et al. Robot-assisted promontofixation and annexectomy for pelvic organ prolapse: Initial experience with the Dexter system. Eur. Urol. Open Sci. 2022; 44(Suppl 4): S346.
2. Forgues A, Thillou D, Emeriau D, et al. 3D partial nephrectomy with Dexter surgical robot. Eur. Urol. Open Sci. 2022; 44(Suppl 4): S403.
3. Berlth F, Capovilla G, Froiio C, et al. On-demand Robotic Gastrectomy with the Dexter Robotic SystemTM. Abstract DGCH. Innov. Surg. Sci. 2023 Mar 13;8(Suppl1):216-322. S267. doi: 10.1515/iss-2023-9009.
4. Mignot H, Capitaine J, Diack B. P-044 Feasibility And Safety of a New 'On-Demand Robotics' Platform For Inguinal Hernia Repair, BJS, 2023; 110 (Suppl 2) znad080.180. doi: 10.1093/bjs/znad080.180.
5. Hahnloser D, Grass F, Feasibility of On-demand Robotics in Colorectal Surgery. First Cases. 2023 Scientific Session of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), Montréal, Canada, 19 March-April 1 2023: Podium Abstracts. Surg. Endosc. 2023; S231. doi: 10.1007/s00464-023-10071-4.
6. Hotz AS, Breitenstein S, Kambakamba P, et al. Implementation of the Dexter Robot System in Daily Practice - First Experiences in Gall Bladder and Hernia Surgery, BJS. 2023; 110 (5), znad178.033. doi: 10.1093/bjs/znad178.033.

Number of studies	10+

ecential robotics

eCential Robotics
https://www.ecential-robotics.com/fr
contact@ecential-robotics.com
France

COBOT

Field of application	Spine Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Robotic 2D/3D imaging system and surgical navigation for minimally invasive spine surgery indications. Platform combining intraoperative 2D/3D C-arm imaging, a robotic arm and a navigation system. The system is open for use with all implants.
Conception-features	7 motorized axes Anti-collision system
Instruments	Range of single-use instruments
Therapeutic indications	Platform currently dedicated to the spine. The platform could be extended in the future to multiple bone surgery indications.
Height / weight / age limits	Pediatric mode on the robot
Regulatory aspects	CE pending FDA (2022)

Publications / studies

1. https://www.ecential-robotics.com/fr/news/article/6/ecential-robotics-booste-la-technologie-de-sa-plateforme-avec-un-bras-robotis-chirurgical
2. N Lonjon, G Cavalié, J Sledge Evaluation of a New Unified Robotic Platform: a Cadaver Study Proceedings of The …, 2022 - wvvw.easychair.org

EDAP TMS SA
https://www.edap-tms.com/en/products-services/prostate-cancer/focal-one
info@edap-tms.com
France

FOCAL ONE

Field of application	Urology
GA	Guidance assistant: semi-automatic
Conception-configuration	This is a HIFU (High-Intensity Focused Ultrasound) system which allows the destruction by heat of localized prostate adenocarcinoma in a precise and safe manner without damaging the surrounding tissue using a guided endorectal probe. It has treatment planning software that merges images obtained by MRI with endorectal ultrasound to target the volume to be treated.
Conception-technical specificities	7.5 MHz Imaging Transducer 3 MHz HIFU transducer Dynamic Focusing technology

Therapeutic indications

HIFU treatments are indicated in several situations:

- In a patient whose cancer is located in the prostate:
  In case of recurrence after a first ultrasound treatment
  In case of local recurrence after radiotherapy.
- Robot-Assisted Prostate Lumpectomy:
  Treats prostate cancer by creating precise and irreversible coagulation necrosis of targeted tissue while preserving surrounding tissue.

Specify size/weight limit	No known indications
Regulatory aspects	CE 2013 FDA 2018

Publications / studies

1. Jost von Hardenberg, Niklas Westhoff, Daniel Baumunk, Daniel Hausmann, Thomas Martini, Alexander Marx, Stefan Porubsky, Martin Schostak, Maurice Stephan Michel, Manuel Ritter. Prostate cancer treatment by the latest focal HIFU device with MRI/TRUS-fusion control biopsies: A prospective evaluation. Urologic Oncology: Seminars and Original Investigations. Volume 36. Issue 9. 2018. Pages 401.e1-401.e9. ISSN 1078-1439. https://doi.org/10.1016/j.urolonc.2018.05.022
2. Arnouil N, Gelet A, Matillon X, Rouviere O, Colombel M, Ruffion A, Mège-Lechevallier F, Subtil F, Badet L, Crouzet S. Traitement focal par HIFU versus prostatectomie radicale robot-assistée pour cancer de la prostate localisé : résultats carcinologiques et fonctionnels à 1 an [Focal HIFU vs robot-assisted total prostatectomy: Functionnal and oncologic outcomes at one year]. Prog Urol. 2018 Oct;28(12):603-610. French. doi: 10.1016/j.purol.2018.07.285. Epub 2018 Sep 19. PMID: 30243461.
3. von Hardenberg J, Westhoff N, Baumunk D, Hausmann D, Martini T, Marx A, Porubsky S, Schostak M, Michel MS, Ritter M. Prostate cancer treatment by the latest focal HIFU device with MRI/TRUS-fusion control biopsies: A prospective evaluation. Urol Oncol. 2018 Sep;36(9):401.e1-401.e9. doi: 10.1016/j.urolonc.2018.05.022. Epub 2018 Aug 6. PMID: 30093211.
4. Govorov AV, Vasilyev AO, Alaverdyan AI, Kolontarev KB, Pushkar DY. [HIFU therapy of localized prostate cancer using image-guided robotic HIFU Focal One]. Urologiia. 2023 May;(2):83-89. PMID: 37401710.
5. Rosenhammer B, Niessen C, Rotzinger L, Reiss J, Schnabel MJ, Burger M, Bründl J. Oncological Outcome and Value of Postoperative Magnetic Resonance Imaging after Focal High-Intensity Focused Ultrasound Therapy for Prostate Cancer. Urol Int. 2019;103(3):270-278. doi: 10.1159/000502553. Epub 2019 Aug 29. PMID: 31466073.
6. CT: Philip CA, Warembourg S, Dairien M, Lefevre C, Gelet A, Chavrier F, Guillen N, Tonoli H, Maissiat E, Lafon C, Dubernard G. Transrectal high-intensity focused ultrasound (HIFU) for management of rectosigmoid deep infiltrating endometriosis: results of Phase-I clinical trial. Ultrasound Obstet Gynecol. 2020 Sep;56(3):431-442. doi: 10.1002/uog.21937. PMID: 31788875.

Number of studies	10+

Edge Medical
http://www.edgemed.ch/
China

MP 1000

Field of application	Gynecology Urology Visceral Thoracic-endocrine
TS	Multi-port telesurgery system
Conception-configuration	Multi-port endoscopic surgical robot. Consists of a doctor's control console, a patient surgery platform, and an image processing platform. It has four mechanical arms, one used to control the endoscope and the other three used to operate various surgical instruments.
Therapeutic indications	Urological surgeries Gynecological procedures Partial kidney resection
Height / weight / age limits	No known indications
Regulatory aspects	NMPA 2022
Publications / studies	No academic articles found

ELMED MEDICAL SYSTEMS

Elmed Medical Systems
https://elmed-as.com/urunlerimiz/avicenna-roboflex/
sales@elmed-as.com
Turkey

AVICENNA ROBOFLEX

Field of application	Urology
TS	Endoluminal telesurgery system
Conception-configuration	Open console allowing manipulation of a flexible ureteroscope, attached to a robotic manipulator allowing rotation, insertion and deflection of the instrument. This feature prevents laser damage and extends the life of the oscilloscope. - 2 joysticks - Touch screen - Radiation reduction The surgeon sits at a console and the flexible URS is attached to a robotic arm on the patient.
Conception-features	This arm can rotate up to 220°, advance up to 150 mm, retract, and deflect up to 262°. Irrigation and movement of the laser fiber can be controlled by the surgeon at the console. There are two joysticks and foot pedals for moving, controlling, and turning on the laser or fluoroscopy. The system is compatible with a wide range of digital flexible ureteroscopes, access sheaths, laser fibers, and baskets. The software prevents the laser from firing unless it is properly outside the ureteroscopy.
Therapeutic indications	(FURS) Flexible Ureteroscopy (RIRS) Retrograde intrarenal surgery for lower pole renal calculi
Height / weight / age limits	No known indications
Regulatory aspects	CE 2013 FDA approval pending

Publications / studies

1. Butticè S, Sahin B, Sener TE, Dragos L, Proietti S, Doizi S, Traxer O. The new Avicenna Roboflex: How does the irrigation system work? Results from an in vitro experiment. Arch Ital Urol Androl. 2018 Sep 30;90(3):155-158. doi: 10.4081/aiua.2018.3.155. PMID: 30362676.
2. Rassweiler JJ, Autorino R, Klein J, Mottrie A, Goezen AS, Stolzenburg JU, Rha KH, Schurr M, Kaouk J, Patel V, Dasgupta P, Liatsikos E. Future of robotic surgery in urology. BJU Int. 2017 Dec;120(6):822-841. doi: 10.1111/bju.13851. Epub 2017 Apr 22. PMID: 28319324.
3. Rassweiler J, Fiedler M, Charalampogiannis N, Kabakci AS, Saglam R, Klein JT. Robot-assisted flexible ureteroscopy: an update. Urolithiasis. 2018 Feb;46(1):69-77. doi: 10.1007/s00240-017-1024-8. Epub 2017 Nov 23. PMID: 29170856.
4. Rassweiler JJ, Serdar GA, Klein J, Rassweiler-Seyfried MC. 50 Jahre Minimal-invasive Chirurgie in der Urologie [50 years of minimally invasive surgery in Urology]. Aktuelle Urol. 2019 Dec;50(6):593-605. German. doi: 10.1055/a-0970-6982. Epub 2019 Oct 9. PMID: 31597178.
5. Remzi Saglam, Ahmet Yaser Muslumanoglu, Zafer Tokatlı, Turhan Çaşkurlu, Kemal Sarica, Ali İhsan Taşçi, Bülent Erkurt, Evren Süer, Ahmet Sinan Kabakci, Glenn Preminger, Olivier Traxer, Jens J. Rassweiler. A New Robot for Flexible Ureteroscopy: Development and Early Clinical Results (IDEAL Stage 1–2b). European Urology. Volume 66. Issue 6. 2014. Pages 1092-1100. ISSN 0302-2838. https://doi.org/10.1016/j.eururo.2014.06.047
6. R: Gauhar V, Traxer O, Cho SY, Teoh JY, Sierra A, Gauhar V, Sarica K, Somani B, Castellani D. Robotic Retrograde Intrarenal Surgery: A Journey from "Back to the Future".J Clin Med. 2022 Sep 19;11(18):5488. doi: 10.3390/jcm11185488. PMID: 36143135.

Number of studies	10+

EndoControl

https://www.endocontrol-medical.com/en/jaimy-en/

info@endocontrol.de

France

JAIMY ADVANCE

Field of application	Pediatrics Visceral Urology Gynecology
CM	Co-manipulator: motorized augmented instruments
Conception-configuration	Motorized laparoscopic needle holder. The instrument is connected via a cable to a control unit.
Conception-features	Unlimited rotation and bi-directional flexion Symmetrical handle designed for right or left handed use 7 degrees of freedom for intra-abdominal procedures
Instruments	Instrument is sterilizable 5mm laparoscopic needle holder Compatible with 5-mm trocars Bidirectional flexion of the instrument tip

Therapeutic indications

Visceral:
- Fundoplication
- Gastric bypass

Notes:
- Colorectal Surgery

Urology:
- Radical Prostatectomy
- Sacrocolpopexy
- Partial nephrectomy
- Ureterovesical reconstruction
- Pyeloplasty

Gynecology:
- Myomectomy
- Hysterectomy
- Sacrocolpopexy
- Endometriosis treatment

Specify size/weight limit	Pediatric: Standard fundoplication Single port fundoplication SP Nissen Pyeloplasty Diaphragmatic plication
Regulatory aspects	CE 2019

Publications / studies

1. Siri E, Crochet P, Charavil A, Netter A, Resseguier N, Agostini A. Learning Intracorporeal Suture on Pelvitrainer Using a Robotized Versus Conventional Needle Holder. J Surg Res. 2020 Jul;251:85-93. doi: 10.1016/j.jss.2020.01.016. Epub 2020 Feb 27. PMID: 32114213.
2. Saeki I, Mukai W, Imaji R, Taguchi T. The "Twitching Technique": A New Space-Irrespective Laparoscopic Ligation Technique Using a JAiMY Needle Holder. J Laparoendosc Adv Surg Tech A. 2019 Aug;29(8):1077-1080. doi: 10.1089/lap.2019.0038. Epub 2019 Jun 4. PMID: 31161953.

Number of studies	2+

ENDOCONTROL

EndoControl
https://www.endocontrol-medical.com/en/viky-en/
info@endocontrol.de
France

VIKY

Field of application	Pediatrics Thoracic-endocrine Visceral Urology Gynecology
CM	Co-manipulator: motorized endoscope holder
Conception-configuration	Fixed on the rail of the operating table, movable during the operation. Compatible with other existing devices.
Conception-features	Voice and foot control Available in 3 sizes: XS - M - XL
Instruments	Fully compatible with all types of endoscopes and trocars

Therapeutic indications

- Gynecological, urological and general laparoscopic surgery with VIKY M
- Thoracic laparoscopic surgery with VIKY XS, with a smaller diameter
- Single-port and single incision laparoscopic surgery with VIKY XL, with a larger diameter

Gynecology:
- Hysterectomy
- Myomectomy
- Sacrocolpopexy
- Endometriosis treatment

Specify size/weight limit	Pediatric laparoscopic surgery with VIKY XS, with a smaller diameter
Regulatory aspects	CE / FDA 2015

Publications / studies

1. S. Voros, G. Haber, J. Menudet, J. Long and P. Cinquin, "ViKY Robotic Scope Holder: Initial Clinical Experience and Preliminary Results Using Instrument Tracking," in IEEE/ASME Transactions on Mechatronics, vol. 15, no. 6, pp. 879-886, Dec. 2010, doi: 10.1109/TMECH.2010.2080683.
2. Swan K, Kim J, Advincula AP. Advanced uterine manipulation technologies. Surg Technol Int. 2010 Oct;20:215-20. PMID: 21082569.
3. Hung AJ, Abreu AL, Shoji S, Goh AC, Berger AK, Desai MM, Aron M, Gill IS, Ukimura O. Robotic transrectal ultrasonography during robot-assisted radical prostatectomy. Eur Urol. 2012 Aug;62(2):341-8. doi: 10.1016/j.eururo.2012.04.032. Epub 2012 Apr 18. PMID: 22521656.
4. Wagner M, Bihlmaier A, Kenngott HG, Mietkowski P, Scheikl PM, Bodenstedt S, Schiepe-Tiska A, Vetter J, Nickel F, Speidel S, Wörn H, Mathis-Ullrich F, Müller-Stich BP. A learning robot for cognitive camera control in minimally invasive surgery. Surg Endosc. 2021 Sep;35(9):5365-5374. doi: 10.1007/s00464-021-08509-8. Epub 2021 Apr 27. PMID: 33904989.
5. T Kudo, S Kanaji, H Harada, Y Ohmura Evaluation of the Efficiency of a Joystick-Guided Robotic Scope Holder Compared to That of Human Scopists: A Prospective Trial 2023 - journals.sagepub.com
6. D Gossot, W Abid, A Seguin-Givelet Motorized scope positioner for solo thoracoscopic surgery Video-Assist Thorac Surg, 2018 - researchgate.net

Number of studies	10+

EndoQuest Robotics (Columbris MX)
https://endoquestrobotics.com/
info@endoquestrobotics.com
USA

COLUMBRIS ELS

Field of application	ENT Visceral
TS	Endoluminal telesurgery system
Conception-configuration	Surgeon's console and robotic cart
Conception-features	With flexible Colubriscope integrating a camera, and two channels 7- degrees of freedom
Conception-technical specificities	Haptic feedback
Instruments	Two channels for 5mm instruments 3.3mm camera 17mm Colubriscope Instruments 2.9mm

Therapeutic indications

Transoral upper gastrointestinal: - Peroral endo myotomy - Transoral incisionless fundoplication	- Transoral sleeve gastroplasty - Endoscopic mucosal resection	Transanal lower gastrointestinal: - Transanal minimally invasive surgery - Transanal total mesorectal excision

Specify size/weight limit	No known indications
Regulatory aspects	FDA Submission 2020
Publications / studies	No academic articles found
Number of studies	0

ENDOQUEST ROBOTICS

EndoQuest Robotics (Columbris MX)
https://endoquestrobotics.com/
info@endoquestrobotics.com
USA

COLUMBRIS SP

Field of application	Visceral Urology Gynecology
TS	Single-port telesurgery system
Conception-configuration	Surgeon's console and single-arm robotic cart
Conception-features	7 degrees of freedom
Conception-technical specificities	3D imaging and augmented reality Haptic feedback
Instruments	Single 10mm port 2.9mm instruments

Therapeutic indications

Visceral:	Urology:	Gynecology:
- Cholecystectomy - Gastrectomy - Fundoplication	- Prostatectomy	- Hysterectomy

Specify size/weight limit	No known indications
Regulatory aspects	FDA Submission 2020
Publications / studies	No academic articles found
Number of studies	0

Fortimedix Surgical B.V.
https://www.fortimedixsurgical.com/our-product-pipeline/symphonxtm-surgical-platform/
info@fortimedix.com
The Netherlands

SYMPHONX SURGICAL PLATFORM

Field of application	Visceral Urology Gynecology
CM	Co-manipulator: motorized augmented instruments
Conception-configuration	The SymphonX Surgical Platform is composed of the reusable SymphonX Introducer, the single-use SymphonX Hub Cap & Sealing Unit, and the single-use SymphonX Instruments that are used as part of laparoscopic surgery according to the intended use. The device fits into a standard 15mm trocar and has 4 channels, allowing the surgeon to use two instruments, a camera and a device.
Conception-features	The device does not require inversion or crossing of the hands to perform the triangulation.
Conception-technical specificities	Two 5mm instruments, a 5mm camera and a 3mm device 360 degree axial rotation
Instruments	Grasper, Maryland, clip applier, scissors, hook-knife and suction & irrigation. Single-use, disposable articulating surgical instruments.
Therapeutic indications	Laparoscopic procedures
Specify size/weight limit	No known indications
Regulatory aspects	FDA 2016 CE 2016

Publications / studies

1. Datta RR, Dieplinger G, Wahba R, Kleinert R, Thomas M, Gebauer F, Schiffmann L, Stippel DL, Bruns CJ, Fuchs HF. True single-port cholecystectomy with ICG cholangiography through a single 15-mm trocar using the new surgical platform "symphonX": first human case study with a commercially available device. Surg Endosc. 2020 Jun;34(6):2722-2729. doi: 10.1007/s00464-019-07229-4. Epub 2019 Oct 28. PMID: 31659506.
2. Datta RR, Schönhage S, Dratsch T, Toader J, Müller DT, Wahba R, Kleinert R, Thomas M, Dieplinger G, Stippel DL, Bruns CJ, Fuchs HF. Learning curve of surgical novices using the single-port platform SymphonX: minimizing OR trauma to only one 15-mm incision. Surg Endosc. 2021 Sep;35(9):5338-5351. doi: 10.1007/s00464-020-07998-3. Epub 2020 Sep 23. PMID: 32968918.

Number of studies	3+

FreeHand LDT
https://www.freehandsurgeon.com/
info@freehandsurgeon.com
UK

FREEHAND V1.2

Field of application	Cardiology | Spine | Thoracic-endocrine | Visceral | Urology | Gynecology
CM	Co-manipulator: motorized endoscope holder
Conception-configuration	Laparoscopic oscilloscope camera controller Robotic arm controlled through the arm control knob Headset Indicator unit Footswitch Vista for urological, upper GI and bariatric surgeries Panorama for gynecological, colorectal and thoracic surgeries
Conception-features	Allows solo surgery. Gives shake-free images. Integrated force limiter software prevents tissue damage. 3-joint design of the arm.
Conception-technical specificities	3D HD 3 speed settings Tilt: 90° continuous, -20° to +70° relative to horizontal plane of RMA (Vista)/ 160° continuous, -80° to +80° relative to horizontal plane of RMA (Panorama) Pan: 180° rotation (-90° to +90° in each direction) (Vista)/ 360° complete rotation (-180° to +180° in each direction) (Panorama) Zoom: 118mm continuous (scope advance or withdrawal through port)
Instruments	Adapts to any camera from 5 to 10mm diameter

Therapeutic indications

Intended for use in minimally invasive laparoscopic, thoracoscopic, urological, gynecological and cardiac surgery where a rigid laparoscope/endoscope is intended for use

Visceral:
- Cholecystectomy
- Hernia repair
- Fundoplication
- Splenectomy
- Appendectomy
- Hemicolectomy
- Gastric banding
- Gastric by pass

Gynecology:
- Hysterectomy

Urology:
- Nephrectomy
- Radical prostatectomy
- Radical cystectomy

Spine:
- Anterior spinal fusion
- Decompression fixation

Thoracic-endocrine:
- Wedge resection
- Lung biopsy
- Pleural biopsy

Cardiology:
- Internal mammary artery dissection for coronary artery bypass
- Coronary artery bypass grafting
- Examination of the evacuated cardiac chamber during performance of valve replacement or repair
- Sympathectomy, lymph node dissection
- Cancerous lesions

Specify size/weight limit	No known indications
Regulatory aspects	CE / FDA 2009

Publications / studies

1. Mittal R, Sbaih M, Motson RW, Arulampalam T. Use of a robotic camera holder (FreeHand®) for laparoscopic appendicectomy. Minim Invasive Ther Allied Technol. 2020 Feb;29(1):56-60. doi: 10.1080/13645706.2019.1576052. Epub 2019 Feb 21. PMID: 30789101.

Number of studies	1

Globus Medical INC.
https://www.globusmedical.com/musculoskeletal-solutions/excelsiusgps/
info@globusmedical.com
USA

EXCELSIUSGPS

Field of application	Neurosurgery | Spine
GA	Guidance assistant: semi-automatic
Conception-configuration	Robotic guidance and navigation system with active robotic arm. Camera. Robot: touchscreen monitor, robotic arm, end effector, base station.
Conception-features	System compatible with preoperative CT, intraoperative CT and fluoroscopy workflows. Provides instrument misalignment detection and correction, navigation integrity monitoring, instrument and implant image guidance, and intra-operative patient motion tracking technology. Lateral and posterior access to the interbody cages.
Conception-technical specificities	Compatible with motors and implants from different manufacturers
Instruments	Plenty of instruments are available, like instruments for screw placement, disc preparation, trialing, cage insertion and cranial; all these instruments are reusable what leads into a cost-efficient operation.

Therapeutic indications

Spine:
- Open scoliosis reconstruction
- Vertebral column resection
- Oncology resection
- Anterior cervical discectomy and fusion
- Posterior lumbar interbody fusion
- Lateral lumbar interbody fusion
- MIS spine surgery
- Posterior cervical fusion
- Sacroiliac joint fusion
- Scoliosis correction
- Vertebral augmentation
- Fracture fixation

Brain:
- Deep Brain Stimulation (DBS)
- Tumor resection

Specify size/weight limit	Spinal deformities --> no age limitations in spine use
Regulatory aspects	CE / FDA 2017

Publications / studies

1. Godzik J, Walker CT, Hartman C, de Andrada B, Morgan CD, Mastorakos G, Chang S, Turner J, Porter RW, Snyder L, Uribe J. A Quantitative Assessment of the Accuracy and Reliability of Robotically Guided Percutaneous Pedicle Screw Placement: Technique and Application Accuracy. Oper Neurosurg (Hagerstown). 2019 Oct 1;17(4):389-395. doi: 10.1093/ons/opy413. PMID: 30753599.
2. Al Saiegh F, Leibold A, Mouchtouris N, Sabourin V, Stefanelli A, Franco D, Harrop J, Jallo J, Prasad S, Heller J. Robot-Assisted Instrumented Fusion of a T8-9 Extension Distraction Fracture and Epidural Hematoma Evacuation: 2-Dimensional Operative Video. Oper Neurosurg (Hagerstown). 2020 Sep 15;19(4):E420-E421. doi: 10.1093/ons/opaa061. PMID: 32259253.
3. Zygourakis CC, Ahmed AK, Kalb S, Zhu AM, Bydon A, Crawford NR, Theodore N. Technique: open lumbar decompression and fusion with the Excelsius GPS robot. Neurosurg Focus. 2018 Jul;45(VideoSuppl1):V6. doi: 10.3171/2018.7.FocusVid.18123. PMID: 29963912.
4. Vo CD, Jiang B, Azad TD, Crawford NR, Bydon A, Theodore N. Robotic Spine Surgery: Current State in Minimally Invasive Surgery. Global Spine J. 2020 Apr;10(2 Suppl):34S-40S. doi: 10.1177/2192568219878131. Epub 2020 May 28. PMID: 32528804; PMCID: PMC7263345.
5. Vardiman AB, Wallace DJ, Booher GA, Crawford NR, Riggleman JR, Greeley SL, Ledonio CG. Does the accuracy of pedicle screw placement differ between the attending surgeon and resident in navigated robotic-assisted minimally invasive spine surgery? J Robot Surg. 2020 Aug;14(4):567-572. doi: 10.1007/s11701-019-01019-9. Epub 2019 Sep 21. PMID: 31542860; PMCID: PMC7347677.
6. Jiang, B., Karim Ahmed, A., Zygourakis, C.C. et al. Pedicle screw accuracy assessment in ExcelsiusGPS® robotic spine surgery: evaluation of deviation from pre-planned trajectory. Chin Neurosurg Jl 4, 23 (2018). https://doi.org/10.1186/s41016-018-0131-x
7. Granit Molliqaj, Luca Paun, Aria Nouri, Pierre-Pascal Girod, Karl Schaller, Enrico Tessitore. Role of Robotics in Improving Surgical Outcome in Spinal Pathologies.
World Neurosurgery.Volume 140. 2020. Pages 664-673. ISSN 1878-8750. https://doi.org/10.1016/j.wneu.2020.05.132
8. R: Elswick CM, Strong MJ, Joseph JR, Saadeh Y, Oppenlander M, Park P. Robotic-Assisted Spinal Surgery: Current Generation Instrumentation and New Applications. Neurosurg Clin N Am. 2020 Jan;31(1):103-110. doi: 10.1016/j.nec.2019.08.012. Epub 2019 Oct 25. PMID: 31739920.

Number of studies	10+

Hangzhou Jianjia Medical Technology Co., Ltd
https://www.jmed.com/en/about.html
China

ARTHROBOT

Field of application	Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Intraoperative navigation control system. Robotic integrated cutting system and Optical Positioning System.
Conception-features	Based on the patient's preoperative CT, quickly reconstruct the 3D model. Combine CT and 3D models to visually display the effect of prosthesis implantation. Personalized planning of prosthesis size and installation angle, and estimated installation effect. Real-time display of grinding progress, indicating the grinding area of surgical planning, and warning of excessive grinding. Make a detailed implant plan and pre-operative rehearsal. Support multi-brand prosthesis selection. Accurate and stable registration. Safety boundary mechanism to avoid excessive grinding. Real-time tracking of joint activities. Accurately execute the surgical plan and eliminate manual operation errors.
Conception-technical specificities	Submillimeter-level optical positioning. High frame refresh rate. Multiple visual, auditory and tactile feedbacks. Zero-gravity operation and precise force feedback. Real-time installation angle display, error control within 1°.
Therapeutic indications	THA, hip replacement, knee replacement. Hip replacement: acetabular + femoral bilateral planning.
Height / weight / age limits	No known indications
Regulatory aspects	NMPA 2022

Publications / studies

1. Li G, Patel NA, Sharma K, Monfaredi R, Dumoulin C, Fritz J, Iordachita I, Cleary K. Body-Mounted Robotics for Interventional MRI Procedures. IEEE Trans Med Robot Bionics. 2020 Nov;2(4):557-560. doi: 10.1109/tmrb.2020.3030532. Epub 2020 Oct 13. PMID: 33778433.
2. Monfaredi R, Iordachita I, Wilson E, Sze R, Sharma K, Krieger A, Fricke S, Cleary K. Development of a shoulder-mounted robot for MRI-guided needle placement: phantom study. Int J Comput Assist Radiol Surg. 2018 Nov;13(11):1829-1841. doi: 10.1007/s11548-018-1839-y. Epub 2018 Aug 11. PMID: 30099660.

Number of studies	2+

Harbin Sagebot Intelligent Medical Equipment Co.,Ltd / Kangduo
http://en.hrbszr.com/index.php?m=content&c=index&a=lists&catid=24
China

KANGDUO

Field of application	Thoracic-endocrine Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	The most popular in China, SR1000 and SR1500- three arm, SR2000- four arm open surgeon control console (a), the patient cart (b), and the vision cart (c). An endoscopic system and surgical instruments. Multi screens: one shows a 3D endoscopic view for surgeon, the other shows crucial information (4K HD fluorescent navigation endoscope and pre-operation 3D-Reconstruction images).
Conception-features	System compatible with 4k fluorescent endoscope and match most 3D endoscope in the market. Equipment is highly compatible and flexible for versatile combinations. Intelligent identification and filtering of tremors to enhance the precision of operations.
Conception-technical specificities	3D high-definition magnified view. 4K HD fluorescent navigation endoscope. 4.3D laparoscopic system, fluorescence-assisted system, VR&AR navigation system, electrotome and other energy platforms, intraoperative devices such as US, etc.
Instruments	Flexible surgical instruments 540°
Therapeutic indications	Prostatectomy, pyeloplasty Prostate cancer, radical prostatectomy
Height / weight / age limits	No known indications
Regulatory aspects	NMPA 2022

Publications / studies

1. Fan S, Zhang Z, Wang J, Xiong S, Dai X, Chen X, Li Z, Han G, Zhu J, Hao H, Yu W, Cui L, Shen C, Li X, Zhou L. Robot-Assisted Radical Prostatectomy Using the KangDuo Surgical Robot-01 System: A Prospective, Single-Center, Single-Arm Clinical Study. J Urol. 2022 Jul;208(1):119-127. doi: 10.1097/JU.0000000000002498. Epub 2022 May 18. PMID: 35442762.
2. [No authors listed] Robot-Assisted Radical Prostatectomy Using the KangDuo Surgical Robot-01 System: A Prospective, Single-Center, Single-Arm Clinical Study. J Urol. 2022 Sep;208(3):744. doi: 10.1097/JU.0000000000002838. Epub 2022 Sep 1. PMID: 35942793.
3. Fan S, Dai X, Yang K, Xiong S, Xiong G, Li Z, Cheng S, Li X, Meng C, Guan H, Huang Y, Mu L, Cui L, Zhou L, Li X. Robot-assisted pyeloplasty using a new robotic system, the KangDuo-Surgical Robot-01: a prospective, single-centre, single-arm clinical study. BJU Int. 2021 Aug;128(2):162-165. doi: 10.1111/bju.15396. Epub 2021 Apr 20. PMID: 33725392.
4. Fan S, Xu W, Diao Y, Yang K, Dong J, Qin M, Ji Z, Shen C, Zhou L, Li X. Feasibility and Safety of Dual-console Telesurgery with the KangDuo Surgical Robot-01 System Using Fifth-generation and Wired Networks: An Animal Experiment and Clinical Study. Eur Urol Open Sci. 2023 Jan 13;49:6-9. doi: 10.1016/j.euros.2022.12.010. eCollection 2023 Mar. PMID: 36691584.
5. Li X, Xu W, Fan S, Xiong S, Dong J, Wang J, Dai X, Yang K, Xie Y, Liu G, Meng C, Zhang Z, Cai L, Zhang C, Zhang Z, Ji Z, Shen C, Zhou L. Robot-assisted Partial Nephrectomy with the Newly Developed KangDuo Surgical Robot Versus the da Vinci Si Surgical System: A Double-center Prospective Randomized Controlled Noninferiority Trial. Eur Urol Focus. 2023 Jan;9(1):133-140. doi: 10.1016/j.euf.2022.07.008. Epub 2022 Nov 26. PMID: 36446724.
6. Dong J, Ji R, Liu G, Zhou J, Wang H, Xu W, Ji Z, Cui L. Feasibility, safety and effectiveness of robot-assisted retroperitoneal partial adrenalectomy with a new robotic surgical system: A prospective clinical study. Front Surg. 2023 Feb 22;10:1071321. doi: 10.3389/fsurg.2023.1071321. eCollection 2023. PMID: 36911621.

Number of studies	10+

HIWIN Healthcare
https://www.hiwin.tw/products/me/mtg_h100.aspx
Taiwan

MTG-H100

Field of application	Thoracic-endocrine Visceral Gynecology Urology
CM	Co-manipulator: motorized endoscope holder
Conception-configuration	The endoscope holding arm focuses on controlling the position and angle of surgical instruments used in minimally invasive surgery (MIS). Robotic holding arm. Control pedal.
Conception-features	3 degrees of freedom. Six-way foot control. Thanks to its unique structure (remote center of movement), the robot can hold the surgical instruments in the desired position during the operation. Robotic holder can be mounted on the operation tables or the trolley.
Conception-technical specificities	3D/4K compatibility
Therapeutic indications	For minimally invasive surgery
Height / weight / age limits	No known indications
Regulatory aspects	CE 2022 FDA pending

Publications / studies

1. H Hamza, VM Baez, A Al-Ansari, AT Becker User interfaces for actuated scope maneuvering in surgical systems: a scoping review. Hawa Hamza 1, Victor M Baez 2, Abdulla Al-Ansari 1, Aaron T Becker 2, Nikhil V Navkar 3. Affiliations expand. PMID: 36971815 PMCID: PMC10234960 DOI: 10.1007/s00464-023-09981-0. Free PMC article.

Number of studies	10+

Human Xtensions Ltd
https://human-x.com/
info@human-x.com
Israel

HANDX

Field of application	Pediatrics (CE) Thoracic-endocrine Visceral Urology Gynecology
CM	Co-manipulator: motorized augmented instruments
Conception-configuration	The HandX platform is a 5mm, fully articulated, SW driven robotized handheld device for laparoscopic usage that allows a full range of movement that can be implemented in any surgical laparoscopic operation.
Conception-features	4 robotic DOF and 4 laparoscopic DOF, SW driven platform that enables periodic SW upgrades.
Conception-technical specificities	The HandX is ambidextrous and fits all hand sizes. Allows both laparoscopic and robotic operation modes. The HandX has scalable DOF and adjustable features. The HandX adapts to all electrosurgical generators in the operating theater.
Instruments	Single use instruments available with articulation: Needle Holder, Self-Righting Needle Holder, Fenestrated Grasper, Monopolar Hook, Monopolar Spatula and Monopolar Scissors.
Therapeutic indications	Laparoscopic procedures
Height / weight / age limits	No known indications
Regulatory aspects	CE 2018 / FDA 2018 / Canada 2022 / Pediatrics (CE)

Publications / studies

1. Needham, V., Camacho, D. & Malcher, F. Initial experience using a handheld fully articulating software-driven laparoscopic needle driver in TAPP inguinal hernia repair. Surg Endosc 35, 3221–3231 (2021).
https://doi.org/10.1007/s00464-021-08446-6
https://human-x.com/wp-content/uploads/2023/02/Can-a-Fully-Articulating-Electromechanical-Laparoscopic-Needle-Driver-Compare-with-a-Robotic-Platform-in-Transabdominal-Preperit.pdf
https://pubmed.ncbi.nlm.nih.gov/36239687/
https://human-x.com/wp-content/uploads/2023/02/Initial-experience-using-a-handheld-fully-articulating-software%E2%80%91driven-laparoscopic-needle-driver-in-TAPP-inguinal-hernia-repair.pdf

Number of studies	3

HURWA

Hurwa
https://www.hurwa.club/
China

HURWA SURGICAL ROBOT

Field of application	Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Total knee replacement surgery navigation and positioning system both navigation and osteotomy. A medical seven-axis robotic arm. An automatic control osteotomy system.
Conception-features	For workflow, see website. Multi-modal, digital preoperative planning information. Highly automated intraoperative registration and execution. Tool arm can realize automatic tool setting. Lock the osteotomy plane, precisely control the amount of osteotomy and angle, and the osteotomy can be achieved by gently pushing the knife handle. Active Registration Technology: operator can independently decide the location of the collection according to the patient's condition and degree of deformity. Complete within three minutes, extremely fast registration. Easy operation, high pass rate. Intelligent image segmentation and 3D reconstruction technology to achieve efficiency. Surgical operations can be previewed, and prosthesis placement can be predicted and planned. The positioning frame only penetrates the single cortex. The surgical plan can be adjusted in real time during the operation.
Conception-technical specificities	Submillimeter-level precise positioning.

Therapeutic indications

Full coverage of orthopedic surgery:
Hardware platform, software modularization, one device can meet multiple types of operations.
- TKA: total knee arthroplasty.
- Hip replacement, unicompartmental replacement, high tibial osteotomy.

Specify size/weight limit	No known indications
Regulatory aspects	NMPA 2022

Publications / studies

1. Li Z, Chen X, Wang X, Zhang B, Wang W, Fan Y, Yan J, Zhang X, Zhao Y, Lin Y, Liu J, Lin J. HURWA robotic-assisted total knee arthroplasty improves component positioning and alignment - A prospective randomized and multicenter study. J Orthop Translat. 2022 Feb 16;33:31-40. doi: 10.1016/j.jot.2021.12.004. eCollection 2022 Mar. PMID: 35228995.
2. Chen X, Li Z, Zhang X, Yan J, Ding L, Song Y, Huo Y, Chan MTV, Wu WKK, Lin J. A new robotically assisted system for total knee arthroplasty: A sheep model study. Int J Med Robot. 2021 Aug;17(4):e2264. doi: 10.1002/rcs.2264. Epub 2021 Apr 25. PMID: 33855810.
3. Li Z, Chen X, Zhang X, Yan J, Song Y, Huo Y, Lin J. Better precision of a new robotically assisted system for total knee arthroplasty compared to conventional techniques: A sawbone model study. Int J Med Robot. 2021 Aug;17(4):e2263. doi: 10.1002/rcs.2263. Epub 2021 Apr 25. PMID: 33837616.
4. Li Z, Zhang X, Ding L, Du K, Yan J, Chan MTV, Wu WKK, Li S. Deep learning approach for guiding three-dimensional computed tomography reconstruction of lower limbs for robotically-assisted total knee arthroplasty. Int J Med Robot. 2021 Oct;17(5):e2300. doi: 10.1002/rcs.2300. Epub 2021 Jun 14. PMID: 34109730.

Number of studies	4+

Interventional Systems (iSYS Medizintechnik GmbH)
https://www.interventional-systems.com/
info@interventional-systems.com
Austria

MICROMATE

Field of application	Neurosurgery | Spine | Orthopedics | Thoracic-endocrine | Visceral | Urology
GA	Guidance assistant: semi-automatic
Conception-configuration	Micromate™ is a medical robotic system designed for percutaneous interventions with enhanced accuracy and control, supporting the user in the positioning of a needle or electrode. The Micromate system is comprised of the Micromate targeting platform that has 4 degrees of freedom, the control unite which enables automatic and manual alignment, unique positioning arms which enables full body reachability, the optical tracking camera, a medical PC and several table adapters that enable the mounting of the device on various types of operating and imaging tables. The device is also available as an OEM solution for third parties.
Conception-features	11 degrees of freedom: 7 are obtained through flexible, manually controlled, gross-positioning using a flexible holding arm, and then 4 degrees of freedom on its end-effector for positioning and angulation of a needle guide. The system contains a workstation for surgical planning and navigation based on intraoperative DICOM data.
Conception-technical specificities	The Micromates unique footprint allows it to fit on every table and fit within almost all imaging gantries. The Micromate SW allows for automatic registration of the device from the 3D scan, planning one or more trajectories and then execution of said trajectories with robotic precision, either automatically or under real-time joystick control.
Instruments	Only a single kit of disposable instruments to perform procedures in the CT system. It comprises a needle guide (for needles from 8G to 21G), a navigation tracker frame, reflective spheres and a sterile drape cover.

Therapeutic indications

Micromate is indicated for any medical condition in which the use of stereotactic, image-guided surgery may be appropriate, and where reference to target can be identified relative to a pre-operative, intra-operative and/or post-operative CT-based or MR-based model or fluoroscopy images.

Skull:
- Base ablation
- Trigeminus neuralgia

Thoracic-endocrine:
- Lung biopsy and ablation

Urology:
- Kidney biopsy and ablation

Spine:
- Spine fusion
- Vertebral ablation
- Kyphoplasty
- Vertebral augmentation
- Spine pain treatment

Visceral:
- Pre-sacral abscess drainage
- Post-AEVAR endoleak embolization
- Para-aortic mass spirotome
- Mesenteric lymph node biopsy
- Mesenteric lymph node ablation
- Liver biopsy and ablation

Orthopedics:
- Hip: Illium-sacrum fracture fixation

Long bones:
- Bone biopsy
- Osteoid osteoma ablation
- Osteosynthesis

Extremities:
- Bone biopsy and drilling
- Fracture fixation

Specify size/weight limit	Same as for adults. No limitations
Regulatory aspects	CE 2020 / FDA (2021) / KOREA 2022

Publications / studies

1. https://www.youtube.com/watch?v=jNocx1R5jc4&ab_channel=SPINEMarketGroup
2. https://thespinemarketgroup.com/accelus-robot/
3. https://eu.accelusinc.com/integrity-implants-and-fusion-robotics-merge-to-form-accelus/

Number of studies	10+

INTUITIVE

Intuitive Surgical

https://www.intuitive.com/en-us/products-and-services/da-vinci

USA

DA VINCI SP

Field of application	ENT Visceral Urology Gynecology
TS	Single-port telesurgery system
Conception-configuration	This model includes a telescopic robotic arm containing 3 flexible instruments and an equally flexible camera. The rest of the system is similar to other Da Vinci systems except for the addition of a foot pedal for camera control.
Conception-technical specificities	2.5 cm trocar
Instruments	Dedicated metallic trocar with a disposable commercial single site access system

Therapeutic indications

Urology:
- Partial nephrectomy and prostatectomy

ENT:
- Surgery for benign and malignant tumors of the mouth and throat
- Total hip prosthesis 4 cm in size
- Benign base of tongue resections

Gynecology (not yet validated):
- Hysterectomy
- Myomectomy
- Sacrocolpopexy
- Adnexal surgeries
- Endometrial cancer surgical staging
- Radical trachelectomy
- Ovarian cystectomy

Visceral + gynecology (not yet validated):
Da Vinci systems facilitate procedures considered difficult in conventional laparoscopy: pyeloplasty, prostatectomy, partial nephrectomy, total hysterectomy, and myomectomies. Other applications can be considered as transrectal and transvaginal procedures.

Specify size/weight limit	No known indications
Regulatory aspects	CE pending in 2024 FDA 2018/2019 (urology/ENT) Japan: urology; gynecology; visceral; thoracic; transoral South Korea: urology; gynecology; visceral; thoracic; transoral NMPA China: yes, not specified

Publications / studies

1. Billah MS, Stifelman M, Munver R, Tsui J, Lovallo G, Ahmed M. Single port robotic assisted reconstructive urologic surgery-with the da Vinci SP surgical system. Transl Androl Urol. 2020 Apr;9(2):870-878. doi: 10.21037/tau.2020.01.06. PMID: 32420202; PMCID: PMC7214978.
2. Agarwal DK, Sharma V, Toussi A, Viers BR, Tollefson MK, Gettman MT, Frank I. Initial Experience with da Vinci Single-port Robot-assisted Radical Prostatectomies. Eur Urol. 2020 Mar;77(3):373-379. doi: 10.1016/j.eururo.2019.04.001. Epub 2019 Apr 19. PMID: 31010600.
3. Noh GT, Oh BY, Han M, Chung SS, Lee RA, Kim KH. Initial clinical experience of single-incision robotic colorectal surgery with da Vinci SP platform. Int J Med Robot. 2020 Jun;16(3):e2091. doi: 10.1002/rcs.2091. Epub 2020 Apr 6. PMID: 32048755.
4. Shin HJ, Yoo HK, Lee JH, Lee SR, Jeong K, Moon HS. Robotic single-port surgery using the da Vinci SP® surgical system for benign gynecologic disease: A preliminary report. Taiwan J Obstet Gynecol. 2020 Mar;59(2):243-247. doi: 10.1016/j.tjog.2020.01.012. PMID: 32127145.
5. Noh GT, Oh BY, Han M, Chung SS, Lee RA, Kim KH. Initial clinical experience of single-incision robotic colorectal surgery with da Vinci SP platform. Int J Med Robot. 2020 Jun;16(3):e2091. doi: 10.1002/rcs.2091. Epub 2020 Apr 6. PMID: 32048755.
6. Steinberg RL, Johnson BA, Meskawi M, Gettman MT, Cadeddu JA. Magnet-Assisted Robotic Prostatectomy Using the da Vinci SP Robot: An Initial Case Series. J Endourol. 2019 Oct;33(10):829-834. doi: 10.1089/end.2019.0263. Epub 2019 Sep 27. PMID: 31411052.
7. Van Abel KM, Yin LX, Price DL, Janus JR, Kasperbauer JL, Moore EJ. One-year outcomes for da Vinci single port robot for transoral robotic surgery. Head Neck. 2020 Aug;42(8):2077-2087. doi: 10.1002/hed.26143. Epub 2020 Mar 19. PMID: 32190942.

8. Cruz CJ, Yang HY, Kang I, Kang CM, Lee WJ. Technical feasibility of da Vinci SP single-port robotic cholecystectomy: a case report. Ann Surg Treat Res. 2019 Oct;97(4):217-221. doi: 10.4174/astr.2019.97.4.217. Epub 2019 Oct 1. PMID: 31620396; PMCID: PMC6779957.
9. Covas Moschovas M, Bhat S, Rogers T, Thiel D, Onol F, Roof S, Sighinolfi MC, Rocco B, Patel V. Applications of the da Vinci single port (SP) robotic platform in urology: a systematic literature review. Minerva Urol Nephrol. 2021 Feb;73(1):6-16. doi: 10.23736/S0393-2249.20.03899-0. Epub 2020 Sep 29. PMID: 32993277.
10. Covas Moschovas M, Bhat S, Rogers T, Onol F, Roof S, Mazzone E, Mottrie A, Patel V. Technical Modifications Necessary to Implement the da Vinci Single-port Robotic System. Eur Urol. 2020 Sep;78(3):415-423. doi: 10.1016/j.eururo.2020.01.005. Epub 2020 Jan 17. PMID: 31959548.
11. RT: Ribeiro U Jr, Dias AR, Ramos MFKP, Yagi OK, Oliveira RJ, Pereira MA, Abdalla RZ, Zilberstein B, Nahas SC, Cecconello I. Short-Term Surgical Outcomes of Robotic Gastrectomy Compared to Open Gastrectomy for Patients with Gastric Cancer: a Randomized Trial. J Gastrointest Surg. 2022 Dec;26(12):2477-2485. doi: 10.1007/s11605-022-05448-0. Epub 2022 Sep 20. PMID: 36127557.
12. RCT: Albers KI, Polat F, Loonen T, Graat LJ, Mulier JP, Snoeck MM, Panhuizen IF, Vermulst AA, Scheffer GJ, Warlé MC. Visualising improved peritoneal perfusion at lower intra-abdominal pressure by fluorescent imaging during laparoscopic surgery: A randomised controlled study. Int J Surg. 2020 May;77:8-13. doi: 10.1016/j.ijsu.2020.03.019. Epub 2020 Mar 17. PMID: 32194255.
13. RCT: Lendvay TS, Brand TC, White L, Kowalewski T, Jonnadula S, Mercer LD, Khorsand D, Andros J, Hannaford B, Satava RM. Virtual reality robotic surgery warm-up improves task performance in a dry laboratory environment: a prospective randomized controlled study. J Am Coll Surg. 2013 Jun;216(6):1181-92. doi: 10.1016/j.jamcollsurg.2013.02.012. Epub 2013 Apr 11. PMID: 23583618.

Number of studies	60+

INTUITIVE

Intuitive Surgical

https://www.intuitive.com/en-us/products-and-services/da-vinci

USA

DA VINCI X

Field of application	Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	4 robotic arms adapted from the Da Vinci Xi system on the Si base + trolley. Immersive control console.
Conception-features	Compatible with dual console.
Conception-technical specificities	Fluorescence FireFly Technology 3D
Instruments	Vascular thermo-fusion (Vessel Sealer Extend™) and smart tissue stapling (SureForm Stapler - SmartFire) complete the EndoWrist® instrumentation range.

Therapeutic indications

Urology:
- Prostatectomy
- Partial and total nephrectomy
- Pyeloplasty
- Cyst removal
- Cystectomy
- Ureteral implantation

Gynecology:
- Hysterectomy for benign conditions
- Hysterectomy for cancer
- Pelvic organ prolapse surgery
- Myomectomy
- Endometriosis resection

Visceral:
- Colon resection surgery
- Rectal resection surgery
- Rectopexy
- Bariatric surgery
- Gallbladder surgery
- Inguinal hernia repair
- Ventral hernia repair
- Nissen fundoplication
- Gastrectomy
- Pancreatectomy and pancreaticoduodenectomy / Whipple procedure
- Small bowel surgery
- Splenectomy

Specify size/weight limit	No known indications
Regulatory aspects	CE / FDA 2017

Publications / studies

1. Rassweiler JJ, Goezen AS, Rassweiler-Seyfried MC, Liatsikos E, Bach T, Stolzenburg JU, Klein J. Der Roboter in der Urologie – eine Analyse aktueller und zukünftiger Gerätegenerationen [Robots in urology-an analysis of current and future devices]. Urologe A. 2018 Sep;57(9):1075-1090. German. doi: 10.1007/s00120-018-0733-0. PMID: 30030596.
2. Somashekhar SP, Deshpande AY, Ashwin KR, Gangasani R, Kumar R. A prospective randomized controlled trial comparing conventional Intuitive® procedure card recommended port placement with the modified Indian (Manipal) technique. J Minim Access Surg. 2020 Jul-Sep;16(3):246-250. doi: 10.4103/jmas.JMAS_18_19. PMID: 31031325; PMCID: PMC7440007.
3. Camerlo A, Delayre T, Fara R. Robotic central hepatectomy for hepatocarcinoma by glissonean approach (with video). Surg Oncol. 2021 Mar;36:82-83. doi: 10.1016/j.suronc.2020.11.011. Epub 2020 Nov 21. PMID: 33316683.
4. Lin JC, Ranasinghe B, Patel A, Rogers CG. Robot-assisted laparoscopic placement of extravascular stent for nutcracker syndrome. J Vasc Surg Cases Innov Tech. 2020 Apr 15;6(3):346-347. doi: 10.1016/j.jvscit.2020.03.013. PMID: 32715169; PMCID: PMC7371954.
5. Camerlo A, Vanbrugghe C, Cohen F, Fara R. Robotic Resection of a Central Liver Solitary Fibrous Tumor (with Video). J Gastrointest Surg. 2020 Dec;24(12):2903. doi: 10.1007/s11605-020-04734-z. Epub 2020 Jul 15. PMID: 32671800.

Number of studies	20+

INTUITIVE

Intuitive Surgical
https://www.intuitive.com/en-us/products-and-services/da-vinci
USA

DA VINCI XI

Field of application	Pediatrics Cardiology Thoracic-endocrine ENT Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	4 new generation robotic arms + trolley. Immersive and multi-dial control console.
Conception-features	7 degrees of freedom. Compatible with dual console. Integration of the Integrated Table Motion system to coordinate the arms with the operating table (TruSystem 7000dV Trumpf Medical) to avoid undocking the system when changing patient positions.
Conception-technical specificities	Fluorescence FireFly Technology 3D
Instruments	8mm + 5mm instruments. Vascular thermo-fusion (Vessel Sealer Extend™) and smart tissue stapling (SureForm stapler - SmartFire) complete the EndoWrist® instrumentation range.

Therapeutic indications

Urology:
- Prostatectomy
- Partial and total nephrectomy
- Pyeloplasty
- Cyst removal
- Cystectomy
- Ureteral implantation

Gynecology:
- Hysterectomy for benign conditions
- Hysterectomy for cancer
- Pelvic organ prolapse surgery
- Myomectomy
- Endometriosis resection

Visceral:
- Colon resection surgery
- Rectal resection surgery
- Rectopexy
- Bariatric surgery
- Gallbladder surgery
- Inguinal hernia repair
- Ventral hernia repair
- Nissen fundoplication
- Gastrectomy
- Pancreatectomy and pancreaticoduodenectomy / Whipple procedure
- Small bowel surgery
- Splenectomy

Cardio-thoracic:
- Mitral valve repair
- Coronary artery bypass grafting (GABG)
- Lung surgery
- Mediastinal mass resection
- Thymectomy

ENT:
- Surgery for benign and malignant tumors of the mouth and throat
- Benign base of tongue resections

Specify size/weight limit	Surgical drills could only be performed in cubes with edges of 70 mm in length or greater. This impairment in small cavities is a major limitation of the Da Vinci surgical system in small cavities, such as in newborns and infants. Although sporadic reports exist on robotic infant surgery, the DaVinci is mainly used in older children.

Regulatory aspects CE / FDA 2014

Publications / studies

1. Fiacchini G, Vianini M, Dallan I, Bruschini L. Is the Da Vinci Xi system a real improvement for oncologic transoral robotic surgery? A systematic review of the literature. J Robot Surg. 2021 Feb;15(1):1-12. doi: 10.1007/s11701-020-01132-0. Epub 2020 Aug 4. PMID: 32749569.
2. Moschovas MC, Bhat S, Sandri M, Rogers T, Onol F, Mazzone E, Roof S, Mottrie A, Patel V. Comparing the Approach to Radical Prostatectomy Using the Multiport da Vinci Xi and da Vinci SP Robots: A Propensity Score Analysis of Perioperative Outcomes. Eur Urol. 2021 Mar;79(3):393-404. doi: 10.1016/j.eururo.2020.11.042. Epub 2020 Dec 24. PMID: 33357994.
3. Giannini A, Malacarne E, Sergiampietri C, Mannella P, Perutelli A, Cela V, Stomati M, Melfi F, Simoncini T. Comparison of perioperative outcomes and technical features using da Vinci Si and Xi robotic platforms for early stages of endometrial cancer. J Robot Surg. 2021 Apr;15(2):195-201. doi: 10.1007/s11701-020-01091-6. Epub 2020 May 23. PMID: 32447594.
4. Dy GW, Jun MS, Blasdel G, Bluebond-Langner R, Zhao LC. Outcomes of Gender Affirming Peritoneal Flap Vaginoplasty Using the Da Vinci Single Port Versus Xi Robotic Systems. Eur Urol. 2021 May;79(5):676-683. doi: 10.1016/j.eururo.2020.06.040. Epub 2020 Jul 2. PMID: 32624272.
5. Yu DY, Chang YW, Lee HY, Kim WY, Kim HY, Lee JB, Son GS. Detailed comparison of the da Vinci Xi and S surgical systems for transaxillary thyroidectomy. Medicine (Baltimore). 2021 Jan 22;100(3):e24370. doi: 10.1097/MD.0000000000024370. PMID: 33546074; PMCID: PMC7837914.
6. Choi YS, Hong YT, Yi JW. Initial Experience With Robotic Modified Radical Neck Dissection Using the da Vinci Xi System Through the Bilateral Axillo-Breast Approach. Clin Exp Otorhinolaryngol. 2021 Feb;14(1):137-144. doi: 10.21053/ceo.2020.01585. Epub 2020 Sep 11. PMID: 32911879; PMCID: PMC7904439.
7. Lee SR, Roh AM, Jeong K, Kim SH, Chae HD, Moon HS. First report comparing the two types of single-incision robotic sacrocolpopexy: Single site using the da Vinci Xi or Si system and single port using the da Vinci SP system. Taiwan J Obstet Gynecol. 2021 Jan;60(1):60-65. doi: 10.1016/j.tjog.2020.10.007. PMID: 33495010.
8. Haese A, Graefen M. Re: Comparing the Approach to Radical Prostatectomy Using the Multiport da Vinci Xi and Single-port da Vinci SP Robots: A Propensity Score Analysis of Perioperative Outcomes. Eur Urol. 2021 Apr 16:S0302-2838(21)00248-7. doi: 10.1016/j.eururo.2021.04.008. Epub ahead of print. PMID: 33875307.
9. Bentivegna E, Koual M, Nguyen-Xuan HT, Plait L, Seidler S, Achen G, Bats AS, Azaïs H. Docking for robotic extraperitoneal para-aortic lymphadenectomy with Da Vinci Xi surgical system. J Gynecol Obstet Hum Reprod. 2021 Mar 26;50(8):102131. doi: 10.1016/j.jogoh.2021.102131. Epub ahead of print. PMID: 33781970.
10. Panattoni A, Giannini A, Morganti R, Mannella P, Perutelli A, Cela V, Simoncini T. Perioperative outcomes of the first five cases of surgeries for endometrial endometrioid cancer using the new integrated table motion for da Vinci Xi®. Int J Med Robot. 2021 Mar 21:e2254. doi: 10.1002/rcs.2254. Epub ahead of print. PMID: 33749118.

Number of studies 100+

INTUITIVE

Intuitive Surgical

https://www.intuitive.com/en-us/products-and-services/ion

USA

ION

Field of application	Thoracic-endocrine
TS	Endoluminal telesurgery system
Conception-configuration	Command station with a monitor. Robotic arm. Peripheral vision probe.
Conception-features	Planning + navigation for biopsy. A real-time vision of the airways with the ION vision probe. Ion can be integrated with existing imaging technologies: fluoroscopy, radial-endobronchial ultrasound and CT.
Conception-technical specificities	Ultra-thin and ultra-manageable catheter with a diameter of 3.5 mm, with a 180° articulation allowing it to reach the 18 segments of the lung.
Therapeutic indications	Minimally invasive biopsies of the peripheral lung for the treatment of lung cancer.
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2019

Publications / studies

1. Jiang J, Chang SH, Kent AJ, Geraci TC, Cerfolio RJ. Current Novel Advances in Bronchoscopy. Front Surg. 2020 Nov 16;7:596925. doi: 10.3389/fsurg.2020.596925. PMID: 33304923; PMCID: PMC7701114.
2. Amie J. Kent, Kim A. Byrnes, Stephanie H. Chang. State of the Art: Robotic Bronchoscopy. Seminars in Thoracic and Cardiovascular Surgery.Volume 32. Issue 4. 2020. Pages 1030-1035. ISSN 1043-0679. https://doi.org/10.1053/j.semtcvs.2020.08.008
3. Agrawal A, Hogarth DK, Murgu S. Robotic bronchoscopy for pulmonary lesions: a review of existing technologies and clinical data. J Thorac Dis. 2020 Jun;12(6):3279-3286. doi: 10.21037/jtd.2020.03.35. PMID: 32642251; PMCID: PMC7330790.
4. Benn, B.S., Romero, A.O., Lum, M. et al. Robotic-Assisted Navigation Bronchoscopy as a Paradigm Shift in Peripheral Lung Access. Lung 199, 177–186 (2021). https://doi.org/10.1007/s00408-021-00421-1
5. Pritchett MA, Bhadra K, Calcutt M, Folch E. Virtual or reality: divergence between preprocedural computed tomography scans and lung anatomy during guided bronchoscopy. J Thorac Dis. 2020 Apr;12(4):1595-1611. doi: 10.21037/jtd.2020.01.35. Erratum in: J Thorac Dis. 2020 Aug;12(8):4593-4595. PMID: 32395297; PMCID: PMC7212155.

Johnson & Johnson
AURIS

J&J / Auris Health
https://www.aurishealth.com/monarch-platform
USA

MONARCH

Field of application	Thoracic-endocrine Urology
TS	Endoluminal telesurgery system
Conception-configuration	Thoracic-endocrine: Monarch™ Endoscopy Cart with up to three robotic arms, Monarch™ Endoscopy Tower, and Monarch™ Bronchoscope System. Urology: Monarch® Tower, Monarch® Cart, Monarch® Fluidics Pump, Monarch® Controller, Monarch® Ureteroscope.
Conception-features	Computer navigation based on 3D models. The platform has a dedicated camera and instrumentation channel that allows continuous vision throughout the procedure to facilitate the biopsy process. Includes electromagnetic (EM) navigation.
Instruments	Single-use channel instruments Aspirating Biopsy Needle Biopsy Forceps Cytology Brush Fluidics Pump Mini-PCNL Suction Catheter Dilation Set Percutaneous Sheath
Therapeutic indications	Diagnostic and therapeutic bronchoscopic procedures Urology diagnostic and therapeutic procedures
Height / weight / age limits	Age 12 and up
Regulatory aspects	FDA 2018

Publications / studies

1. Murgu SD. Robotic assisted-bronchoscopy: technical tips and lessons learned from the initial experience with sampling peripheral lung lesions. BMC Pulm Med. 2019 May 9;19(1):89. doi: 10.1186/s12890-019-0857-z. PMID: 31072355; PMCID: PMC6506952.
2. Jiang J, Chang SH, Kent AJ, Geraci TC, Cerfolio RJ. Current Novel Advances in Bronchoscopy. Front Surg. 2020 Nov 16;7:596925. doi: 10.3389/fsurg.2020.596925. PMID: 33304923; PMCID: PMC7701114.
3. C. F. Graetzel, A. Sheehy and D. P. Noonan, "Robotic bronchoscopy drive mode of the Auris Monarch platform*," 2019 International Conference on Robotics and Automation (ICRA), 2019, pp. 3895-3901, doi: 10.1109/ICRA.2019.8793704.
4. Murgu, S.D. Robotic assisted-bronchoscopy: technical tips and lessons learned from the initial experience with sampling peripheral lung lesions. BMC Pulm Med 19, 89 (2019). https://doi.org/10.1186/s12890-019-0857-z
5. Jiang J, Chang SH, Kent AJ, Geraci TC, Cerfolio RJ. Current Novel Advances in Bronchoscopy. Front Surg. 2020 Nov 16;7:596925. doi: 10.3389/fsurg.2020.596925. PMID: 33304923; PMCID: PMC7701114.
6. Shiwata, T., Gregor, A., Inage, T. et al. Bronchoscopic navigation and tissue diagnosis. Gen Thorac Cardiovasc Surg 68, 672–678 (2020). https://doi.org/10.1007/s11748-019-01241-0
7. Wagh A, Ho E, Murgu S, Hogarth DK. Improving diagnostic yield of navigational bronchoscopy for peripheral pulmonary lesions: a review of advancing technology. J Thorac Dis. 2020 Dec;12(12):7683-7690. doi: 10.21037/jtd-2020-abpd-003. PMID: 33447461; PMCID: PMC7797818.
8. Khan F, Seaman J, Hunter TD, Ribeiro D, Laxmanan B, Kalsekar I, Cumbo-Nacheli G.Diagnostic outcomes of robotic-assisted bronchoscopy for pulmonary lesions in a real-world multicenter community setting. BMC Pulm Med. 2023 May 9;23(1):161. doi: 10.1186/s12890-023-02465-w. PMID: 37161376.
9. Iwamoto SK, Tsai WS. Novel approaches utilizing robotic navigational bronchoscopy: a single institution experience. J Robot Surg. 2023 Jun;17(3):1001-1006. doi: 10.1007/s11701-022-01507-5. Epub 2022 Nov 29. PMID: 36447009.

Number of studies	300+

Johnson & Johnson AG / DePuy Synthes
https://www.jnjmedtech.com/en-emea/companies/depuy-synthes
USA

VELYS™ ROBOTIC-ASSISTED SOLUTION

Field of application	Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	The main components of the VELYS™ Robotic-Assisted Solution are: base station, satellite station, robotic-assisted device, holding arm, instrumentation, saw handpiece.
Conception-features	The main function of the Robotic-Assisted Device is to maintain the Saw Blade within the planned resection planes. Throughout the procedure, the surgeon and/or clinical staff navigate through the surgical workflow using the Footswitch or the Touchscreens on the Base and Satellite Stations. The Holding Arm enables the draped Robotic-Assisted Device to be fixed to the OR bedrail on the operative knee side for resections. Once positioned on the bedrail, the Holding Arm is used to adjust the position of the Robotic-Assisted Device. The Saw is attached to the Planar Articulation of the draped Robotic-Assisted Device via the sterile Saw Interface.
Conception-technical specificities	The surgeon presses the Footswitch to control the movement of the motorized Robotic-Assisted Device and positions the Saw in each resection plane. During a resection step, the surgeon releases the Planar Articulation, makes the Saw visible to the Camera on the Base Station and actuates the Saw to complete the planned resection. The Planar articulation enables the NATURAL CONTROL™ Technology which provides free movement of the Saw within the resection plane. This plane is set using the ADAPTIVE TRACKING™ Technology, where the Robotic-Assisted Device adjusts and controls the plane using the position of the PURESIGHT™ Reflectors tracked by the Camera.
Instruments	18 Reusable Instruments 7 Single-Use Instruments
Therapeutic indications	Total knee arthroplasty Unicompartmental knee arthroplasty
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2021 CE 2023

Publications / studies

1. Clatworthy M. Patient-Specific TKA with the VELYS™ Robotic-Assisted Solution. Surg Technol Int. 2022 May 19;40:315-320. doi: 10.52198/22.STI.40.OS1561. PMID: 35325451.
2. Doan GW, Courtis RP, Wyss JG, Green EW, Clary CW. Image-Free Robotic-Assisted Total Knee Arthroplasty Improves Implant Alignment Accuracy: A Cadaveric Study. J Arthroplasty. 2022 Apr;37(4):795-801. doi: 10.1016/j.arth.2021.12.035. Epub 2022 Jan 1. PMID: 34979253.
3. Morrisey ZS, Barra MF, Guirguis PG, Drinkwater CJ. Transition to Robotic Total Knee Arthroplasty With Kinematic Alignment is Associated With a Short Learning Curve and Similar Acute-Period Functional Recoveries. Cureus. 2023 May 11;15(5):e38872. doi: 10.7759/cureus.38872. eCollection 2023 May. PMID: 37303372.
4. Doan GW An Accuracy and Precision Analysis of the VELYS™ Robotic Assisted Solution 2021 - search.proquest.com
5. Hamilton WG, Brenkel I, Clatworthy M, et al. Comparison of existing and new total knee arthroplasty implant systems from the same manufacturer: a prospective, multicenter study, 2019. Poster presented at: American Academy of Orthopaedic Surgeons 2019 Annual Meeting; March 12–16, 2019; Las Vegas, NV. Poster PO614.
6. Fisher D, Parkin D. Optimizing the value of your patients' TKA: how to leverage data from patient reported outcomes. Becker's Hospital Review webinar. October 3, 2019. Accessed October 18, 2019. www.ATTUNEevidence.com/clinical-evidence

Number of studies	10+

TINAVI | 天智航

J&J / Tinavi
http://en.tinavi.com/index.php?c=article&a=type&tid=62
info@tinavi.com
China

TIROBOT & TIROBOT II

Field of application	Neurosurgery | Spine | Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Robotic platform for spinal surgery, consisting of an intraoperative planning interface and integrated navigation. Robotic arm. Workstation. Optical tracking system.
Conception-features	Robotic arm can operate in motorized or manual mode. Integrated navigation features include intraoperative imaging, optical navigation and intraoperative screw planning. Real-time surgical planning. Double foot pedals.
Conception-technical specificities	Compatible to 2D and 3D modes
Instruments	Disposable Toolkits

Therapeutic indications

Spine + trauma
(Indications approved for use in spine and trauma in China):
- Femoral neck surgery
- Pelvic surgery
- Pedicle screw fixation
- Degenerative scoliosis fusion
- MIS-TLIF
- Posterior C1, C2 transarticular screw fixation
- Margel and brooks surgery
- Anterior odontoid process screw fixation
- Posterior pedicle screw fixation
- Lateral mass screw fixation
- Tibiotalar joint fusion
- Tibial plateau reconstructions
- Scaphoid fracture percutaneous screw fixation

Specify size/weight limit	No known indications
Regulatory aspects	Pending CE / FDA | NMPA (2016)

Publications / studies

1. Tian W, Zhang Q, Han XG, Yuan Q, He D, Liu YJ. Robot-assisted direct repair of spondylolysis: A case report. Medicine (Baltimore). 2020 Jan;99(4):e18944. doi: 10.1097/MD.0000000000018944. PMID: 31977911; PMCID: PMC7004664.
2. Tian W. Robot-Assisted Posterior C1-2 Transarticular Screw Fixation for Atlantoaxial Instability: A Case Report. Spine (Phila Pa 1976). 2016 Oct;41 Suppl 19:B2-B5. doi: 10.1097/BRS.0000000000001674. PMID: 27145470.
3. Long T, Li KN, Gao JH, Liu TH, Mu JS, Wang XJ, Peng C, He ZY. Comparative Study of Percutaneous Sacroiliac Screw with or without TiRobot Assistance for Treating Pelvic Posterior Ring Fractures. Orthop Surg. 2019 Jun;11(3):386-396. doi: 10.1111/os.12461. Epub 2019 May 11. PMID: 31077570; PMCID: PMC6595115.
4. RCT: Han X, Tian W, Liu Y, Liu B, He D, Sun Y, Han X, Fan M, Zhao J, Xu Y, Zhang Q. Safety and accuracy of robot-assisted versus fluoroscopy-assisted pedicle screw insertion in thoracolumbar spinal surgery: a prospective randomized controlled trial. J Neurosurg Spine. 2019 Feb 8:1-8. doi: 10.3171/2018.10.SPINE18487. Epub ahead of print. PMID: 30738398.
5. Le X, Tian W, Shi Z, Han X, Liu Y, Liu B, He D, Yuan Q, Sun Y, Xu Y. Robot-Assisted Versus Fluoroscopy-Assisted Cortical Bone Trajectory Screw Instrumentation in Lumbar Spinal Surgery: A Matched-Cohort Comparison. World Neurosurg. 2018 Dec;120:e745-e751. doi: 10.1016/j.wneu.2018.08.157. Epub 2018 Aug 30. PMID: 30172976.
6. Wu XB, Wang JQ, Sun X, Zhao CP. Guidance for Treatment of Pelvic Acetabular Injuries with Precise Minimally Invasive Internal Fixation Based on the Orthopaedic Surgery Robot Positioning System. Orthop Surg. 2019 Jun;11(3):341-347. doi: 10.1111/os.12452. Epub 2019 May 7. PMID: 31062515; PMCID: PMC6595112.
7. Bao BX, Yan H, Tang JG. Thoracic pedicle screw insertion assisted by the TiRobot system for spinal tuberculosis. Asian J Surg. 2021 May 1:S1015-9584(21)00228-1. doi: 10.1016/j.asjsur.2021.04.011. Epub ahead of print. PMID: 33947623.
8. Granit Molliqaj, Luca Paun, Aria Nouri, Pierre-Pascal Girod, Karl Schaller, Enrico Tessitore. Role of Robotics in Improving Surgical Outcome in Spinal Pathologies. World Neurosurgery.Volume 140. 2020. Pages 664-673. ISSN 1878-8750. https://doi.org/10.1016/j.wneu.2020.05.132
9. RCT: Wang JQ, Wang Y, Feng Y, Han W, Su YG, Liu WY, Zhang WJ, Wu XB, Wang MY, Fan YB. Percutaneous Sacroiliac Screw Placement: A Prospective Randomized Comparison of Robot-assisted Navigation Procedures with a Conventional Technique. Chin Med J (Engl). 2017 Nov 5;130(21):2527-2534. doi: 10.4103/0366-6999.217080. PMID: 29067950.
10. SR: Schuijt HJ, Hundersmarck D, Smeeing DPJ, van der Velde D, Weaver MJ. Robot-assisted fracture fixation in orthopaedic trauma surgery: a systematic review. OTA Int. 2021 Oct 5;4(4):e153. doi: 10.1097/OI9.0000000000000153. eCollection 2021 Dec. PMID: 34765903.

Number of studies	50+

Karl Storz
https://www.karlstorz.com/ch/fr/highlights-micro.htm
info@karlstorz.com
Germany

ARTIP CRUISE & VITOM 2D/3D

Field of application

Microsurgery | Pediatrics | Plastic surgery | Cardiology | Neurosurgery | Spine | Thoracic-endocrine | ENT | Urology| Gynecology

GA

Guidance assistant: visualization assistant

Conception-configuration

The ARTip CRUISE mobile platform is a motorized arm with exoscope and control unit.

Conception-features

It offers the pivot function (rotation of the central axis of the image) and the programming of positions.
For positioning the VITOM 3D exoscope equipped with the IMAGE1 S 2d/3d camera head and controlled using the IMAGE1 PILOT control unit.

Conception-technical specificities

VITOM ICG fluorescence NIR/ICG

Therapeutic indications

Neurosurgery:
- Tumor biopsy
- Tumor resection
- Nerve decompression
- Intracranial bleeding
- Vascular surgery

Oral and maxillofacial surgery:
- Dysgnathia surgery
- Flap-plasty
- Orbital surgery

ENT:
- Tumor resection
- Tympanoplasty
- Laryngeal surgery
- Adenotomy
- Blepharoplasty
- Septoplasty
- Open rhinoplasty
- Thyroplasty
- Thyroidectomy
- Eardrum paracentesis
- Tympanostomy tubes
- Cochlear implants

Cardiology:
- Mitral valve surgery
- Pediatric cardiac surgery

Gynecology:
- Colposcopy
- Conization

Hand surgery and Plastic surgery:
- Reconstructive surgery
- Median nerve neurolysis
- Dupuytren's contracture
- Ulnar shortening osteotomy
- Ulnar head prosthesis
- Arthroplasty
- Ganglion resection correction of trigger finger and mallet finger
- Four-corner arthrodesis

Spine:
- Herniated disks
- Spinal stenoses
- Spondylodeses
- Vertebral fracture

Specify size/weight limit

Hypospadias, anorectal malformation, artial spetal defect

Regulatory aspects

CE 2020

Publications / studies

1. Siller S, Zoellner C, Fuetsch M, Trabold R, Tonn JC, and Zausinger S, A high-definition 3D exoscope as an alternative to the operating microscope in spinal microsurgery.
2. Cantarella G, Pignataro L. A High-Definition 3-Dimensional Exoscope With the ARTip Cruise System as an Effective New Tool for Phonosurgery: A Preliminary Report. J Voice. 2021 Aug 6:S0892-1997(21)00233-2. doi: 10.1016/j.jvoice.2021.07.008. Online ahead of print. PMID: 34373157.
3. De Virgilio A, Costantino A, Ebm C, Conti V, Mondello T, Di Bari M, Cugini G, Mercante G, Spriano G. High definition three-dimensional exoscope (VITOM 3D) for microsurgery training: a preliminary experience. Eur Arch Otorhinolaryngol. 2020 Sep;277(9):2589-2595. doi: 10.1007/s00405-020-06014-7. Epub 2020 May 7. PMID: 32377858.
4. De Virgilio A, Costantino A, Mondello T, Conti V, Pirola F, Russo E, Mercante G, Spriano G. Pre-Clinical Experience With the VITOM 3D and the ARTip Cruise System for Micro-Laryngeal Surgery. Laryngoscope. 2021 Jan;131(1):136-138. doi: 10.1002/lary.28675. Epub 2020 Apr 16. PMID: 32297976.

Number of studies

20+

Keranova
https://www.keranova.fr/keranova-2/
contact@keranova.fr
France

FEMTOMATRIX

Field of application	Ophthalmology
GA	Guidance assistant: automatic
Conception-configuration	It has a robotic arm carrying the laser effector, incorporates OCT imaging and a phacoemulsification unit with irrigation/suction.
Conception-features	The FemtoMatrix allows the automated processing of characters by performing phacoemulsification of the lens instead of a traditional manual phacoemulsification.
Conception-technical specificities	Ultra-fast multiple impact matrix femtosecond laser technology 3D
Therapeutic indications	PHOTOemulsification on a cataract lens Cataract surgery Corneal incisions Capsulotomies Emulsification of the lens nucleus Relaxing incisions configurable at very high speed and very precise
Height / weight / age limits	No known indications
Regulatory aspects	Pending CE in 2023

Publications / studies

1. R. Tahiri Joutei Hassani, O. Sandali, A. Ouadfel, M. Packer, F. Romano, G. Thuret, P. Gain, M.D. de Smet, C. Baudouin. Que sera la chirurgie de la cataracte du futur ? Alternatives et voies de développement. Journal Français d'Ophtalmologie. Volume 43. Issue 9. 2020. Pages 929-943. ISSN 0181-5512. https://doi.org/10.1016/j.jfo.2020.05.006
2. Denise M. Visco, Raman Bedi, Mark Packer, Femtosecond laser–assisted arcuate keratotomy at the time of cataract surgery for the management of preexisting astigmatism. Journal of Cataract & Refractive Surgery. Volume 45. Issue 12. 2019. Pages 1762-1769. ISSN 0886-3350. https://doi.org/10.1016/j.jcrs.2019.08.002
3. E. Valas Teuma, Gary Gray, Raman Bedi, Mark Packer, Femtosecond laser–assisted capsulotomy with capsular marks for toric IOL alignment: Comparison of tensile strength with standard femtosecond laser capsulotomy. Journal of Cataract & Refractive Surgery. Volume 45. Issue 8. 2019. Pages 1177-1182. ISSN 0886-3350. https://doi.org/10.1016/j.jcrs.2019.03.021
4. de Saint Jean A, Dufournel D, Stodulka P, Romano F, Bernard A. Comparison of ultrasound phacoemulsification and FemtoMatrix® PhotoEmulsification® cataract surgery. Front Med (Lausanne). 2023 Apr 17;10:1157486. doi: 10.3389/fmed.2023.1157486. eCollection 2023. PMID: 37138745.

Number of studies	4+

KU LEUVEN

Ku Leuven
https://www.mynutia.com/
info@mynutia.com
Belgium

MYNUTIA

Field of application	Opthalmology
GA	Guidance assistant: semi-automatic
Conception-configuration	Co-manipulator system allows direct control of the instrument and its movements by the surgeon with compensation for tremor movements.
Conception-features	Comanipulative system (surgical tool is moved simultaneously by the surgical system and the surgeon). The surgical system allows instrument motions in the following directions: straight motion in and out of the eye, left and right rotation around the incision point, forward and backward rotation around the incision point.
Conception-technical specificities	Three main features: - A tenfold reduction of the needle tip vibrations with the aid of the installed mechanical damping technology. - Stabilization of the eye, the retina and the targeted vessel by eliminating instrument motions tangential to the sclera when manipulating the instrument. This is realized with the mechanical architecture of the surgical system. - Needle immobilization during the drug infusion with the aid of robust electromagnetic braking technology.
Instruments	The system is compatible with the cannulation instrument and the calibration instrument developed by the Assisted Eye Surgery group of the Mechanical Engineering Department from the University of Leuven. Those instruments are reusable (prior sterilization).
Therapeutic indications	Vitreoretinal surgery
Height / weight / age limits	No known indications
Regulatory aspects	Waiting for CE/FDA

Publications / studies

1. Yang, U.-J., Kim, D., Hwang, M., Kong, D., Kim, J., Nho, Y.-H., Lee, W. and Kwon, D.-S. (2021), A novel microsurgery robot mechanism with mechanical motion scalability for intraocular and reconstructive surgery. Int J Med Robot, 17: e2240. https://doi.org/10.1002/rcs.2240
2. C. Shin et al., "Semi-Automated Extraction of Lens Fragments Via a Surgical Robot Using Semantic Segmentation of OCT Images With Deep Learning - Experimental Results in Ex Vivo Animal Model," in IEEE Robotics and Automation Letters, vol. 6, no. 3, pp. 5261-5268, July 2021, doi: 10.1109/LRA.2021.3072574.

Number of studies	1

Levita Magnetics
https://www.levita.com/
info@levita.com
Chile

MARS

Field of application	Visceral Urology
CM	Co-manipulator: motorized augmented instruments
Conception-configuration	Magnetic-assisted robotic surgery
Therapeutic indications	Abdominal procedures Sleeve gastrectomy and same-day discharge cholecystectomy procedures
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2023
Publications / studies	No academic articles found

Levita Magnetics
https://www.levita.com/
info@levita.com
Chile

LEVITA MAGNETIC SURGICAL SYSTEM

Field of application	Visceral Urology
CM	Co-manipulator: motorized augmented instruments
Conception-configuration	The Levita Magnetic Surgical System is composed of two hand-held instruments, Magnetic Grasper comprised of a detachable Grasper Tip and a Shaft, and an external Magnetic Controller.
Instruments	Magnetic Grasper (sterile, single use) Magnetic Controller (non-sterile, reusable)
Therapeutic indications	Obesity procedures (sleeve gastrectomy) To grasp and retract the body and the fundus of the gallbladder in laparoscopic cholecystectomy procedures and the liver in bariatric procedures and prostate and periprostatic tissue in prostatectomy procedures and the colon, rectum, and pericolorectal tissue in colorectal proceduresto facilitate access and visualization of the surgical site.
Height / weight / age limits	BMI range of 20 to 60 kg/m²
Regulatory aspects	FDA 2017

Publications / studies

1. Fulla J, Small A, Kaplan-Marans E, Palese M. Magnetic-Assisted Robotic and Laparoscopic Renal Surgery: Initial Clinical Experience with the Levita Magnetic Surgical System. J Endourol. 2020 Dec;34(12):1242-1246. doi: 10.1089/end.2020.0043. Epub 2020 Jun 12. PMID: 32237897.
2. Steinberg RL, Johnson BA, Cadeddu JA. Magnetic-assisted Robotic Surgery to Facilitate Reduced-port Radical Prostatectomy. Urology. 2019 Apr;126:237. doi: 10.1016/j.urology.2019.01.017. Epub 2019 Jan 24. PMID: 30685447.
3. CT: Rivas H, Robles I, Riquelme F, Vivanco M, Jiménez J, Marinkovic B, Uribe M. Magnetic Surgery: Results From First Prospective Clinical Trial in 50 Patients. Ann Surg. 2018 Jan;267(1):88-93. doi: 10.1097/SLA.0000000000002045. PMID: 27759614.

Number of studies	10+

Medicaroid Corporation
https://www.medicaroid.com/en/product/hinotori/
info@medicaroid.eu
Japan

HINOTORI

Field of application	Visceral/gastroenterology Urology Gynecology Cardiology Thoracic-endocrine
TS	Multi-port telesurgery system
Conception-configuration	Telemanipulator composed of three elements: the surgeon's cockpit, the operational unit and the vision unit. - Immersive console - The microscope-type eyepiece - Loop-shaped handles
Conception-features	The four robotic arms have multiple joints and can move along 8 axes.
Conception-technical specificities	3D view
Instruments	Reusables Dedicated trocar HF Series Clip Applier (in 3 types: S, ML, and L) Universal grasper

Therapeutic indications

Urology:	Gynecology:	Visceral:
- Prostatectomy - Partial Nephrectomy	- Total hysterectomy	- Gastrectomy - Colectomy

Specify size/weight limit	No known indications
Regulatory aspects	Japan 2020/2022 (urology/gynecology, visceral) HSA (2023) CE submission soon FDA submission soon

Publications / studies

1. Koukourikis P, Rha KH. Robotic surgical systems in urology: What is currently available? Investig Clin Urol. 2021 Jan;62(1):14-22. doi: 10.4111/icu.20200387. PMID: 33381927; PMCID: PMC7801159.
2. Kikuchi, K, Suda, K, Shibasaki, S, Tanaka, T, Uyama, I. Challenges in improving the minimal invasiveness of the surgical treatment for gastric cancer using robotic technology. Ann Gastroenterol Surg. 2021; 00: 1– 10. https://doi.org/10.1002/ags3.12463
3. R: Alip SL, Kim J, Rha KH, Han WK. Future Platforms of Robotic Surgery. Urol Clin North Am. 2022 Feb;49(1):23-38. doi: 10.1016/j.ucl.2021.07.008. Epub 2021 Oct 25. PMID: 34776052.
4. R: Salkowski M, Checcucci E, Chow AK, Rogers CC, Adbollah F, Liatsikos E, Dasgupta P, Guimaraes GC, Rassweiler J, Mottrie A, Breda A, Crivellaro S, Kaouk J, Porpiglia F, Autorino R. New multiport robotic surgical systems: a comprehensive literature review of clinical outcomes in urology. Ther Adv Urol. 2023 Jun 5;15:17562872231177781. doi: 10.1177/17562872231177781. eCollection 2023 Jan-Dec. PMID: 37325289.
5. E: Hinata N, Yamaguchi R, Kusuhara Y, Kanayama H, Kohjimoto Y, Hara I, Fujisawa M. Hinotori Surgical Robot System, a novel robot-assisted surgical platform: Preclinical and clinical evaluation. Int J Urol. 2022 Oct;29(10):1213-1220. doi: 10.1111/iju.14973. Epub 2022 Jul 18. PMID: 35851692.
6. Motoyama D, Matsushita Y, Watanabe H, Tamura K, Otsuka A, Fujisawa M, Miyake H. Robot-assisted adrenalectomy using a hinotori surgical robot system: Report of first series of six cases. Asian J Endosc Surg. 2023 Jul;16(3):489-495. doi: 10.1111/ases.13212. Epub 2023 May 25. PMID: 37231618.

Number of studies	10+

Medrobotics
Expanding the reach of surgery ®

Medrobotics Corporation
https://medrobotics.com/gateway/flex-system-int/
info@robotics-surgical.com
USA

FLEX

Field of application	Thoracic-endocrine | ENT | Visceral | Gynecology | Urology
TS	Endoluminal telesurgery system
Conception-configuration	Flex Robotic and Flex Colorectal Drive. Console-controlled video endoscope. Flex console. Flex cart with arm.
Conception-features	Open Architecture Instrumentation. Allows the use of instruments via operator channels. 180 degree path.
Conception-technical specificities	3D HD visualization
Instruments	3.5mm instruments, laser holder, monopolar scissors, monopolar spatula, needle driver, monopolar needle knife, fenestrated grasper, monopolar Maryland dissector, 2 different straight laryngeal blades, 2 different curved laryngeal blades, 2 different laryngeal blades, 5 different tongue blades.

Therapeutic indications

- Colorectal surgery.
- Surgery of the oropharynx, hypopharynx and larynx.

The Medrobotics Flex® Robotic System is a device intended for robot-assisted visualization and surgical site access to the oropharynx, hypopharynx, and larynx in adults (≥ 22 years of age). The Medrobotics Flex® Robotic System is intended to provide robot-assisted control of the Flex® Colorectal Drive during visualization of and surgical site access to the anus, rectum and distal colon. The Flex® Robotic System also provides accessory channels for compatible flexible instruments used in surgery. Access to anus, rectum, distal colon, oropharynx, hypopharynx, larynx.

Specify size/weight limit	>=22 years old
Regulatory aspects	CE 2014/2016 (ENT/visceral, urology) FDA 2015/2017/2018 (ENT/visceral, urology/gynecology, thoracic-endocrine) Australia 2017

Publications / studies

1. Paull JO, Graham A, Parascandola S, Hota S, Stein S, Umapathi B, Abdullah A, Pudalov N, Obias V. Transvaginal rectopexy using the Flex® Colorectal Drive Robotic System: a proof-of-concept approach to rectal prolapse. Tech Coloproctol. 2020 May;24(5):471-474. doi: 10.1007/s10151-020-02180-2. Epub 2020 Mar 4. PMID: 32130545.
2. Carmichael H, D'Andrea AP, Skancke M, Obias V, Sylla P. Feasibility of transanal total mesorectal excision (taTME) using the Medrobotics Flex® System. Surg Endosc. 2020 Jan;34(1):485-491. doi: 10.1007/s00464-019-07019-y. Epub 2019 Jul 26. PMID: 31350608.
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4. Jones DB, Stefanidis D, Korndorffer JR Jr, Dimick JB, Jacob BP, Schultz L, Scott DJ. SAGES University MASTERS Program: a structured curriculum for deliberate, lifelong learning. Surg Endosc. 2017 Aug;31(8):3061-3071. doi: 10.1007/s00464-017-5626-6. Epub 2017 Jun 20. Erratum in: Surg Endosc. 2017 Aug 10. PMID: 28634631.
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Number of studies	30+

Medtronic

Medtronic
https://www.medtronic.com/
cs.switzerland@medtronic.com
USA

HUGO ™

Field of application	Visceral | Urology | Gynecology | Pediatrics | Cardiology | Thoracic-endocrine
TS	Multi-port telesurgery system
Conception-configuration	The HUGO robot is made up of 4 independent arms offering modularity and flexibility (use of 1 to 4 arms). The open surgeon console provides an immersive 3D experience while enabling communication with the surgical team and observers.
Conception-features	Composed of 4 modular arms on wheels, a control console and a viewing tower integrating Karl Storz endoscopy. Articulated robotic arms will provide a modular and portable solution with flexible positioning. Its modularity offers the possibility for the surgeon to switch to standard laparoscopic surgery after having used an arm. The control console incorporates two hand controllers with haptic feedback, foot pedals, 3DHD viewing monitor with passive glasses.
Conception-technical specificities	FT 10 Valleylab generator supplied. Image one S STORZ endoscope supplied.

Therapeutic indications

Urology:
- Radical prostatectomy
- Partial nephrectomy

Gynecology:
- Radical hysterectomy
- Vaginal hysterectomy

Visceral:
- Cholecystectomy
- Gastrectomy
- Anterior rectal resection
- Esophagomyotomy
- Hernia, colorectal, bariatric
- (Not liver and pancreas)

Thoracic

Cardiac

Specify size/weight limit	No known indications
Regulatory aspects	CE 2021/2022 (urology and gynecology/visceral) Australia TGA: urology and gynecology Canada: visceral MHLW PMDA Japan: urology and gynecology India

Publications / studies

1. Longmore, S.K.; Naik, G.; Gargiulo, G.D. Laparoscopic Robotic Surgery: Current Perspective and Future Directions. Robotics 2020, 9, 42. https://doi.org/10.3390/robotics9020042
2. Dunning J. Disruptive technology will transform what we think of as robotic surgery in under ten years. Ann Cardiothorac Surg. 2019 Mar;8(2):274-278. doi: 10.21037/acs.2019.03.02. PMID: 31032213; PMCID: PMC6462560.
3. Cisu, Theodorea; Crocerossa, Fabioa,b; Carbonara, Umbertoa,c; Porpiglia, Francescod; Autorino, Riccardoa New robotic surgical systems in urology: an update, Current Opinion in Urology: January 2021 - Volume 31 - Issue 1 - p 37-42 doi: 10.1097/MOU.0000000000000833.
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5. Ragavan N, Bharathkumar S, Chirravur P, Sankaran S, Mottrie A. Evaluation of Hugo RAS System in Major Urologic Surgery: Our Initial Experience. J Endourol. 2022 Aug;36(8):1029-1035. doi: 10.1089/end.2022.0015. Epub 2022 Mar 8. PMID: 35156838.

Number of studies	50+

Medtronic

Medtronic
https://www.medtronic.com/
swisscontact@medtronic.com
USA

MAZOR X STEALTH STATION

Field of application	Spine
GA	Guidance assistant: semi-automatic
Conception-configuration	1 central console with screen containing the robotic arm for storage, 1 robotic arm attached to the operating table, 1 camera for navigation.
Conception-features	4 degrees of freedom for the robotic arm, surgery in the operating zone, robotic guidance with navigated visual assistance.
Conception-technical specificities	3 percutaneous incisions, 1 open incision attached to the operating table, pre-operative 3D with fluoroscopic image fusion, intraoperative 3D (O-arm), advanced planning software, vertebrae segmenting software, integrated navigation, patient movement detection.
Instruments	Around fifty instruments available depending on the type of surgery, in use around ten instruments after selection (reusable)

Therapeutic indications

Surgery to correct scoliosis; Arthrodesis of the dorsal spine (degenerative, traumatic or tumor pathology); Arthrodesis of the lumbar spine (degenerative, traumatic or tumor pathology); Vertebral interbody fusion; Vertebral biopsy (tumor pathology); Kyphoplasty (vertebral fractures); spinal spondylolisthesis; system approve for cervical, thoracic, lumbar, sacrum.
Future: expansion of therapeutic indications from the cervix to the sacrum.

Specify size/weight limit	For pediatrics: spinal deformities
Regulatory aspects	CE / FDA 2019 Canada 2021

Publications / studies

1. Buza JA 3rd, Good CR, Lehman RA Jr, Pollina J, Chua RV, Buchholz AL, Gum JL. Robotic-assisted cortical bone trajectory (CBT) screws using the Mazor X Stealth Edition (MXSE) system: workflow and technical tips for safe and efficient use. J Robot Surg. 2021 Feb;15(1):13-23. doi: 10.1007/s11701-020-01147-7. Epub 2020 Sep 28. PMID: 32989623.
2. Lee NJ, Zuckerman SL, Buchanan IA, Boddapati V, Mathew J, Leung E, Park PJ, Pham MH, Buchholz AL, Khan A, Pollina J, Mullin JP, Jazini E, Haines C, Schuler TC, Good CR, Lombardi JM, Lehman RA. Is There a Difference Between Navigated and Non-Navigated Robot Cohorts in Robot-Assisted Spine Surgery? A Multicenter, Propensity-Matched Analysis of 2,800 Screws and 372 Patients. Spine J. 2021 May 19:S1529-9430(21)00253-9. doi: 10.1016/j.spinee.2021.05.015. Epub ahead of print. PMID: 34022461.
3. De Biase G, Chen S, Akinduro O, Quinones-Hinojosa A, Abode-Iyamah K. Awake Robotic Minimally Invasive L4-5 Transforaminal Lumbar Interbody Fusion. World Neurosurg. 2021 Apr;148:93. doi: 10.1016/j.wneu.2021.01.005. Epub 2021 Jan 13. PMID: 33453426.
4. Lieberman IH, Kisinde S, Hesselbacher S. Robotic-Assisted Pedicle Screw Placement During Spine Surgery. JBJS Essent Surg Tech. 2020 May 21;10(2):e0020. doi: 10.2106/JBJS.ST.19.00020. PMID: 32944411; PMCID: PMC7478327.
5. Khan A, Meyers JE, Siasios I, Pollina J. Next-Generation Robotic Spine Surgery: First Report on Feasibility, Safety, and Learning Curve. Oper Neurosurg (Hagerstown). 2019 Jul 1;17(1):61-69. doi: 10.1093/ons/opy280. PMID: 30247684.
6. Molliqaj G, Schatlo B, Alaid A, Solomiichuk V, Rohde V, Schaller K, Tessitore E. Accuracy of robot-guided versus freehand fluoroscopy-assisted pedicle screw insertion in thoracolumbar spinal surgery. Neurosurg Focus. 2017 May;42(5):E14. doi: 10.3171/2017.3.FOCUS179. PMID: 28463623.
7. Staartjes VE, Molliqaj G, van Kampen PM, et al. The European Robotic Spinal Instrumentation (EUROSPIN) study: protocol for a multicentre prospective observational study of pedicle screw revision surgery after robot-guided, navigated and freehand thoracolumbar spinal fusion. BMJ Open 2019;9:e030389. doi:10.1136/bmjopen-2019-030389.
8. Granit Molliqaj, Luca Paun, Aria Nouri, Pierre-Pascal Girod, Karl Schaller, Enrico Tessitore. Role of Robotics in Improving Surgical Outcome in Spinal Pathologies. World Neurosurgery.Volume 140. 2020. Pages 664-673. ISSN 1878-8750. https://doi.org/10.1016/j.wneu.2020.05.132
9. Enrico Tessitore, Granit Molliqaj, Claudio Schonauer, and Bawarjan Schatlo. The Robotic Arm Guidance Systems: Principles and Indications. AG 2018 23. DOI 10.1007/978-3-319-60143-4_3.

Number of studies	70+

Medtronic

Medtronic
https://www.medtronic.com/
USA

STEALTH AUTOGUIDE

Field of application	Neurosurgery
GA	Guidance assistant: semi-automatic
Conception-configuration	The Stealth Autoguide™ system is a positioning and guidance system for the spatial positioning and orientation of instrument holders or tool guides that neurosurgeons use to guide standard neurosurgical instruments. It is based on a preoperative plan and feedback generated by an image-guided navigation system equipped with 3D imaging software.
Conception-features	The Stealth Autoguide™ system provides robot-assisted trajectory alignment for Medtronic instruments used during navigated biopsies, stereotactic EEG screw placement and bone anchor placement for Visualase™ procedures.
Conception-technical specificities	Providing a tracking system to continuously monitor position using a StealthStation™ system. Alignment to the active surgical plane defined on a StealthStation™ system. Provide a working channel intended for the orientation and use of customized, procedure-specific surgical instruments. Assist in the creation of a cranial access hole using Midas Rex™ depth stop accessories and tools.
Instruments	The Stealth Autoguide™ system consists of a surgical trajectory platform and procedure-specific accessories. Together, the products act as a complete solution for trajectory alignment procedures.
Therapeutic indications	The Stealth Autoguide™ system is a remote positioning and guidance system for neurological conditions where stereotactic surgery may be appropriate (e.g. stereotactic biopsy, stereotactic EEG, laser tissue ablation).
Height / weight / age limits	No known indications
Regulatory aspects	CE FDA 2019

Publications / studies

1. Wolfsberger S, Minchev G, Kronreif G, et al. 146 Development of A Miniaturized Robotic Platform for Stereotactic Neurosurgery: Experience With Stealth AutoGuide From the First Series of 133 Patients. Neurosurgery. 2018;65(CN_suppl_1): 96-96.

Meere Company
http://www.revosurgical.com
info@revosurgical.com
South Korea

REVO-I

Field of application

ENT
Visceral
Urology
Gynecology

TS

Multi-port telesurgery system

Conception-configuration

Revo-i surgical robotics system consists of three pieces of equipment: the master console, the operation cart and the vision cart. The master console's 3D HD viewer shows the surgical site with three dimensions. It has ergonomic settings where surgeons can comfortably adjust their seating height, 3D viewer slope, armrest height, etc.
The operation cart performs the surgery by using instruments mounted on the instrument arm and the endoscope mounted on the camera arm. There are four arms, including one camera arm and three instrument arms.
The vision cart has the imaging processing systems where it transfers the images taken by the endoscope not only to the master console with 3D images, but also to the monitor at the vision cart. It uses a 3D endoscope from STORZ Germany linked to Revo-i system. A large 27-inch high-definition touch screen monitor is provided, and the multi-joint monitor arm helps staff easily position the monitor in the desired direction.

Conception-features

You can easily control the zoom-in and out functions of the camera and instruments with 7DOF (degrees of freedom). The device employs human hand motion recognition to enable precise surgery with 540 degrees of rotation.

Conception-technical specificities

An advanced energy, ultrasonic device Revo SONIC.
Revo SONIC uses ultrasound vibrations to cut through tissue while stopping bleeding at the same time (simultaneous sealing and cutting). Similar to laparoscopic surgery, surgeons are able to perform safer procedures and minimize tissue damage or trauma using the advanced technological tools of robotic surgery.

Instruments

Revo-i instruments have a multi-joint structure with 7 degrees of freedom, which enables them to move similarly to a human wrist. This is extremely helpful in managing the surgical area during a surgical procedure. All the most useful and frequently used instrument types in minimally invasive surgery can be fitted to the robotic device, including: offering forceps, needle holders, clip appliers and energy instruments that can be both monopolar or bipolar.
Adopts commercial laparoscopic trocars.

Therapeutic indications

Urology:
- Partial nephrectomy
- Radical prostatectomy

Gynecology:
- Hysterectomy
- Fallopian tube reconstruction / salpingectomy
- Oophorectomy
- Myomectomy
- Ovarian cystectomy

Visceral:
- Central pancreatectomy
- Hepatopancreatic biliary surgery
- Pylorus preserving pancreaticoduodenectomy
- Colorectal Surgery
- HPB surgery
- Appendectomy
- Low anterior resection
- Cholecystectomy

Head and Neck:
- Tonsillar cancer
- Prophylactic tonsillectomy

Specify size/weight limit

No known indications

Regulatory aspects	MDFS 2017 CE & FDA not now

Publications / studies

1. Lim JH, Lee WJ, Choi SH, Kang CM. Cholecystectomy using the Revo-i robotic surgical system from Korea: the first clinical study. Updates Surg. 2020 Sep 16. doi: 10.1007/s13304-020-00877-5. Epub ahead of print. PMID: 32936390.
2. Rao PP. Robotic surgery: new robots and finally some real competition! World J Urol. 2018 Apr;36(4):537-541. doi: 10.1007/s00345-018-2213-y. Epub 2018 Feb 9. PMID: 29427003.
3. Lim JH, Lee WJ, Park DW, Yea HJ, Kim SH, Kang CM. Robotic cholecystectomy using Revo-i Model MSR-5000, the newly developed Korean robotic surgical system: a preclinical study. Surg Endosc. 2017 Aug;31(8):3391-3397. doi: 10.1007/s00464-016-5357-0. Epub 2016 Nov 21. PMID: 27873012.
4. Ku G, Kang I, Lee WJ, Kang CM. Revo-i assisted robotic central pan createctomy. Ann Hepatobiliary Pancreat Surg. 2020 Nov 30;24(4):547-550. doi: 10.14701/ahbps.2020.24.4.547. PMID: 33234762; PMCID: PMC7691199.
5. Kang I, Hwang HK, Lee WJ, Kang CM. First experience of pancreaticoduodenectomy using Revo-i in a patient with insulinoma. Ann Hepatobiliary Pancreat Surg. 2020 Feb;24(1):104-108. doi: 10.14701/ahbps.2020.24.1.104. Epub 2020 Feb 27. PMID: 32181438; PMCID: PMC7061047.
6. Chang, K. D., Abdel Raheem, A., Choi, Y. D., Chung, B. H. & Rha, K. H. Retzius-sparing robot-assisted radical prostatectomy using the Revo-i robotic surgical system: surgical technique and results of the first human trial. BJU Int 122, 441–448 (2018).
7. Navarro, Jonathan Geograpo, et al. Revo-i assisted minimally invasive pancreaticoduodenectomy: how I do it. Annals of Robotic and Innovative Surgery, 2021, 2.1: 7-14.
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Number of studies	20+

MicroPort (& R.One (Joint Venture))
https://microport.com/healthcare-professional/surgical-robots
China

HONGHU (SKYWALKER PLATFORM)

Field of application	Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Honghu Orthopedic surgery navigation and positioning system. Surgical console (a robotic arm platform), navigation console (an optical tracking navigation platform), software system (including preoperative planning software).
Conception-features	Honghu features a preoperative planning system able to generate a personalized surgical scheme (3D virtual bone model) for patients based on the data collected from 3D CT scanning. It also features a highly dexterous lightweight manipulator that allows for smooth completion of the osteotomy process. SkyWalker Total Knee System is intended to assist the surgeon to perform Total Knee Arthroplasty (TKA) procedures by providing software-defined spatial boundaries for orientation and reference information to anatomical structures for the accurate placement of compatible knee implant components.
Instruments	Integrated osteotomy tool
Therapeutic indications	Total knee arthroplasty (TKA), removing damaged cartilage and bones from the surface of the knee joint and replacing them with artificial implants. (Total hip arthroplasty in design stage) Hip and spine trauma functions in the future. TKA procedures.
Height / weight / age limits	No known indications
Regulatory aspects	NMPA FDA 2022 CE 2022

Publications / studies

1. Xia R, Zhai Z, Zhang J, Yu D, Wang L, Mao Y, Zhu Z, Wu H, Dai K, Yan M, Li H. Verification and clinical translation of a newly designed "Skywalker" robot for total knee arthroplasty: A prospective clinical study. J Orthop Translat. 2021 Jun 24;29:143-151. doi: 10.1016/j.jot.2021.05.006. eCollection 2021 Jul. PMID: 34249612.

MicroPort

MicroPort
https://microport.com/healthcare-professional/surgical-robots
China

TOUMAI

Field of application	Thoracic-endocrine Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	Toumai primarily consists of an immersive and ergonomic surgeon's console, a patient-side cart with four robotic arms.
Conception-features	Real-time visualization of the target anatomy with natural depth-of-field, which facilitates accurate tissue identification and tissue layer differentiation. Robotic arms with high degrees of freedom. Filtering out tremors. Interactive robotic arms.
Conception-technical specificities	3D HD vision system
Therapeutic indications	Laparoscopy surgery. Prostatectomy, partial nephrectomy, radical prostatectomy.
Height / weight / age limits	No known indications
Regulatory aspects	NMPA 2022
Publications / studies	No academic articles found

microsure
robot assisted microsurgery

Microsure
http://microsure.nl/musa/
info@microsure.nl
The Netherlands

MUSA

Field of application	Microsurgery Pediatrics Plastic and reconstructive surgery
TS	Multi-port telesurgery system
Conception-configuration	MUSA 2: joystick table and a suspension with robotic arms, both are attached to the operating table. MUSA 3: robotic arm cart and a surgeon console.
Conception-features	Combination with a conventional microscope or digital microscope of your choice. This joystick-controlled microsurgery system reduces the range of motion according to a predefined scale and eliminates tremors. Arms supporting microsurgical instruments and is associated with conventional surgical microscopes. Compatible with existing microsurgical workflow, operating techniques and instruments.
Therapeutic indications	The robot makes it possible to work on targets less than one millimeter in size. Reestablish the connection between vessels or nerves as small as 0.3 mm. A robot for open microsurgical procedures such as anastomosis of vessels or nerves. Oncological surgery. Surgical procedures are complex interventions on small tissue structures - for example, surgery of lymph-venous anastomoses, pediatric vascular surgery, surgery of free flaps, and replantation of fingers and hands. Lymphatic surgery. Free flap surgery. Hand surgery.
Height / weight / age limits	Pediatric vascular surgery.
Regulatory aspects	CE 2019 for MUSA 2

Publications / studies

1. Van Mulken, T.J.M., Scharmga, A.M.J., Schols, R.M. et al. The journey of creating the first dedicated platform for robot-assisted (super)microsurgery in reconstructive surgery. Eur J Plast Surg 43, 1–6 (2020). https://doi.org/10.1007/s00238-019-01563-5
2. Van Mulken, T.J.M., Schols, R.M., Scharmga, A.M.J. et al. First-in-human robotic supermicrosurgery using a dedicated microsurgical robot for treating breast cancer-related lymphedema: a randomized pilot trial. Nat Commun 11, 757 (2020). https://doi.org/10.1038/s41467-019-14188-w
3. Yang, U.-J., Kim, D., Hwang, M., Kong, D., Kim, J., Nho, Y.-H., Lee, W. and Kwon, D.-S. (2021), A novel microsurgery robot mechanism with mechanical motion scalability for intraocular and reconstructive surgery. Int J Med Robot, 17: e2240. https://doi.org/10.1002/rcs.2240
4. Van Mulken TJM, Wolfs JAGN, Qiu SS, Scharmga AMJ, Schols RM, Spiekerman van Weezelenburg MA, Cau R, van der Hulst RRWJ; MicroSurgical Robot Research Group. One-Year Outcomes of the First Human Trial on Robot-Assisted Lymphaticovenous Anastomosis for Breast Cancer-Related Lymphedema. Plast Reconstr Surg. 2022 Jan 1;149(1):151-161. doi: 10.1097/PRS.0000000000008670. PMID: 34936615.
5. Van Mulken TJM, Boymans CAEM, Schols RM, Cau R, Schoenmakers FBF, Hoekstra LT, Qiu SS, Selber JC, van der Hulst RRWJ. Preclinical Experience Using a New Robotic System Created for Microsurgery. Plast Reconstr Surg. 2018 Nov;142(5):1367-1376. doi: 10.1097/PRS.0000000000004939. PMID: 30119108.

Number of studies	6+

MMI

https://www.mmimicro.com/symani-system-overview
info@mmimicro.com
Italy

SYMANI

Field of application	Microsurgery | Pediatrics | Plastic and reconstructive surgery | ENT / cervico facial | Opthalmology | Neurosurgery | Orthopedics
TS	Multi-port telesurgery system
Conception-configuration	Flexible platform consisting of two robotic arms Ergonomic console + manipulators controlled by the surgeon + foot controller
Conception-features	Symani NanoWrist instruments with 7 degrees of freedom Head-up viewing system
Conception-technical specificities	3D viewing system 7-20X motion scaling with shake filtering
Instruments	Symani NanoWrist instruments 3 mm
Therapeutic indications	Free flap reconstructions including perforator-to-perforator Lymphatic surgery such as lymph-venous anastomosis (LVA) and vascularized lymph node transfers (VLNT). Trauma reconstructions and replantations. Peripheral nerve repair. Reconstructions for congenital malformations. Microsurgical Vessel Repair.
Specify size/weight limit	No known indications
Regulatory aspects	CE 2020 Soon FDA submission

Publications / studies

Clinical Evidence & Scientific Evaluations in Progress – Worldwide Launch Starting Now.
First Wet Labs and histology assessments on Rats have shown decreased thrombosis rates vs. manual anastomosis.
First Human Use Interventions in 2020 – University Hospital Florence, Careggi, under the Lead of Prof. M. Innocenti.
First installations started this year in Switzerland & Austria, to be continued.
MMI Post Market Study / Registry Set up & Available for Participation.

1. R: Grünherz L, Gousopoulos E, Barbon C, Uyulmaz S, Giovanoli P, Lindenblatt N [Robotics in plastic surgery]. Chirurgie (Heidelb). 2023 Apr;94(4):325-329. doi: 10.1007/s00104-022-01790-w. Epub 2023 Jan 10. PMID: 36625922.
2. Savastano A, Rizzo S. A Novel Microsurgical Robot: Preliminary Feasibility Test in Ophthalmic Field. Transl Vis Sci Technol. 2022 Aug 1;11(8):13. doi: 10.1167/tvst.11.8.13. PMID: 35976656.
3. Schäfer B, Bahm J, Beier JP. Nerve Transfers Using a Dedicated Microsurgical Robotic System. Plast Reconstr Surg Glob Open. 2023 Aug 14;11(8):e5192. doi: 10.1097/GOX.0000000000005192. eCollection 2023 Aug. PMID: 37583397.
4. Barbon C, Grünherz L, Uyulmaz S, Giovanoli P, Lindenblatt N. Exploring the learning curve of a new robotic microsurgical system for microsurgery. JPRAS Open. 2022 Sep 10;34:126-133. doi: 10.1016/j.jpra.2022.09.002. eCollection 2022 Dec. PMID: 36304073.
5. Lindenblatt N, Grünherz L, Wang A, Gousopoulos E, Barbon C, Uyulmaz S, Giovanoli P. Early Experience Using a New Robotic Microsurgical System for Lymphatic Surgery. Plast Reconstr Surg Glob Open. 2022 Jan 10;10(1):e4013. doi: 10.1097/GOX.0000000000004013. eCollection 2022 Jan. PMID: 35028251.
6. Innocenti M, Malzone G, Menichini G. First-in-Human Free Flap Tissue Reconstruction Using a Dedicated Microsurgical Robotic Platform. Plast Reconstr Surg. 2023 May 1;151(5):1078-1082. doi: 10.1097/PRS.0000000000010108. Epub 2022 Dec 23. PMID: 36563175.
7. Weinzierl A, Barbon C, Gousopoulos E, von Reibnitz D, Giovanoli P, Grünherz L, Lindenblatt N. Benefits of robotic-assisted lymphatic microsurgery in deep anatomical planes. JPRAS Open. 2023 Jul 19;37:145-154. doi: 10.1016/j.jpra.2023.07.001. eCollection 2023 Sep. PMID: 37546233.

Number of studies	8+

Momentis Surgical (Memic)
https://www.momentissurgical.com/anovo-surgical-system/
info@momentissurgical.com
Israel

ANOVO (HOMINIS)

Field of application	Gynecology
TS	Endoluminal telesurgery system
Conception-configuration	Telesurgery system consisting of a robotic unit and a surgeon console.
Conception-features	Transvaginal pelvic telesurgery system. It has two articulated flexible robotic arms that mimic the movements of the human shoulder, elbow and wrist. The articulation of the instruments allows obstacles to be avoided, optimizing access and maneuvering angles.
Conception-technical specificities	Electrosurgical generator for monopolar and bipolar energies
Instruments	360-degree articulation of the instruments

Therapeutic indications

Transvaginal procedures:
- Benign hysterectomy
- Salpingectomy
- Oophorectomy
- Adnexectomy
- Ovarian Cyst Removal

Specify size/weight limit	No known indications
Regulatory aspects	FDA 2021

Publications / studies

1. Lior Lowenstein, Emad Matanes, Zeev Weiner, Jan Baekelandt. Robotic transvaginal natural orifice transluminal endoscopic surgery for bilateral salpingo oophorectomy. European Journal of Obstetrics & Gynecology and Reproductive Biology: X. Volume 7. 2020. 100113. ISSN 2590-1613. https://doi.org/10.1016/j.eurox.2020.100113
2. Lior Lowenstein, Omer Mor, Emad Matanes, Roy Lauterbach, Sari Boulus, Zeev Weiner, Jan Baekelandt. Robotic Vaginal Natural Orifice Transluminal Endoscopic Hysterectomy for Benign Indications. Journal of Minimally Invasive Gynecology. Volume 28. Issue 5. 2021. Pages 1101-1106. ISSN 1553-4650. https://doi.org/10.1016/j.jmig.2020.10.021
3. Alshiek, J., Marroquin, J. & Shobeiri, S.A. Vaginal ultrasound-guided Pouch of Douglas robotic entry in a live ovine model and human female cadaveric specimens. J Robotic Surg (2021). https://doi.org/10.1007/s11701-021-01203-w
4. Voelker R. A First in Surgical Devices for Transvaginal Hysterectomy. JAMA. 2021;325(13):1246. doi:10.1001/jama.2021.4592

Number of studies	8+

Moon Surgical
www.moonsurgical.com
contact@moonsurgical.com
France

MAESTRO

Field of application	Thoracic-endocrine ENT Visceral Urology Gynecology
CM	Co-manipulator: motorized augmented instruments
Conception-configuration	The Maestro system is a co-manipulation surgical robot. It consists of two robotic arms mounted on a mobile motorized chassis. The operating theater assistant positions the system at the side of the bed and uses the control screen to move the arms into the correct position for the operation. The technician can then attach the instruments to the end of the arms.
Conception-features	The Maestro system is a comanipulation system. It provides the surgeon with two additional arms, enabling him or her to control retraction and vision of the operating field. With no human intermediary, the surgeon receives constant retraction and stable vision, reducing frustration and mental workload.
Conception-technical specificities	Maestro's unique architecture is based on the transparency of arm movement. The surgeon can manipulate them and position them in the ideal position while perceiving the force feedback.
Instruments	Maestro is compatible with all 5 and 10 millimeter diameter off-the-shelf instruments.
Height / weight / age limits	No known indications
Regulatory aspects	CE 2023 FDA 2022

Publications / studies

1. First human surgery using a surgical assistance robotics device for laparoscopic cholecystectomies (Guy-Bernard Cadière, MD, PhD; Jacques Himpens, MD, PhD; Mathilde Poras, MD; Luca Pau MD; Nicolas Boyer MD; Benjamin Cadière, MD).

Number of studies	1

Neocis
https://www.neocis.com/
USA

YOMI DENTAL ROBOT

Field of application	ENT
GA	Guidance assistant: semi-automatic
Conception-configuration	A computerized robotic navigational system.
Conception-features	It provides assistance in the preoperative and intraoperative phases of dental implantation surgery. Yomi provides software for planning procedures and offers robotic navigational guidance for surgical instruments during procedures.
Therapeutic indications	Guided bone reduction (also known as alveoloplasty) of the mandible and/or maxilla. Dental implant.
Height / weight / age limits	Adult patients with partial edentulism and complete edentulism who meet the necessary requirements for dental implants.
Regulatory aspects	FDA 2022

Publications / studies

1. Talib HS, Wilkins GN, Turkyilmaz I. Flapless dental implant placement using a recently developed haptic robotic system. Br J Oral Maxillofac Surg. 2022 Nov;60(9):1273-1275. doi: 10.1016/j.bjoms.2022.05.008. Epub 2022 May 31. PMID: 35697577.
2. R: van Riet TCT, Chin Jen Sem KTH, Ho JTF, Spijker R, Kober J, de Lange J. Robot technology in dentistry, part one of a systematic review: literature characteristics. Dent Mater. 2021 Aug;37(8):1217-1226. doi: 10.1016/j.dental.2021.06.001. Epub 2021 Jun 20. PMID: 34158195.
3. R: van Riet TCT, Chin Jen Sem KTH, Ho JTF, Spijker R, Kober J, de Lange J. Robot technology in dentistry, part two of a systematic review: an overview of initiatives. Dent Mater. 2021 Aug;37(8):1227-1236. doi: 10.1016/j.dental.2021.06.002. Epub 2021 Jun 20. PMID: 34162501.

Noah Medical

Noah Medical
https://www.noahmed.com/
USA

GALAXY SYSTEM

Field of application	Thoracic-endocrine
TS	Endoluminal telesurgery system
Conception-configuration	Bronchoscopic visualization of and access to patient airways to conduct diagnostic and therapeutic procedures. Integrated with an X-ray-enhanced nodule-targeting system. An integrated system for navigated robotic bronchoscopy. Integrated tomosynthesis and augmented fluoroscopy, a single-used disposable bronchoscope, and a small, compact footprint. Noah Medical built TiLT+ Technology to overcome CT-to-body divergence by providing real-time navigation and lesion updates with readily available C-arm fluoroscopy. Peripheral lung navigation.
Therapeutic indications	Cochlear implants, osteospongiosis, cholesteatoma, tympanoplasty, middle and inner ear. Therapy (not yet)
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2023

Publications / studies

1. Bhadra K, Rickman OB, Mahajan AK, Hogarth DK. "Tool-in-lesion" Accuracy of Galaxy System-A Robotic Electromagnetic Navigation BroncHoscopy With Integrated Tool-in-lesion-Tomosynthesis Technology: The MATCH Study. J Bronchology Interv Pulmonol. 2023 Apr 19. doi: 10.1097/LBR.0000000000000923. Online ahead of print. PMID: 37072895.

NuVasive

NuVasive
https://www.nuvasive.com/surgical-solutions/pulse/
info@nuvasive.com
USA

PULSE

Field of application	Spine
GA	Guidance assistant: semi-automatic
Conception-configuration	The Pulse system is a guidance platform associated with the C-arm CIOS SPINE mobile 3D from Siemens. Surgical planning with Integrated Global Alignment® (iGA®).
Conception-features	Neuromonitoring

Therapeutic indications

- MIS spine procedures
- PLIF
- TLIF
- ALIF
- XLIF
- XLIF corpectomy
- Posterior cervical fusion
- Anterior cervical discectomy and Fusion in spine surgery
- MAS PLIF
- MAS TLIF fusion
- Degenerative Disc Disease (DDD)
- Lumbar spinal stenosis
- Degenerative spondylolisthesis
- Adult degenerative scoliosis
- Deformity
- Microdiscectomy
- Decompression
- Spinal Cord Stim
- Spinal Cord (Tumors, Untethering, Rhizotomy)
- Kyphoplasty, SI Fusion
- Corpectomy (tumors, infection)
- Revision
- Trauma

Specify size/weight limit	For pediatrics: early onset scoliosis
Regulatory aspects	FDA 2018 CE 2021

Publications / studies

1. D'Souza M, Gendreau J, Feng A, et al. Erratum: Robotic-Assisted Spine Surgery: History, Efficacy, Cost, And Future Trends [Corrigendum]. Robot Surg. 2019 Dec 23;6:25. doi: 10.2147/RSRR.S238276. Erratum for: Robot Surg. 2019 Nov 07;6:9-23. PMID: 31921933; PMCID: PMC6935019.
2. Joseph JR, Smith BW, Liu X, Park P. Current applications of robotics in spine surgery: a systematic review of the literature. Neurosurg Focus. 2017 May;42(5):E2. doi: 10.3171/2017.2.FOCUS16544. PMID: 28463618.
3. Farber, S. Harrison and Pacult, Mark A. and Godzik, Jakub and Walker, Corey T. and Turner, Jay D. and Porter, Randall W. and Uribe, Juan S. Robotics in Spine Surgery: A Technical Overview and Review of Key Concepts. Frontiers in Surgery. 2021. 8 (24). doi: 10.3389/fsurg.2021.578674.

Number of studies	10+

Olympus

https://www.olympus-europa.com/medical/rmt/media/en/content/content-msd/images/srp-pages/srp-orbeye/orbeye_concept_brochure_53297.pdf

Japan

ORBEYE

Field of application

Microsurgery
Pediatrics
Plastic and reconstructive surgery
Neurosurgery
Spine
Thoracic-endocrine
ENT
Urology

GA

Guidance assistant: visualization assistant

Conception-configuration

The Olympus ORBEYE is a Orbital Exoscopic Camera System.
The camera unit can be controlled with a foot switch.

Conception-features

Bright light observation modes.

Conception-technical specificities

Simultaneous 4K 3D viewing 26x magnification
Cold Light LED / Fluorescence, IR - Infrared Light / BL - Blue Light / NBI - Narrow Band Imaging

Therapeutic indications

Neurovascular procedures

Transsphenoidal pituitary surgery

Intra axial tumor surgery

Spine surgery

Microsurgery

Neurosurgery:
- Aneurysm clipping
- ECIC cerebrovascular bypass
- Craniotomy with tumor resection
- Craniotomy & decompression
- Cavernous malformation
- Arteriovenous malformation
- Epilepsy
- Deep brain hemorrhage
- Chiari malformation
- Carotid endarterectomy
- And more

Spine:
- Microdiscectomy
- Laminectomy
- ACDF: Anterior Cervical Discecotomy & Fusion
- PLIF: Posterior Lumbar Interbody Fusion
- TLIF: Transforaminal Lumbar Interbody Fusion
- MIS spine: (MAST & METrX)
- Open lumbar spine decompression
- Direct lateral (OLIF & XLIF)
- Spondololysthesis deformity correction
- Spinal cord stimulator placement
- Spinal cord tumor resection

ENT:
- Microvascular anastomosis of the head and neck
- Thyroidectomy
- Hemithyroidectomy
- Parathyroidectomy
- Carotid body tumor-vascular and ENT
- Microlaryngoscopy
- Laryngectomy
- Tympanoplasty with mastoidectomy
- Tympanoplasty
- Cochlear implant
- Acoustic neuroma-neuro
- Hemilaryngectomy

Male infertility microsurgery

Pediatrics for cases such as living liver transplants, cardiovascular valve repair and other surgical procedures

Cardiovascular procedures in adults

Specify size/weight limit

The ORBEYE video microscope makes it possible to replace lens-based optics, which is especially helpful when operating on babies or the spine.

Regulatory aspects

FDA 2019

Publications / studies

1. R: Amoo M, Henry J, Javadpour M. Beyond magnification and illumination: preliminary clinical experience with the 4K 3D ORBEYE™ exoscope and a literature review. Acta Neurochir (Wien). 2021 Aug;163(8):2107-2115. doi: 10.1007/s00701-021-04838-8. Epub 2021 Apr 2. PMID: 33797629.
2. R: Kijima N, Kishima H.[Utility of Neurosurgical Procedures Using 4K 3D Exoscopes: Clinical Experience with a 4K 3D Exoscope and Review of Literature]. No Shinkei Geka. 2022 Jul;50(4):889-901. doi: 10.11477/mf.1436204644. PMID: 35946373.

Number of studies

40+

Perfint Healthcare Pvt Ltd
www.perfinthealthcare.com
info@perfinthealthcare.com
India

MAXIO III

Field of application	Thoracic-endocrine Visceral Urology Gynecology
GA	Guidance assistant: semi-automatic
Conception-configuration	MAXIO® software supports an image processing system and an electromechanical, multi-axis (5-axis) arm equipped with an instrument holder or tool guide. The imaging system imports CT/PET-CT scan images and uses them to construct a 3D graphic representation. A physician can use the image to target specific regions of interest with one or more straight / rigid interventional instruments. MAXIO® software provides a view of the placement and trajectory of each instrument. Once the physician has accepted the plan, the MAXIO® system moves the instrument holder or tool guide into place in accordance with the physician-targeted placement and trajectory. The physician is then able to manually guide placement of each instrument through the instrument holder or tool guide. MAXIO® system additionally provides a graphic representation based on published data provided by instrument manufacturer relative to the targeted instrument position(s) on the reconstructed CT/PET-CT image and provides visual comparison of pre-procedure and post-procedure images.
Conception-features	Robotic arm has 3DOF.
Conception-technical specificities	Axial view representation Plan up to 2 needles Check scan needle verification Report generation
Instruments	ROBIO EX system supports up to 2 needle planning. It is a reusable medical equipment.
Therapeutic indications	Percutaneous interventions like tumor ablation, biopsy, pain management, Brachy needle placement, drainage etc using rigid straight needles in thorax abdomen and pelvis.
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2023 CE 2024 Canada 2023 China 2025 (not yet)
Publications / studies	No academic articles found
Number of studies	28

Point Robotics
https://www.pointroboticsinc.com/en
Taiwan

THE KINGUIDE SYSTEM

Field of application	Spine Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Point Robotics' technology pairs its navigation and surgical planning system with a hand-held robot framework. Surgeons use a parallel manipulator built into the framework to oversee the placement of bone and implant screws while situated directly at the operation site, guided by the navigation technology. Wider application of orthopedic surgical robots in the spine, joints and trauma surgeries will be the development trend in the coming decade.
Conception-features	Surgeon's extra pair of hands.
Therapeutic indications	A broader application of orthopedic surgical robots in spine surgeries, joint procedures, and trauma will be the development trend in the coming decade.
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2023 CE in progress NMPA in progress
Publications / studies	No academic articles found

PRECEYES
a ZEISS company

Preceyes B.V.
http://www.preceyes.nl/
info@preceyes.nl
The Netherlands

PRECEYES

Field of application	Opthalmology
TS	Multi-port telesurgery system
Conception-configuration	The system is fixed on the operating table. The surgeon manipulates the robot using a joystick and uses the conventional operating microscope to guide the gestures. Screen user interface, motion controller, instrument manipulator, head rest, foot switch.
Conception-features	Precision < 20 µm and a positional resolution of 3 µm was reported. Touch screen user interface, 6-function foot pedal. Instrument positioning: Four degrees of freedom, controllable motionless point at the sclerotomy, movement reach 80° × 80°× 40 mm, instrument rotation 720°. Instrument manipulator positioning: Three degrees of freedom, motorized, movement reach 50 × 40 × 60 mm. Motion controller: Four degrees of freedom, motorized, movement reach 70° × 70° × 55 mm, stylus rotation 300°.
Instruments	The PRECEYES Surgical System is compatible with different sizes of instruments: 23G, 25G and 27G.
Therapeutic indications	This robot is intended for vitreoretinal surgery: Subretinal injections, staining and ERM peeling, vein cannulation, extended modular application for MIGS.
Height / weight / age limits	No known indications
Regulatory aspects	CE 2019 FDA in progress

Publications / studies

1. R: de Smet MD, Naus GJL, Faridpooya K, Mura M. Robotic-assisted surgery in ophthalmology. Curr Opin Ophthalmol. 2018 May;29(3):248-253. doi: 10.1097/ICU.0000000000000476. PMID: 29553953.
2. Maberley DAL, Beelen M, Smit J, Meenink T, Naus G, Wagner C, de Smet MD. A comparison of robotic and manual surgery for internal limiting membrane peeling. Graefes Arch Clin Exp OphProthèse totale de hanchelmol. 2020 Apr;258(4):773-778. doi: 10.1007/s00417-020-04613-y. Epub 2020 Feb 3. PMID: 32009194.
3. De Smet MD, de Jonge N, Iannetta D, Faridpooya K, van Oosterhout E, Naus G, Meenink TCM, Mura M, Beelen MJ. Human/robotic interaction: vision limits performance in simulated vitreoretinal surgery. Acta OphProthèse totale de hanchelmol. 2019 Nov;97(7):672-678. doi: 10.1111/aos.14003. Epub 2018 Dec 27. PMID: 30588753.
4. Molaei A, Abedloo E, de Smet MD, Safi S, Khorshidifar M, Ahmadieh H, Khosravi MA, Daftarian N. Toward the Art of Robotic-assisted Vitreoretinal Surgery. J OphProthèse totale de hanchelmic Vis Res. 2017 Apr-Jun;12(2):212-218. doi: 10.4103/jovr.jovr_63_17. PMID: 28540014; PMCID: PMC5423376.
5. CT: Faridpooya K, van Romunde SHM, Manning SS, van Meurs JC, Naus GJL, Beelen MJ, Meenink TCM, Smit J, de Smet MD. Randomised controlled trial on robot-assisted versus manual surgery for pucker peeling. Clin Exp Ophthalmol. 2022 Dec;50(9):1057-1064. doi: 10.1111/ceo.14174. Epub 2022 Oct 17. PMID: 36177965.
6. R: Ladha R, Caspers LE, Willermain F, de Smet MD. Subretinal Therapy: Technological Solutions to Surgical and Immunological Challenges. Front Med (Lausanne). 2022 Mar 23;9:846782. doi: 10.3389/fmed.2022.846782. eCollection 2022. PMID: 35402424
7. R: Tahiri Joutei Hassani R, Sandali O, Ouadfel A, Packer M, Romano F, Thuret G, Gain P, de Smet MD, Baudouin C. [What will cataract surgery look like in the future? Alternatives in the pipeline]. J Fr Ophtalmol. 2020 Nov;43(9):929-943. doi: 10.1016/j.jfo.2020.05.006. Epub 2020 Aug 7. PMID: 32778347.
8. CT: Cehajic-Kapetanovic J, Xue K, Edwards TL, Meenink TC, Beelen MJ, Naus GJ, de Smet MD, MacLaren RE. First-in-Human Robot-Assisted Subretinal Drug Delivery Under Local Anesthesia. Am J Ophthalmol. 2022 May;237:104-113. doi: 10.1016/j.ajo.2021.11.011. Epub 2021 Nov 14. PMID: 34788592.

Number of studies	20+

PROCEPT BIOROBOTICS

Procept BioRobotics
https://www.procept-biorobotics.com/aquabeam-surgical-robotic-system/
info@procept-biorobotics.com
USA

AQUABEAM

Field of application	Urology
TS	Endoluminal telesurgery system
Conception-configuration	Minimally invasive endoscopic surgical treatment platform for benign prostatic hyperplasia. It allows the removal of prostate tissue under visual control (cystoscopy) and ultrasound (transrectal ultrasound), robot-assisted, thanks to a high-pressure water jet ("waterjet"). The resection uses a new technology with using a high pressure jet called Aquabeam under visual and ultrasound control of the surgeon. It allows, using a robot-assisted, to resect prostates of 80 ml avoiding transvesical resection. Console Aquabeam Engine bloc Aquabeam Foot Switch Planning unit Articulated arm Endoscope
Conception-features	Real-time, multidimensional imaging.
Therapeutic indications	Treatment of benign prostatic hyperplasia (BPH). resection and removal of prostate tissue for treatment due to benign prostatic hyperplasia.
Height / weight / age limits	Prostate volume between 30mL and 80mL.
Regulatory aspects	CE 2017 FDA 2019

Publications / studies

1. CT: Study WATER.
2. CT: Study WATER II.
3. CT: Study OPEN WATER.
4. Whiting, D., Ng, K.L. & Barber, N. Initial single centre experience of Aquablation of the prostate using the AquaBeam system with athermal haemostasis for the treatment of benign prostatic hyperplasia: 1-year outcomes. World J Urol (2021). https://doi.org/10.1007/s00345-020-03534-z
5. Reale, G., Cimino, S., Bruno, G. et al. "Aquabeam® System" for benign prostatic hyperplasia and LUTS: birth of a new era. A systematic review of functional and sexual outcome and adverse events of the technique. Int J Impot Res 31, 392–399 (2019). https://doi.org/10.1038/s41443-019-0158-3
6. J. Wilisch, B. Pradere, V. Misrai, H. Baumert, S. Doizi, S. Lebdai, N.B. Delongchamps, A. Benchikh, E.D. Negra, M. Fourmarier, A. Chevrot, Y. Rouscoff, P.E. Theveniaud, S. Vincendeau, A. Descazeaud, J. Gas, G. Robert. Mise au point sur les nouvelles techniques chirurgicales et interventionnelles dans la prise en charge de l'obstruction sous-vésicale liée à l'hyperplasie bénigne de la prostate. Progrès en Urologie. Volume 31. Issue 5. 2021. Pages 266-274. ISSN 1166-7087. https://doi.org/10.1016/j.purol.2020.12.001
7. MacRae C, Gilling P. How I do it: Aquablation of the prostate using the AQUABEAM system. Can J Urol. 2016 Dec;23(6):8590-8593. PMID: 27995858.
8. Nguyen DD, Barber N, Bidair M, Gilling P, Anderson P, Zorn KC, Badlani G, Humphreys M, Kaplan S, Kaufman R, So A, Paterson R, Goldenberg L, Elterman D, Desai M, Lingeman J, Roehrborn C, Bhojani N. Waterjet Ablation Therapy for Endoscopic Resection of prostate tissue trial (WATER) vs WATER II: comparing Aquablation therapy for benign prostatic hyperplasia in 30-80 and 80-150 mL prostates. BJU Int. 2020 Jan;125(1):112-122. doi: 10.1111/bju.14917. Epub 2019 Nov 8. PMID: 31599044; PMCID: PMC6972548.
9. Netsch C, Abt D, Rieken M, Gross AJ. (Wieder) eine Revolution in der Therapie des benignen Prostatasyndroms? Aquaablation und Prostataembolisation [A (new) revolution in the treatment of benign prostatic hyperplasia? Aqua-ablation and prostate embolization]. Urologe A. 2020 Oct;59(10):1177-1186. German. doi: 10.1007/s00120-020-01312-8. PMID: 32886138.

Number of studies	30+

Quantum Surgical
https://www.quantumsurgical.com/
info@quantumsurgical.com
France

EPIONE 1.0.3

Field of application

Thoracic-endocrine | Visceral | Urology

GA

Guidance assistant: semi-automatic

Conception-configuration

The Epione solution is comprised of a radiologist console and a single-arm navigated robot.
Epione is a robotic platform designed for percutaneous procedures specially in interventional oncology and minimally invasive treatment of cancers in the abdomen. It is designed to plan and confirm needle placement with 3D ablation zone overlays, improve needle placement accuracy and account for real-time patient respiration movement, target challenging tumors with precise multi-needle placements and oblique trajectories, shorten needle insertion time while utilizing preferred ablation device (MW/RF/CRYO/IRE), limit radiation exposure with needle placements performed outside the gantry and confirm adequate tumor margin coverage.

Conception-features

The Epione solution includes a 6-degrees-of-freedom collaborative robotic arm that allows flexible and precise placement of the needle guide, outside of the CT scan gantry. Instruments are guided with optical tracking that monitors real time the patient position and respiration phase.

Conception-technical specificities

The Epione technology allows rapid and precise needle placement through different features: automatic or collaborative guidance mode of the robotic arm, haptic feedback to confirm we are at the desired location, up to 7 needle placements in our predefined multi-needle patterns. Advanced software is also available to segment lesions and ablation zone, to determine adequate ablation coverage of the target and evaluate if the tumor margins have been adequately treated.

Instruments

A procedure with Epione requires to use 3 reusable instruments: a patient reference, a navigation probe and a needle guide, as well as few disposables: navigation spheres, skin markers, drapes and an adhesive film.

Therapeutic indications

Minimally invasive treatments for liver cancer allows percutaneous ablations of tumors located in the abdomen.
All abdominal cancers.
Lung metastases (clinical trial).

Thoracic-endocrine:
- Percutaneous procedures in the lungs

Urology:
- CE: Percutaneous procedures in the kidney (biopsy, ablation, fiducials…)
- FDA: Percutaneous ablation in the kidney

Visceral:
- Percutaneous procedures in the abdomen (biopsy, ablation, fiducials…)

Specify size/weight limit

No known indications

Regulatory aspects

CE 2021/2023 (visceral; urology/thoracic-endocrine)
FDA 2023 (visceral; urology)
NMPA 2023

Publications / studies

1. Robotic assistance for percutaneous needle insertion in the kidney: preclinical proof on a swine animal model, Eur Radiol Exp. 2022 Mar 8;6(1):13. De baère et al https://pubmed.ncbi.nlm.nih.gov/35257224/
2. Robotic-assisted percutaneous microwave ablation of hepatocellular carcinoma, Diagn Interv Imaging. 2023 May;104(5):258-260, Milot et al https://pubmed.ncbi.nlm.nih.gov/36792426/
3. Evaluation of a New CT-Guided Robotic System for Percutaneous Needle Insertion for Thermal Ablation of Liver Tumors: A Prospective Pilot Study, Cardiovasc Intervent Radiol. 2022 Nov;45(11):1701-1709, De baère et al https://pubmed.ncbi.nlm.nih.gov/36127519/
4. Feasibility, safety, and accuracy of a CT-guided robotic assistance for percutaneous needle placement in a swine liver model Sci Rep. 2021 Mar 4;11(1):5218. Guiu et al https://www.nature.com/articles/s41598-021-84878-3.pdf

Number of studies

4

RENISHAW
apply innovation™

Renishaw
https://www.renishaw.com/en/neuromate-robotic-system-for-stereotactic-neurosurgery--10712
info@renishaw.com
UK

NEUROMATE

Field of application	Neurosurgery
GA	Guidance assistant: semi-automatic
Conception-configuration	1 robotic arm Planning software
Conception-features	6 degrees of freedom. NEUROINSPIRE planning software. Optional NEUROLOCATE module which, combined with a 2D or 3D intraoperative X-ray device, allows the performance of stereotactic procedures. MRI, CT and angiographic neuroimages.
Instruments	Standard tool holder for standard neurosurgical instruments

Therapeutic indications

Stereotactic neurosurgery procedures:
- DBS
- Biopsy
- Implantation of depth electrodes for epilepsy monitoring (SEEG)
- Motor cortex stimulation (MCS)

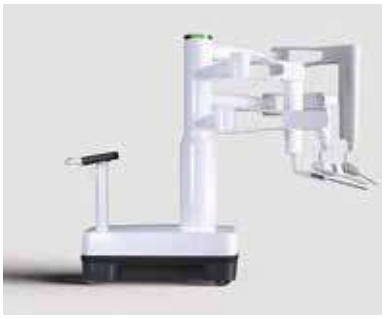
Neuroendoscopy

Specify size/weight limit	Pediatrics: stereoelectroencephalography (SEEG) for epilepsy
Regulatory aspects	CE / FDA 1997 Japan 2015

Publications / studies

1. Kalbhenn T, Cloppenborg T, Coras R, Fauser S, Hagemann A, Omaimen et al. Stereotactic depth electrode placement surgery in paediatric and adult patients with the Neuromate robotic device: Accuracy, complications and epileptological results. Seizure. 2021 Apr;87:81-87. doi: 10.1016/j.seizure.2021.03.004. Epub 2021 Mar 8. PMID: 33730649.
2. Ribault S, Simon E, Berthiller J, Polo G, Nunes A, Brinzeu A, Mertens P, Danaila T, Thobois S, Laurencin C. Comparison of clinical outcomes and accuracy of electrode placement between robot-assisted and conventional deep brain stimulation of the subProthèse totale de hanchelamic nucleus: a single-center study. Acta Neurochir (Wien). 2021 May;163(5):1327-1333. doi: 10.1007/s00701-021-04790-7. Epub 2021 Mar 2. PMID: 33649878.
3. Hiremath GK. Robotic Deep Brain Stimulation (R-DBS)-"Awake" Deep Brain Stimulation Using the Neuromate Robot and O-Arm. Neurol India. 2020 Nov-Dec;68(Supplement):S328-S332. doi: 10.4103/0028-3886.302450. PMID: 33318371.
4. Candela-Cantó S, Alamar M, Aláez C, Muchart J, Forero C, de la Gala C, Munuera J, Serrano S, Quintillá JM, Hinojosa J. Highly realistic simulation for robot-assisted hypoProthèse totale de hanchelamic hamartoma real-time MRI-guided laser interstitial thermal therapy (LITT). Childs Nerv Syst. 2020 Jun;36(6):1131-1142. doi: 10.1007/s00381-020-04563-0. Epub 2020 Mar 12. PMID: 32166344.
5. CT: Varma TR, Eldridge PR, Forster A, Fox S, Fletcher N, Steiger M, Littlechild P, Byrne P, Sinnott A, Tyler K, Flintham S. Use of the NeuroMate stereotactic robot in a frameless mode for movement disorder surgery. Stereotact Funct Neurosurg. 2003;80(1-4):132-5. doi: 10.1159/000075173. PMID: 14745222.
6. CT: Candela S, Vanegas MI, Darling A, Ortigoza-Escobar JD, Alamar M, Muchart J, Climent A, Ferrer E, Rumià J, Pérez-Dueñas B. Frameless robot-assisted pallidal deep brain stimulation surgery in pediatric patients with movement disorders: precision and short-term clinical results. J Neurosurg Pediatr. 2018 Oct;22(4):416-425. doi: 10.3171/2018.5.PEDS1814. Epub 2018 Jul 20. PMID: 30028274.

Number of studies	50+



RobSurgical

Rob Surgical
https://www.robsurgical.com/bitrack/
rss@robsurgical.com
Spain

BITRACK

Field of application	Thoracic-endocrine Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	The platform consists of a single cart with four robotic arms and an open-format surgical console. The robotic arms are mounted on a flexible floating fulcrum which offers improved accessibility and access to the surgical cart around various patient positions.
Conception-features	The system enables hybrid surgery with open ports that allow robotic instruments and traditional surgery instruments to operate simultaneously. Submillimeter precision. 7 degrees of freedom to the instrument tip: - 3 degrees for position in space - 3 degrees for orientation - 1 degree for opening and closing the end effector
Conception-technical specificities	3D-HD Haptic feedback
Instruments	Single use 8 mm of diameter instruments Compatible BITRACK instruments & Compatible with conventional instruments Monopolar Bipolar
Therapeutic indications	- General surgery - Urology (radical nephrectomies) - Colon and rectal - Gynecology - Thoracic
Specify size/weight limit	No known indications
Regulatory aspects	Pending CE in 2024 FDA in progress (authorization to conduct FIH clinical trials (2023))

Publications / studies

1. Koukourikis P, Rha KH. Robotic surgical systems in urology: What is currently available? Investig Clin Urol. 2021 Jan;62(1):14-22. doi: 10.4111/icu.20200387. PMID: 33381927; PMCID: PMC7801159.
2. Almujalhem, A, Rha, KH. Surgical robotic systems: What we have now? A urological perspective. BJUI Compass. 2020; 1: 152– 159. https://doi.org/10.1111/bco2.31
3. Hoeckelmann M, Rudas IJ, Fiorini P, Kirchner F, Haidegger T. Current Capabilities and Development Potential in Surgical Robotics. International Journal of Advanced Robotic Systems. May 2015. doi:10.5772/60133.
4. Casilla-Lennon, Marianne & Hittelman, Adam & Netto, José Murillo. (2020). New Robotic Systems. 10.1007/978-3-030-57219-8_27.

Sinamed
https://sinamed.ir/
info@sinamed.ir
Iran

SINAFLEX

Field of application	Pediatrics Cardiology Orthopedics Thoracic-endocrine ENT Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	This system has two main subsystems including a master robotic console at surgeon's side and a slave robotic system at patient's side with two or three robotic arms and a laparoscopic arm (RoboLens) which are installed on the sides of a specific surgery bed.
Instruments	5mm diameter instruments single-use flexible instruments
Therapeutic indications	Sinaflex has been designed to perform different laparoscopic surgeries in the abdominal cavity such as prostatectomy, hysterectomy, cholecystectomy, and nephrectomy. Sinaflex is also going to be able to perform cardiovascular and arthroscopic surgeries in the future.
Height / weight / age limits	Sinaflex is designed to work on small cavities. It has passed the preclinical test on medium size animals such as dogs. It may also be used for pediatric surgery.
Regulatory aspects	Waiting for CE/FDA

Publications / studies

1. Aghanouri M, Kheradmand P, Mousavi M, Moradi H, Mirbagheri A, Kinematic and Workspace Analysis of the Master Robot in the Sinaflex Robotic Telesurgery System Annu Int Conf IEEE Eng Med Biol Soc. 2021 Nov; 2021:4777-4780. doi: 10.1109/EMBC46164.2021.9629933. PMID: 34892279 DOI: 10.1109/EMBC46164.2021.9629933.

Number of studies	1

Smith & Nephew

https://www.smith-nephew.com/professional/microsites/navio/

UK

NAVIO FPS

Field of application	Orthopedics
GA	Guidance assistant: manual
Conception-configuration	Platform featuring a handpiece combined with an optical navigation system.
Conception-features	Resection is performed by speed modulation and retraction of a burr, monitored in real time on the 3D modeling monitor.
Therapeutic indications	Partial and total knee arthroplasty.
Specify size/weight limit	No known indications
Regulatory aspects	CE 2012 FDA 2018

Publications / studies

1. Jess H. Lonner. Robotically Assisted Unicompartmental Knee Arthroplasty with a Handheld Image-Free Sculpting Tool. Operative Techniques in Orthopaedics. Volume 25, Issue 2. 2015. Pages 104-113. ISSN 1048-6666. https://doi.org/10.1053/j.oto.2015.03.001.
2. MergenProthèse totale de hancheler, G., Batailler, C., Lording, T. et al. Is robotic-assisted unicompartmental knee arthroplasty a safe procedure? A case control study. Knee Surg Sports Traumatol Arthrosc 29, 931–938 (2021). https://doi.org/10.1007/s00167-020-06051-z
3. Leelasestaporn C. (2018) Robotic UKA. In: Sugano N. (eds) Computer Assisted Orthopaedic Surgery for Hip and Knee. Springer, Singapore. https://doi.org/10.1007/978-981-10-5245-3_6
4. Allen M.W., Jacofsky D.J. (2019) Evolution of Robotics in Arthroplasty. In: Lonner J. (eds) Robotics in Knee and Hip Arthroplasty. Springer, Cham. https://doi.org/10.1007/978-3-030-16593-2_2
5. Chen, X., Li, Z., Zhang, X., Yan, J., Ding, L., Song, Y., Huo, Y., Chan, M.T., Wu, W.K. and Lin, J. (2021), A new robotically assisted system for total knee arthroplasty: A sheep model study. Int J Med Robot e2264. https://doi.org/10.1002/rcs.2264
6. Liu, P., Lu, Ff., Liu, Gj. et al. Robotic-assisted unicompartmental knee arthroplasty: a review. Arthroplasty 3, 15 (2021). https://doi.org/10.1186/s42836-021-00071-x

Soteria Medical

https://www.soteria-medical.com/
info@soteria-medical.com

SOTERIA RCM

Field of application	Urology
TS	Endoluminal telesurgery system
Conception-configuration	MRI-guided puncture robot. The system consists of a manipulator (robot) fully compatible with MRI. This manipulator is connected by 7 meters of tubing to a control unit using a wall-mounted power supply. The control unit is located in the MRI control room and broadcasts the movement calculated by the software dedicated to the robot.
Therapeutic indications	Treatment of benign prostatic hyperplasia (BPH). Prostate biopsy/endorectal.
Height / weight / age limits	No known indications
Regulatory aspects	CE / FDA 2018

Publications / studies

1. Chen, L., Paetz, T., Dicken, V., Krass, S., Issawi, J. A., Ojdanić, D., Krass, S., Tigelaar, G., Sabisch, J., Poelgeest, A. V., and Schaechtele, J. (March 1, 2015). "Design of a Dedicated Five Degree-of-Freedom Magnetic Resonance Imaging Compatible Robot for Image Guided Prostate Biopsy." ASME. J. Med. Devices. March 2015; 9(1): 015002. https://doi.org/10.1115/1.4029506
2. Vilanova, J.C., Pérez de Tudela, A., Puig, J. et al. Robotic-assisted transrectal MRI-guided biopsy. Technical feasibility and role in the current diagnosis of prostate cancer: an initial single-center experience. Abdom Radiol 45, 4150–4159 (2020). https://doi.org/10.1007/s00261-020-02665-6
3. Bomers JGR, Bosboom DGH, Tigelaar GH, Sabisch J, Fütterer JJ, Yakar D. Feasibility of a 2nd generation MR-compatible manipulator for transrectal prostate biopsy guidance. Eur Radiol. 2017 Apr;27(4):1776-1782. doi: 10.1007/s00330-016-4504-2. Epub 2016 Jul 19. PMID: 27436021; PMCID: PMC5334446.

SSInnovations / Surgical Robotic Solutions
https://ssinnovations.com/
info@ssinnovations.org
India

SSI MANTRA

Field of application	Cardiology Thoracic-endocrine ENT Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	3 to 5 arms on individual motorized carts, open surgeon's console.
Conception-features	Modular Robotic Arms with multiple adjustments. Choose between three-module or five-module configurations.
Conception-technical specificities	Large 3D 4K Monitor Vision 2D Touch Monitor System Controls
Instruments	Reusables Dedicated trocar

Therapeutic indications

Lung surgery.
Validated in India in more than 35 different surgical procedures.
Robotic cardiac bypass procedures.
200+ surgical procedures.

Urology:
- Radical nephrectomy
- Partial nephrectomy
- Radical cystectomy
- Radical prostatectomy

Gynecology:
- Hysterectomy
- Radical hysterectomy
- Pelvic lymphadenectomy

Thoracic:
- Thymectomy

Specify size/weight limit	No known indications
Regulatory aspects	Awaiting FDA approval in 2023 Awaiting CE approval in 2024 India in 2022
Publications / studies	No academic articles found

Stryker Osteonics SA
www.stryker.com
ch@stryker.com
USA

MAKO ROBOTIC ARM 3.11

Field of application	Orthopedics Spine
GA	Guidance assistant: semi-automatic
Conception-configuration	1 robotic arm, 1 camera module with screen, 1 guidance module.
Conception-features	Full range of motion due to 6 joints that work together.
Conception-technical specificities	3D advanced CT based planning, haptic boundaries, extended intraoperative planning, normal approach as used for knee/hip replacement with extra incision for pins to place arrays.
Therapeutic indications	Total knee, partial knee, total hip. Shoulder replacement, spine, revision knee, revision hip (not yet).
Height / weight / age limits	No known indications
Regulatory aspects	CE 2008 FDA 2015 CE new version (2023-01-03 - 2026-08-31)

Publications / studies

1. Luis Grau, Max Lingamfelter, Danielle Ponzio, Zachary Post, Alvin Ong, David Le, Fabio Orozco. Robotic arm assisted total knee arthroplasty workflow optimization, operative times and learning curve. Arthroplasty Today. Volume 5. Issue 4. 2019. Pages 465-470. ISSN 2352-3441. https://doi.org/10.1016/j.artd.2019.04.007
2. Marcovigi A, Zambianchi F, Sandoni D, Rivi E, Catani F. Robotic-arm assisted partial knee arthroplasty: a single centre experience. Acta Biomed. 2017 Jun 7;88(2S):54-59. doi: 10.23750/abm.v88i2-S.6514. PMID: 28657565; PMCID: PMC6179000.
3. Domb BG, Chen JW, Kyin C, Bheem R, Karom J, Shapira J, Rosinsky PJ, Lall AC, Maldonado DR. Primary Robotic-Arm Assisted Total Hip Arthroplasty: An Analysis of 501 Hips With 44-Month Follow-up. Orthopedics. 2021 Feb 9:1-7. doi: 10.3928/01477447-20210201-01. Epub ahead of print. PMID: 33561868.
4. Bardou-Jacquet J, Murgier J, Laudet F, Fabre T. Combining load sensor and robotic technologies for ligament balance in total knee arthroplasty. Orthop Traumatol Surg Res. 2021 Mar 10:102889. doi: 10.1016/j.otsr.2021.102889. Epub ahead of print. PMID: 33713872.
5. Caldora P, D'Urso A, Banchetti R, Arniani S, Colcelli D, Ciampalini L, Guastafierro P, Lup D. Blood transfusion, hospital stay and learning curve in robotic assisted total hip arthroplasty. J Biol Regul Homeost Agents. 2020 Jul-Aug;34(4 Suppl. 3):37-49. Congress of the Italian Orthopaedic Research Society. PMID: 33261255.
6. Sires JD, Wilson CJ. CT Validation of Intraoperative Implant Position and Knee Alignment as Determined by the MAKO Total Knee Arthroplasty System. J Knee Surg. 2020 Mar 4. doi: 10.1055/s-0040-1701447. Epub ahead of print. PMID: 32131103.
7. Hadley CJ, Grossman EL, Mont MA, Salem HS, Catani F, Marcovigi A. Robotic-Assisted versus Manually Implanted Total Hip Arthroplasty: A Clinical and Radiographic Comparison. Surg Technol Int. 2020 Nov 28;37:371-376. PMID: 33175395.
8. Klasan A, Carter M, Holland S, Young SW. Low femoral component prominence negatively influences early revision rate in robotic unicompartmental knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. 2020 Dec;28(12):3906-3911. doi: 10.1007/s00167-020-05886-w. Epub 2020 Feb 6. PMID: 32030503.

Number of studies	330+

Synaptive

Synaptive Medical
www.synaptivemedical.com
product.requests@synaptivemedical.com
Canada

"MODUS X" (VERSION 4) (PREVIOUSLY "MODUS V")

Field of application	Pediatrics Neurosurgery Spine ENT
CM	Co-manipulator: motorized endoscope holder
Conception-configuration	Modus X is a robotic exoscope featuring advanced 4K 3D optics and fluorescence visualization used across neurosurgery, spine, otolaryngology, and microsurgical reconstruction. Modus X features hands-free control with both tracked instruments and voice control.
Conception-features	Modus X features a robotic arm that performs XYZ automated movement on six axes. The arm can be moved hands-free using memory positions, voice control, or tracked surgical instruments. It features integrated surgical navigation with automated whole brain tractography.
Conception-technical specificities	Modus X features 4K 3D optics and LED based fluorescence visualization.
Instruments	Reusable pointers and suction devices. Suction tubes are reposable. Single use tracking for NICO BrainPath retractor.
Therapeutic indications	Microsurgical interventions under exoscopy (brain and spine neurosurgery). Modus X is a positioning system for optical devices used for extracorporeal visualization of the operating field during surgery. Modus X is ideally suited for visualizing open procedures such as those performed in cranial, spinal, and ENT (ear, nose, throat) surgery.
Height / weight / age limits	No limit.
Regulatory aspects	CE/FDA 2017 Health Canada and Australia approved

Publications / studies

1. Exoscope Improves Visualization and Extent of Hippocampal Resection in Temporal Lobectomy, Wu et al. 2022.
2. A Novel Use of the Exoscope for In-Vivo Microvascular Free Flaps, McMaine et al., 2023.
3. Robotic-Assisted Digital Exoscope for Resection of Cerebral Metastases: A Case Series, Schupper et al., 2021.
4. Postoperative Outcomes Following Glioblastoma Resection Using a Robot-Assisted Digital Surgical Exoscope: A Case Series, Barron et al., 2020.

Number of studies	35

Think Surgical

TMINI

Field of application	Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Camera Robotic arm
Conception-features	A miniature, wireless robotic system that assists surgeons in performing total knee replacement. CT-based three-dimensional surgical plan. Cutting guides.
Therapeutic indications	Total knee replacement
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2023
Publications / studies	No academic articles found

Think Surgical Inc.
https://thinksurgical.com/professionals/technology/
USA

TSOLUTION ONE

Field of application	Orthopedics
GA	Guidance assistant: automatic
Conception-configuration	The system consists of TPLAN®, a 3D pre-surgical planning workstation and TCAT®, an active robot.
Conception-features	The machining of the bone is carried out according to the preoperative plan carried out on the planning software (TPLAN®). It performs part of the operation independently under the supervision of the surgeon. Submillimeter dimensional accuracy. This active robot carries out the machining of hard tissues in the case of fitting hip and knee prostheses. The system is optimized for Think Surgical Inc prostheses but says it is open to integrating implants from other manufacturers.
Therapeutic indications	Total hip and knee prostheses.
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2014/2020 (hip/knee) CE 2017

Publications / studies

1. Liow MHL, Chin PL, Pang HN, Tay DK, Yeo SJ. THINK surgical TSolution-One® (Robodoc) total knee arthroplasty. SICOT J. 2017;3:63. doi: 10.1051/sicotj/2017052. Epub 2017 Oct 30. PMID: 29087292; PMCID: PMC5663203.
2. Lincoln & Chin, Pak & Pang, Hee & Tay, Darren & Yeo, Seng-Jin. (2017). THINK surgical TSolution-One ® (Robodoc) total knee arthroplasty. SICOT-J. 3. 63. 10.1051/sicotj/2017052.
3. Chan J, Auld TS, Long WJ, Kreuzer S, Campanelli V, Liebelt R, Kissin YD. Active Robotic Total Knee Arthroplasty (Prothèse totale de genou): Initial Experience with the TSolution One ® Prothèse totale de genou System. Surg Technol Int. 2020 Nov 28;37:299-305. PMID: 32681727.
4. Dungy DS, Netravali NA. Active Robotics for Total Hip Arthroplasty. Am J Orthop (Belle Mead NJ). 2016 May-Jun;45(4):256-9. PMID: 27327918.
5. St Mart JP, Goh EL, Shah Z. Robotics in total hip arthroplasty: a review of the evolution, application and evidence base. EFORT Open Rev. 2020 Dec 4;5(12):866-873. doi: 10.1302/2058-5241.5.200037. PMID: 33425375; PMCID: PMC7784137.

Number of studies	5+

Venus Concept (Restoration Robotics)
https://www.venusconcept.com/en-gl/artas-ix.htm
info@venusconcept.com
France

ARTAS IX

Field of application	Plastic and reconstructive
GA	Guidance assistant: automatic
Conception-configuration	Robotic arm System cart Needle mechanism Patient chair Imaging subsystem: 2 stereo cameras
Conception-features	The ARTAS® Robotic Hair Restoration System is a hair transplantation platform that allows harvesting and implantation of the recipient site. Multi-camera stereoscopic vision system with 44-micron resolution. Seven-axis robot arm. 3D pre-operative planning.
Conception-technical specificities	Robot arm with 0.1mm repeatability.
Instruments	Needle single use
Therapeutic indications	Robotic Hair Restoration System.
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2011 CE 2012

Publications / studies

1. CT: Miguel Canales, M.D.,Restoration Robotics Computer-Assisted Versus Manual Hair Harvest Comparative Study https://www.clinicaltrials.gov/study/NCT00926211?term=NCT00926211&rank=1

Number of studies	1

VIRTUALINCISION

Virtual Incision
www.virtualincision.com
info@virtualincision.com
USA

MIRA SURGICAL SYSTEM

Field of application	Visceral Gynecology
TS	Single-port telesurgery system
Conception-configuration	The MIRA Surgical System consists of a minibot that has two instrument arms and an integrated articulating camera. These components are portable and small enough to fit in a surgical tray, opening up the possibility of doing robotic-assisted surgery in any operating room at any time. Like other systems, it is accompanied by a surgeon console and a companion cart that houses the electrosurgical equipment.
Conception-features	Each instrument arm has 6 degrees of freedom, with joints resembling those of a human. There is a shoulder, elbow, and infinite wrist-roll. The camera is fully articulating.
Conception-technical specificities	What makes MIRA unique is the small, portable, user-friendly design. The system is designed to be easily set up in minutes by surgically trained staff, a stark contrast to the large, complex systems already on the market. The steps are streamlined and it does not require draping or docking. Both the minibot and camera are designed to be sterilized before use up to 15 times. Insertion of the Minibot is accomplished using a GelPort® Laparoscopic System made by Applied Medical and at least one assistant trocar port to enable the device to reach virtually anywhere in the abdomen without external arm collisions.
Instruments	The instruments are single-use and provided sterile. The system is planned to have monopolar scissor, bipolar grasper, and needle drivers. Additional instruments are currently under development.

Therapeutic indications

- Bowel resection, gynecology, general surgery.
- Optimized for MIS bowel resection procedures.
- Complex multi-quadrant abdominal surgeries.
- Colon resection.
- Gall bladder removal.
- Hernia repair.

Specify size/weight limit	No known indications
Regulatory aspects	FDA de novo submission FDA approuved IDE supplement (2022) CE in progress

Publications / studies

1. Casilla-Lennon M.M., Hittelman A.B., Netto J.M.B. (2020) New Robotic Systems. In: Gargollo P.C. (eds) Minimally Invasive and Robotic-Assisted Surgery in Pediatric Urology. Springer, Cham. https://doi.org/10.1007/978-3-030-57219-8_27
2. Ahmad, A., Ahmad, Z.F., Carleton, J.D. et al. Robotic surgery: current perceptions and the clinical evidence. Surg Endosc 31, 255–263 (2017). https://doi.org/10.1007/s00464-016-4966-y

WEGO
weigaoholding.com
info@wego-intervention.com
China

MICROHAND-S SYSTEM

Field of application	Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	Flexible robotic arm. Endoscope is equipped with an imaging system that provides real-time, high-resolution images.
Conception-features	Mechanical arm that can rotate and swing freely within 360 degrees. Capacity for remote operation. Performs simple medical tasks such as suturing quickly and automatically. Position and sensitivity of the robot can be adjusted from the operation board according to the doctor's requirements - for example, making the robot's "arms" lighter and more suitable to the needs of the operation. Uses a different form of isomorphic control modeling technology, which enables more accurate hand - eye - instrument motion consistency in a three-dimensional (3D) visual environment.
Conception-technical specificities	Advanced Energy: Ultrasonic (rigid). Endoscope is equipped with a dual CMOS sensor 3D stereoscopic imaging system. Virtual haptic feedback sensitivity.
Instruments	Reusables
Therapeutic indications	Colorectal resection. Gastric perforation repair and an appendectomy.
Specify size/weight limit	No known indications
Regulatory aspects	NMPA approved

Publications / studies

1. Luo D, Liu Y, Zhu H, Li X, Gao W, Li X, Zhu S, Yu X. The MicroHand S robotic-assisted versus Da Vinci robotic-assisted radical resection for patients with sigmoid colon cancer: a single-center retrospective study. Surg Endosc. 2020 Aug;34(8):3368-3374. doi: 10.1007/s00464-019-07107-z. Epub 2019 Sep 3. PMID: 31482355.
2. Li W, Kong K, Li P, Wang G, Cui B, Zhu L, Zhu S. Robot-assisted sleeve gastrectomy in patients with obesity with a novel Chinese domestic MicroHand SII surgical system. BMC Surg. 2021 May 25;21(1):260. doi: 10.1186/s12893-021-01259-3. PMID: 34034737.
3. Liang K, Xing Y, Li J, Wang S, Li A, Li J. Motion control skill assessment based on kinematic analysis of robotic end-effector movements. Int J Med Robot. 2018 Feb;14(1). doi: 10.1002/rcs.1845. Epub 2017 Jun 29. PMID: 28660644.
4. Zhang Z, Wang Y, Zhang Z, Zheng J, Su Z, Gui H, Jiao W, Yang X, Niu H. Application of deterministic networking for reducing network delay in urological telesurgery: A retrospective study. Int J Med Robot. 2022 Apr;18(2):e2365. doi: 10.1002/rcs.2365. Epub 2022 Jan 15 PMID: 34996124.

Number of studies	4

Yuanhua Intelligent Technology / Yuanhua Technology
https://yuanhuatech.com/
info@yuanhuatech.com
China

YUANHUA SURGICAL ROBOT

Field of application	Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	Surgical robot arm and an AI-powered surgical planning system.

Therapeutic indications

- Knee arthroplasty, periacetabular osteotomy, and spine surgeries.
- Knee or hip replacements, trauma and spinal procedures.
- Total knee arthroplasty (for joint replacement surgeries).
- Total knee arthroplasty (TKA), removing damaged cartilage and bones from the surface of the knee joint and replacing them with artificial implants.

Specify size/weight limit	No known indications
Regulatory aspects	NMPA 2022

Publications / studies

1. https://onlinelibrary.wiley.com/doi/full/10.1111/os.13323
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9480831/

ZIMMER BIOMET

Zimmer Biomet
https://www.zimmerbiomet.com/medical-professionals/knee/product/rosa-knee-system.html
USA

ROSA KNEE

Field of application	Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	The system offers two modeling options, one by radiological image and the other using anatomical data collected by the optical platform. The system benefits from the Rosa® robotic arm which has three control modes: automatic, collaborative and stationary. Thus, the surgeon can perform the placement of the arm manually by applying gentle force to it.
Conception-features	2D X-ray to 3D bone modeling imaging based on X-Atlas® technology. Imageless case option. Perform multiple techniques including Personalized Alignment™, Gap Balancing, Measured Resection and Hybrid alignment in real time.
Therapeutic indications	Partial (2021) and total (2019) knee arthroplasty. Direct anterior total hip arthroplasty (08/2021).
Height / weight / age limits	No known indications
Regulatory aspects	CE / FDA 2019 (Knee) FDA 2021 (Hip)

Publications / studies

1. Klein, Gregg & James, Dugal & Lonner, Jess. (2019). Total Knee Arthroplasty Technique: ROSA® Knee. 10.1007/978-3-030-16593-2_18.
2. Sébastien Parratte, Andrew J. Price, Lee M. Jeys, William F. Jackson, Henry D. Clarke. Accuracy of a New Robotically Assisted Technique for Total Knee Arthroplasty: A Cadaveric Study. The Journal of Arthroplasty, Volume 34. Issue 11. 2019. Pages 2799-2803. ISSN 0883-5403 https://doi.org/10.1016/j.arth.2019.06.040
3. Sébastien Parratte,Andrew J. Price,Lee M. Jeys,William F. Jackson,Henry D. Clarke. Accuracy of a New Robotically Assisted Technique for Total Knee Arthroplasty: A Cadaveric Study. The Journal of Arthroplasty. Elsevier. 2019. VOLUME 34. ISSUE 11. P2799-2803. DOI: https://doi.org/10.1016/j.arth.2019.06.040
4. Mancino F, Cacciola G, Malahias MA, De Filippis R, De Marco D, Di Matteo V, A G, Sculco PK, Maccauro G, De Martino I. What are the benefits of robotic-assisted total knee arthroplasty over conventional manual total knee arthroplasty? A systematic review of comparative studies. Orthop Rev (Pavia). 2020 Jun 25;12(Suppl 1):8657. doi: 10.4081/or.2020.8657. PMID: 32913593; PMCID: PMC7459388.
5. R: Batailler C, Hannouche D, Benazzo F, Parratte S. Concepts and techniques of a new robotically assisted technique for total knee arthroplasty: the ROSA knee system.
6. Fary, C. Tripuraneni K, Klar B, Ren AN, Abshagen S, Verheul R. Orthopaedic Proceedings, Earlier Gains in Active Range of Motion Following Robotic-Assisted Total Knee Arthroplasty Compared with Conventional Instrumentation 2023;105-B(SUPP_2):43-43. doi:doi:10.1302/1358-992X.2023.2.043.
7. Khan IA, Vaile JR, DeSimone CA, Parsell DE, Heinze JD, Alessi A, Xu W, Shah RP, Pickering T, Cafferky NL, Lonner JH.Image-Free Robotic-Assisted Total Knee Arthroplasty Results in Quicker Recovery but Equivalent One-Year Outcomes Compared to Conventional Total Knee Arthroplasty J Arthroplasty. 2023 Feb 18:S0883-5403(23)00131-6. doi: 10.1016/j.arth.2023.02.023. Epub ahead of print. PMID: 36801477.
8. Schrednitzki D, Horn CE, Lampe UA, Halder, Imageless robotic-assisted total knee arthroplasty is accurate in vivo: a retrospective study to measure the postoperative bone resection and alignment AM. Arch Orthop Trauma Surg. 2022 Oct 21. doi: 10.1007/s00402-022-04648-2. Epub ahead of print. PMID: 36269397.
9. Rossi SMP, Benazzo F., Individualized alignment and ligament balancing technique with the ROSA® robotic system for total knee arthroplasty Int Orthop. 2023 Mar;47(3):755-762. doi: 10.1007/s00264-022-05671-z. Epub 2023 Jan 4. PMID: 36596998.
10. Bolam SM, Tay ML, Zaidi F, et al., Introduction of ROSA Robotic-Arm System for Total Knee Arthroplasty is Associated with a Minimal Learning Curve for Operative Time, Journal of Experimental Orthopaedics. 2022;9(1):86.
11. Mancino F, Rossi SMP, Sangaletti R, Lucenti L, Terragnoli F, Benazzo F., A New Robotically Assisted Technique Can Improve Outcomes of Total Knee Arthroplasty Comparing to an Imageless Navigation System, Arch Orthop Trauma Surg. 2022.
12. Atul F. Kamath, Sridhar M. Durbhakula, Trevor Pickering, Nathan L. Caferky, Trevor G. Murray, Michael A. Wind Jr., Stéphane Méthot*. Improved Accuracy and Fewer Outliers with a Novel CT free Robotic THA System in Matched Pair Analysis with Manual THA† A Cadaveric Study, Journal of Robotic Surgery. Published online: 28 October 2021.

Number of studies	10+

ZIMMER BIOMET

Zimmer Biomet
https://www.zimmerbiomet.com/medical-professionals/cmf/rosa-brain.html
USA

ROSA ONE

Field of application	Neurosurgery
GA	Guidance assistant: semi-automatic
Conception-configuration	The platform consists of a mobile workstation fitted with a positioning arm. Robot + navigation (possibly cranial or transnasal endoscope holder) + (frameless laser registration) and o-ct (spine) use. 1 robotic arm.
Conception-features	The planning software allows the calculation of the optimal trajectory to reduce vascular damage and that of the functional areas of the brain. 6 degrees of freedom. Kind of "GPS" of the cranial box.
Conception-technical specificities	Haptic ability

Therapeutic indications

Brain:
- Stereo Electroencephalography (SEEG)
- Deep Brain Stimulation (DBS)
- Stereotactic biopsy ventricular endoscopy
- Transnasal endoscopy
- Deformities and spinal tumors

- Spine: (not supported anymore)
- Degenerative spine diseases
- Traumatology

Specify size/weight limit	Pediatric epilepsy and neurooncology surgery
Regulatory aspects	FDA 2012 (Rosa Brain) FDA 2016 (Rosa Spine) (not supported anymore) CE 2014 (Rosa Spine) (not supported anymore)

Publications / studies

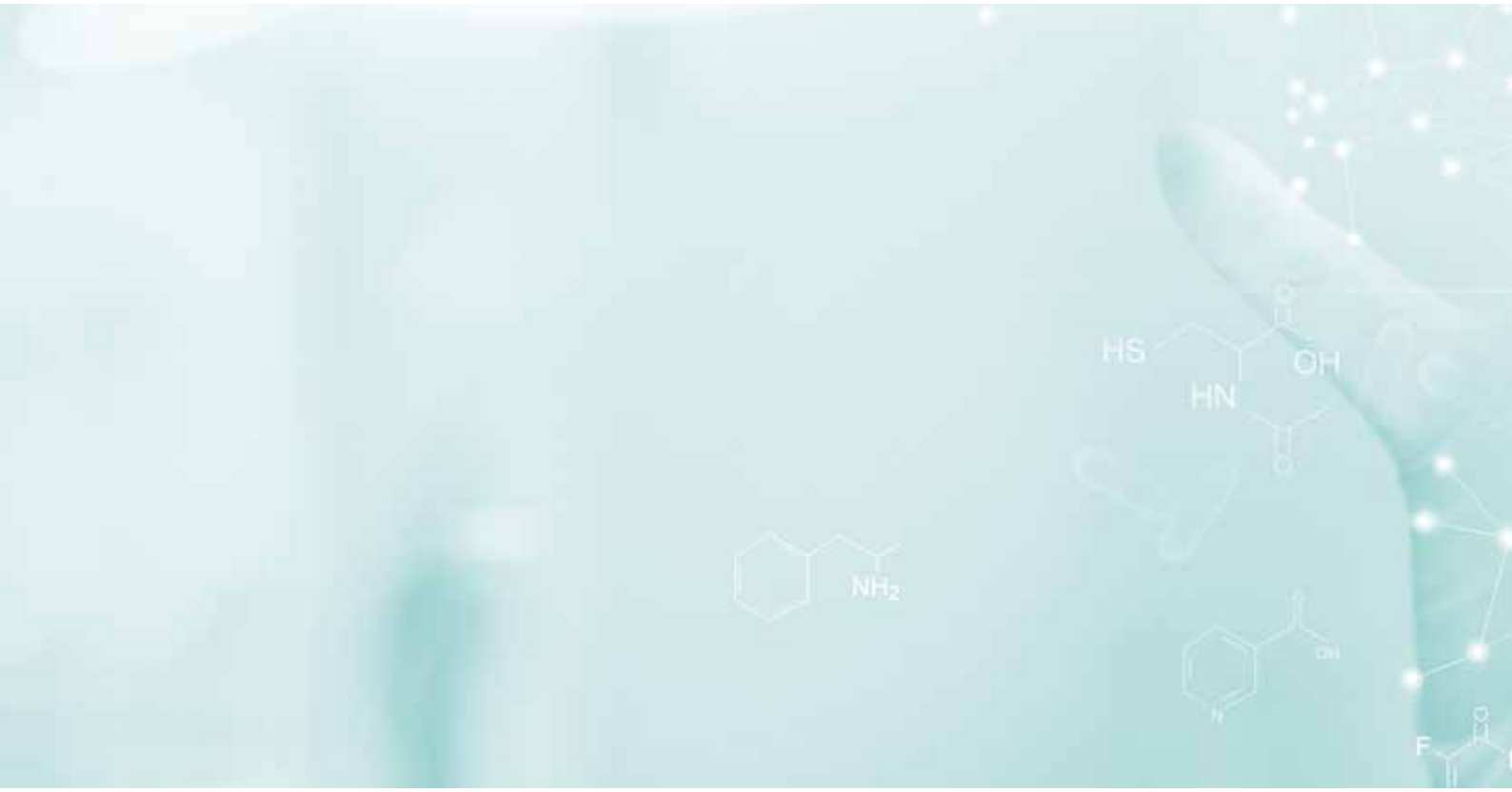
1. Lu C, Chen S, An Y, Meng F, Wang Y, Wei P, Fan X, Shan Y, Zhao G. How can the accuracy of SEEG be increased?-an analysis of the accuracy of multilobe-spanning SEEG electrodes based on a frameless stereotactic robot-assisted system. Ann Palliat Med. 2021 Apr;10(4):3699-3705. doi: 10.21037/apm-20-2123. Epub 2021 Mar 10. PMID: 33691455.
2. Stumpo V, Staartjes VE, Klukowska AM, Golahmadi AK, Gadjradj PS, Schröder ML, Veeravagu A, Stienen MN, Serra C, Regli L. Global adoption of robotic technology into neurosurgical practice and research. Neurosurg Rev. 2020 Nov 30. doi: 10.1007/s10143-020-01445-6. Epub ahead of print. PMID: 33252717.
3. Gupta M, Chan TM, Santiago-Dieppa DR, Yekula A, Sanchez CE, Elster JD, Crawford JR, Levy ML, Gonda DD. Robot-assisted stereotactic biopsy of pediatric brainstem and Prothèse totale de hanchelamic lesions. J Neurosurg Pediatr. 2020 Dec 25:1-8. doi: 10.3171/2020.7.PEDS20373. Epub ahead of print. PMID: 33361479.
4. Pillai A, RatnaProthèse totale de hanchenkom A, Ramachandran SN, Udayakumaran S, Subhash P, Krishnadas A. Expanding the Spectrum of Robotic Assistance in Cranial Neurosurgery. Oper Neurosurg (Hagerstown). 2019 Aug 1;17(2):164-173. doi: 10.1093/ons/opy229. PMID: 30203040.
5. Iordanou JC, Camara D, Ghatan S, Panov F. Approach Angle Affects Accuracy in Robotic Stereoelectroencephalography Lead Placement. World Neurosurg. 2019 Aug;128:e322-e328. doi: 10.1016/j.wneu.2019.04.143. Epub 2019 Apr 25. PMID: 31028981.
6. Staartjes VE, Molliqaj G, van Kampen PM, et al. The European Robotic Spinal Instrumentation (EUROSPIN) study: protocol for a multicentre prospective observational study of pedicle screw revision surgery after robot-guided, navigated and freehand thoracolumbar spinal fusion. BMJ Open 2019;9:e030389. doi:10.1136/bmjopen-2019-030389.
7. Granit Molliqaj, Luca Paun, Aria Nouri, Pierre-Pascal Girod, Karl Schaller, Enrico Tessitore. Role of Robotics in Improving Surgical Outcome in Spinal Pathologies. World Neurosurgery.Volume 140. 2020. Pages 664-673. ISSN 1878-8750. https://doi.org/10.1016/j.wneu.2020.05.132
8. Enrico Tessitore, Granit Molliqaj, Claudio Schonauer, and Bawarjan Schatlo. The Robotic Arm Guidance Systems: Principles and Indications. AG 2018 23. DOI 10.1007/978-3-319-60143-4_3.

INDEX OF SYSTEMS BY CONTROL TYPE

TS Telesurgery system

CM Co-manipulator

GA Guidance assistant


HS
OH
HN
NH2
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F

ROBOTIC PLATFORMS IN DEVELOPMENT

Accelus & Atec

REMI

Field of application	Spine
Conception-configuration	Remi Robotic Navigation System for Use with 2D Fluoroscopy-Based Imaging System. The Remi Robotic Navigation System is a robotic targeting and navigation platform that assists surgeons with robotic-assisted pedicle screw placement in the lumbar spine. The Remi 2D system utilizes a near-field optical tracking camera to track spinal instruments relative to an anatomical model based on a 3D imaging scan or 2D fluoroscopic images of the patient. REMI has a small, table-mounted navigation system, which helps in positioning instrumentation and implants more accurately during surgery.
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2021/2023 / Technology in the process of transfer
Publications / studies	No academic articles found

Agilis Robotics
https://www.agilisrobotics.com/
info@agilisrobotics.com
China

AGILIS ROBOTICS SYSTEM

Field of application	ENT | Visceral | Urology
Conception-configuration	Endoscopic surgery. The system consists of a control console with disposable robot arms and accessories, as well as flexible robotic arms. World's smallest flexible and dexterous endoscopic robot system. The robot is controlled by a clinician who uses a pen-like controller to manipulate the robot's movements, which, when combined with artificial intelligence (AI)-enhanced image guidance, can greatly reduce the learning curve for doctors when performing endoscopic submucosal dissection (ESD) procedures.
Conception-features	Unparalleled flexibility. 5 degrees of freedom per arm and a totally flexible body. Ultra-thin instruments are as small as 2.5 mm in diameter.
Therapeutic indications	Complex procedures of tissue resection with great precision and ease inside natural orifices.
Height / weight / age limits	No known indications
Regulatory aspects	FDA 2025 | NMPA 2025
Publications / studies	No academic articles found

Caranx Medical
www.caranx-medical.com
contact@caranx-medical.com
France

TAVIPILOT 1

Field of application	Cardiology
Conception-configuration	TAVIPILOT 1 is a robot to accurately control and place existing TAVI devices and valves.
Conception-features	Single robotic device with supervised autonomy. The robot places the valve under the supervision of the clinician who can decide whether to let the robot place the valve or to teleoperate it.
Conception-technical specificities	AI-based image processing for both pre-operative and intra-operative images
Instruments	Relies on existing TAVI instruments
Therapeutic indications	TAVI
Height / weight / age limits	No known indications
Regulatory aspects	Will be submitted for CE mark (cardiology) Will be submitted for FDA approval (cardiology)
Publications / studies	No academic articles found

OBELIA

Field of application	Visceral
Conception-configuration	Endoscopic robot
Conception-features	Single robotic device with supervised autonomy. The robot performs the stomach reduction under the supervision of the clinician. The clinician can decide whether to let the robot do the procedure or to teleoperate it.
Conception-technical specificities	AI-based image processing
Therapeutic indications	Stomach reduction
Height / weight / age limits	No known indications
Regulatory aspects	Will be submitted for CE mark (bariatric procedure) Will be submitted for FDA approval (bariatric procedure)
Publications / studies	No academic articles found

Cornerstone robotics
https://www.csrbtx.com/
contact@csrbtx.com
China

SENTIRE

Field of application	Visceral / Urology / Gynecology
TS	Multi-port telesurgery system
Conception-configuration	Patient platform with 4 robotic arms, an image processing and energy platform.
Height / weight / age limits	No known indications
Publications / studies	No academic articles found

DLR
https://www.dlr.de/rm/en/desktopdefault.aspx/tabid-11674/#gallery/28728
Germany

MIROSURGE

Field of application	Visceral
TS	Multi-port telesurgery system
Conception-configuration	The system includes a surgeon's console and 3 bed-mounted arms: 2 arms for laparoscopic instruments and an arm for a 3D stereo-endoscope.
Conception-features	2 arms with 7 degrees of freedom
Conception-technical specificities	Haptic feedback, 3D/HD monitor
Instruments	10mm MICA instruments each with 3 degrees of freedom
Therapeutic indications	Laparoscopic abdominal procedures
Height / weight / age limits	No known indications
Regulatory aspects	Prototyping 2018

Publications / studies

1. Peters BS, Armijo PR, Krause C, Choudhury SA, Oleynikov D. Review of emerging surgical robotic technology. Surg Endosc. 2018 Apr;32(4):1636-1655. doi: 10.1007/s00464-018-6079-2. Epub 2018 Feb 13. PMID: 29442240.
2. Hagn U, Konietschke R, Tobergte A, Nickl M, Jörg S, Kübler B, Passig G, Gröger M, Fröhlich F, Seibold U, Le-Tien L, Albu-Schäffer A, Nothhelfer A, Hacker F, Grebenstein M, Hirzinger G. DLR MiroSurge: a versatile system for research in endoscopic telesurgery. Int J Comput Assist Radiol Surg. 2010 Mar;5(2):183-93. doi: 10.1007/s11548-009-0372-4. Epub 2009 Jun 13. PMID: 20033517.
3. Hagmann K, Hellings-Kuß A, Klodmann J, Richter R, Stulp F, Leidner D. A Digital Twin Approach for Contextual Assistance for Surgeons During Surgical Robotics Training. Front Robot AI. 2021 Sep 21;8:735566. doi: 10.3389/frobt.2021.735566. eCollection 2021. PMID: 34621791.
4. Tobergte et al., "The sigma.7 haptic interface for MiroSurge: A new bi-manual surgical console" in Proc. of the IEEE International Conference on Intelligent Robots and Systems (IROS), San Francisco, USA, pp. 3023-3030, September 2011.
5. Tobergte et al., "MiroSurge - Advanced User Interaction Modalities in Minimally Invasive Robotic Surgery", MIT Press Journals: PRESENCE - Teleoperators and Virtual Environments, vol. 19, no. 5, pp. 400-414, October 2010.
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7. [No authors listed] [Minimal invasive surgery--MicroSurge--an innovative robotics system]. Zentralbl Chir. 2009 Sep;134(5):397-400. doi: 10.1055/s-0029-1241106. Epub 2009 Sep 30. PMID: 19795345.
8. Berkelman P. Haptics in Surgical Robotics ieeesmc2023.org.

Number of studies	10+

Edge Medical
http://www.edgemed.ch/
China

SP1000

Field of application	Gynecology
TS	Single-port telesurgery system
Conception-configuration	Single-port endoscopic surgical robot still under development. The three parts of the EDGE SP1000 system: the doctor's console, video cart and the patient's console.
Therapeutic indications	Gynecological surgeries Ovarian cyst removal
Height / weight / age limits	No known indications

Publications / studies

1. Liu C, Lai C, Yao X, Li K, Wang J, Huang J, Xu K. Robot-Assisted Nephrectomy Using the Newly Developed EDGE SP1000 Single-Port Robotic Surgical System: A Feasibility Study in Porcine Model. J Endourol. 2020 Nov;34(11):1149-1154. doi: 10.1089/end.2020.0208. PMID: 32911971.
2. Kang L, Liu HS, Zeng ZW, Luo SL, Zhang XW, Huang L, Wang JC, Lan P. First preclinical experience with the newly developed EDGE SP1000 single-port robotic surgical system-assisted transanal total mesorectal excision. Gastroenterol Rep (Oxf). 2021 Oct 28;9(6):603-605. doi: 10.1093/gastro/goab039. eCollection 2021 Dec. PMID: 34925860.
3. Liu Y, Yi Y, Deng P, Zhang W. Preclinical evaluation of the new EDGE SP 1000 single-port robotic surgical system in gynecology minimal access surgery. Surg Endosc. 2022 Jul;36(7):4780-4785. doi: 10.1007/s00464-021-08819-x. Epub 2021 Oct 25. PMID: 34697678.

Number of studies	3+

Harbin Sagebot Intelligent Medical Equipment Co.,Ltd/
Kangduo
http://en.hrbszr.com/index.php?m=content&c=index&a=lists&catid=24
China

FLEXIBLE SURGICAL ROBOT VIA URETHRA

Field of application	Urology
Conception-configuration	Flexible surgical robot via urethra

SPINAL ENDOSCOPIC SURGICAL ROBOT

Field of application	Spine
Conception-configuration	Spinal endoscopic surgical robot

SURGICAL ROBOT VIA ORAL CAVITY

Field of application	ENT
Conception-configuration	Surgical robot via oral cavity

COCHLEAR IMPLANT SYSTEM SURGICAL ROBOT

Field of application	ENT
Conception-configuration	Cochlear implant system surgical robot

Height / weight / age limits	No known indications
Regulatory aspects	In development
Publications / studies	No academic articles found

Johnson & Johnson / Verb Surgical
USA

OTTAVA

Field of application	Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	6 robotic arms, surgeon's console
Conception-features	7 degrees of freedom External motion compensation Advanced visualization
Conception-technical specificities	Virtual, auditory and tactile feedback Machine learning capabilities
Therapeutic indications	Not yet validated
Specify size/weight limit	No known indications
Regulatory aspects	Development phase In 2026
Publications / studies	No academic articles found

LEM Surgical
https://lemsurgical.com/
info@lemsurgical.com
Switzerland

'SAPIEN' SYSTEM

Field of application	Spine
Height / weight / age limits	No known indications
Regulatory aspects	FDA soon
Publications / studies	No academic articles found

MicroPort

https://microport.com/healthcare-professional/surgical-robots

China

SPINE SURGICAL ROBOT

Field of application	Spine
Height / weight / age limits	No known indications
Regulatory aspects	NMPA 2025
Publications / studies	No academic articles found

TRANS-BRONCHIAL SURGICAL ROBOT

Field of application	Thoracic-endocrine
Therapeutic indications	Natural orifice surgery Trans-bronchial diagnosis and treatment
Height / weight / age limits	No known indications
Regulatory aspects	NMPA 2025
Publications / studies	No academic articles found

TAVR SURGICAL ROBOT

Therapeutic indications	Panvascular surgery. Heart valve replacement surgery.
Height / weight / age limits	No known indications
Regulatory aspects	NMPA 2025
Publications / studies	No academic articles found

Monogram robot
https://www.monogramorthopedics.com/
info@monogramorthopedics.com
USA

MONOGRAM ORTHOPEDICS

Field of application	Orthopedics
Conception-configuration	A navigated CT-based (personalized surgical plan) robotic system. Customized implant that is 3D printed to match the patient's anatomy. High-efficiency rotary cutting system and tracking cameras to mitigate any line-of-sight issues. The robot executes all of its cuts autonomously (with surgeon oversight).
Therapeutic indications	Initially focus on hip and knee replacements.
Height / weight / age limits	No known indications
Regulatory aspects	FDA in progress
Publications / studies	No academic articles found

Perfint Healthcare Pvt Ltd
www.perfinthealthcare.com
info@perfinthealthcare.com
India

ROBIO EX

Field of application	Thoracic-endocrine | Visceral | Urology | Gynecology
GA	Guidance assistant: semi-automatic
Conception-configuration	ROBIO EX is designed to work with any CT /PET-CT that conforms to DICOM 3.0 standards (covered in 3.6.9). ROBIO EX is an electromechanical instrument for assisting the medical practitioner in performing various needle based procedures. With the guidance of the application software, the device is capable of positioning its robotic arm at the entry point so that the medical practitioner is guided to insert the needle through the end effectors.
Conception-features	Robotic arm has 3DOF.
Conception-technical specificities	Software supports the following features: - 3D, MRP visualization - Liver segmentation - Image registration - Tumor and No-Go segmentation - Multi (Max of 6) needle planning with Sequential and Simultaneous - Collision detection between, Needle-Needle, Needle-Robot, Robot-CT couch - Check scan needle verification - Post ablation verification and residual tumor information - Ability to place the device on both side of the CT/PET-CT - Procedure based report
Instruments	MAXIO system supports up to 6 needle planning. It's a medical equipment can be reused.
Therapeutic indications	Percutaneous interventions like tumor ablation, biopsy, pain management, Brachy needle placement, drainage etc using rigid straight needles in thorax abdomen and pelvis.
Height / weight / age limits	No known indications
Regulatory aspects	CE 2024 | China 2026
Publications / studies	No academic articles found
Number of studies	28

Ronovo Surgical
https://www.ronovosurgical.com/
info@ronovosurgical.com
China

CARINA

Field of application	Gynecology Urology
Conception-configuration	Carina, a modular system enables configurable robotic assistance
Conception-features	Choose between 3-module or 4-module configurations
Conception-technical specificities	3D HD stereoscopic view
Instruments	Full suite of instruments

Therapeutic indications

Laparoscopic surgeries:
- Hysterectomy with bilateral salpingo-oophorectomy and iliac lymph node dissection.
- Numerous surgical maneuvers were precisely executed, including target exposure, dissection and coagulation of the uterine artery, transection of distal side of the cervix, and suturing of vaginal stump.
- Simulated pelvic lymphadenectomy to test ability to delicately dissect, coagulate and resect around vessels for complete exposure of internal and external iliac arteries.
- Unilateral partial nephrectomy, where it successfully exposed and mobilized the renal artery, followed by renal tissue resection and suturing, and ended with simulated vesicourethral anastomosis.
- Partial nephrectomy, ureteroplasty, renal venotomy and suturing, as well as unilateral nephrectomy.

Specify size/weight limit	No known indications
Regulatory aspects	NMPA in 2024
Publications / studies	No academic articles found

Sold to GBI no news since
USA

AUTOLAP

Field of application	Visceral Urology Gynecology
CM	Co-manipulator: motorized endoscope holder
Conception-configuration	Robotic arm attached to the operating table. Guided by joystick. Image guided laparoscope positioning system. Tissue collision warning system prevents lens tainting and reduces the number of endoscope withdrawals.
Conception-technical specificities	Advanced Energy: Ultrasonic (rigid)
Therapeutic indications	General laparoscopic procedures. Bariatric laparoscopic surgery. Hernia repair.
Height / weight / age limits	No known indications
Regulatory aspects	CE / FDA 2013 Technology in the process of transfer

Publications / studies

1. Wijsman PJM, Broeders IAMJ, Brenkman HJ, Szold A, Forgione A, Schreuder HWR, Consten ECJ, Draaisma WA, Verheijen PM, Ruurda JP, Kaufman Y. First experience with THE AUTOLAP™ SYSTEM: an image-based robotic camera steering device. Surg Endosc. 2018 May;32(5):2560-2566. doi: 10.1007/s00464-017-5957-3. Epub 2017 Nov 3. PMID: 29101564.
2. Wijsman PJM, Molenaar L, Van't Hullenaar CDP, van Vugt BST, Bleeker WA, Draaisma WA, Broeders IAMJ. Ergonomics in handheld and robot-assisted camera control: a randomized controlled trial. Surg Endosc. 2019 Dec;33(12):3919-3925. doi: 10.1007/s00464-019-06678-1. Epub 2019 Feb 11. PMID: 30746574; PMCID: PMC6831540.
3. Rade M, Birkett D, Sherman J, Nepomnayshy D. Evaluation of a stand-alone robotic camera holding system: technology Prothèse totale de hanchet improves laparoscopy. Minim Invasive Ther Allied Technol. 2020 Aug 27:1-6. doi: 10.1080/13645706.2020.1806078. Epub ahead of print. PMID: 32852261.
4. Wijsman PJM, Voskens FJ, Molenaar L, van 't Hullenaar CDP, Consten ECJ, Draaisma WA, Broeders IAMJ. Efficiency in image-guided robotic and conventional camera steering: a prospective randomized controlled trial. Surg Endosc. 2021 May 11. doi: 10.1007/s00464-021-08508-9. Epub ahead of print. PMID: 33977377.

Number of studies	4+

Beijing Rossum Robot Technology Co., Ltd
http://xn--9krz51cpxgnmn.com/
info@rossumrobot.cn
China

ROSENBOT

Field of application	Orthopedics
GA	Guidance assistant: semi-automatic
Conception-configuration	The Rosenbert®intelligent orthopedic surgery robot is used for the treatment of pelvic fractures. Planning algorithm and 3D real-time navigation.
Height / weight / age limits	No known indications
Regulatory aspects	NMPA 2023 (not yet)

Publications / studies

1. R: Zhao C, Cao Q, Sun X, Wu X, Zhu G, Wang Y. Intelligent robot-assisted minimally invasive reduction system for reduction of unstable pelvic fractures. Injury. 2023 Feb;54(2):604-614. doi: 10.1016/j.injury.2022.11.001. Epub 2022 Nov 4. PMID: 36371315.
2. Saber AY, Marappa-Ganeshan R, Mabrouk A. Robotic-Assisted Total Knee Arthroplasty. 2023 Aug 14. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan–. PMID: 33232066.

Number of studies

SHURUI

Beijing Surgerii Technology Co. Ltd
http://en.surgerii.com.cn/
China

SURGERII SYSTEM

Field of application	Thoracic-endocrine Visceral Urology Gynecology
TS	Multi-port telesurgery system
Conception-configuration	Surgerii's resulting platform consists of a surgeon console, an equipment cart, and four modular patient-side carts, each driving a surgical manipulator or a stereo high-dimension endoscope. SPACE Tech: Single-Port Access Continuum Endoscopic Technology flexible continuum robotic arm.
Conception-features	Each surgical manipulator has six degrees of freedom. Patient-side carts remain totally stationary during surgery. 2.5 cm incision. Dual Continuum Mechanism, these backbones can apply both pull and push forces, making the surgical tools adequately strong for surgical operations.
Conception-technical specificities	3D high-definition magnified view. 4K HD fluorescent navigation endoscope. 4.3D laparoscopic system, fluorescence-assisted system, VR&AR navigation system, electrotome and other energy platform, intraoperative devices such as US, etc.
Instruments	Three snake-like surgical instruments. In the future, development of new instruments to make incisions down to 1.5 cm.
Therapeutic indications	In the future, development of NOTES
Height / weight / age limits	No known indications
Regulatory aspects	CE in progress FDA in progress NMPA in progress
Publications / studies	No academic articles found

TITAN MEDICAL

Titan Medical
https://titanmedicalinc.com/technology/
info@titanmedicalinc.com
Canada

ENOS (SPORT)

Field of application	ENT Visceral Urology Gynecology
TS	Single-port telesurgery system
Conception-configuration	The SPORT system has an open workstation and a single-arm mobile platform.
Conception-features	7 degrees of freedom. 22mm conduit that can be introduced through a 25mm incision.
Conception-technical specificities	3D monitor with passive glasses
Instruments	Reusables. 8mm single-use instruments.

Therapeutic indications

The system is in the preclinical phase where various minimally invasive procedures on animal and cadaver models have been performed (cholecystectomies, Nissen fundoplications, splenectomies and hepatic pedicle dissections).
The system provides other areas of application such as transoral or transanal procedures.

Specify size/weight limit	No known indications
Regulatory aspects	On hold FDA IDE submission summer 2023 CE submission after FDA submission Commercialization in 2 years

Publications / studies

1. Seeliger B, Diana M, Ruurda JP, Konstantinidis KM, Marescaux J, Swanström LL. Enabling single-site laparoscopy: the SPORT platform. Surg Endosc. 2019 Nov;33(11):3696-3703. doi: 10.1007/s00464-018-06658-x. Epub 2019 Jan 8. PMID: 30623255; PMCID: PMC6795913.

True Digital Surgery
https://www.truedigitalsurgery.com/occipta/
info@truedigitalsurgery.com
The Netherlands

OCCIPTA

Field of application	Plastic and reconstructive
GA	Guidance assistant: visualization assistant
Conception-configuration	Robotic arm. Fully head-up design. Foot pedal control.
Conception-features	6-axis robotic arm. Lock-on-target technology. Autofocus after movement. Waypoint position memory technology.
Conception-technical specificities	Affirm 800: 3D ICG Fluorescence Magnification up to 145x1 when looking at the 55'' 4K 3D screen 10:1 optical zoom
Therapeutic indications	Reconstructive microsurgery
Height / weight / age limits	No known indications
Publications / studies	No academic articles found

Vicarious Surgical
https://www.vicarioussurgical.com/
info@vicarioussurgical.com
USA

BETA 2 SYSTEM

Field of application	Visceral | Gynecology
Conception-configuration	Human-like surgical robots to transport surgeons inside the patient to perform minimally invasive surgery. "Specifically, [Vicarious] has reduced the system's arms, which will allow for greater dexterity, refined system motor and joint controls, and updated video processing technology and software." Surgeons wear a VR headset.
Conception-features	The starting point: a 1.5 cm (0.6 in.) incision through which the robot enters the patient's body.
Conception-technical specificities	Camera with 360-degree views. Each arms with 28 sensor.
Therapeutic indications	Ventral hernias. Hysterectomy, inguinal hernia, cholecystectomy, and GI procedures such as bowel resection.
Specify size/weight limit	No known indications
Regulatory aspects	FDA submission in 2024
Publications / studies	No academic articles found

Virtuoso Surgical
https://virtuososurgical.net/
USA

VIRTUOSO SYSTEM

Field of application	Neurosurgery Orthopedics Thoracic-endocrine ENT Gynecology Urology
Conception-configuration	Robotic endoscopic surgery. Virtuoso's endoscopic surgical system delivers two robotically controlled, needle-sized manipulators that work from the tip of a rigid endoscope less than half the diameter of a U.S. dime. The Virtuoso Surgical system includes two robotically controlled, needle-sized manipulators working from the tip of a rigid endoscope that is less than half the diameter of a U.S. dime. The scope itself is far smaller than current robotic endoscope hardware, and the manipulators are 1mm in diameter. Equipped with a camera, the endoscope comes with an array of manipulators depending on the procedure, and electrosurgical tools. The new Virtuoso Surgical system comprises two needle-sized small manipulators controlled by robots. These manipulators, with a diameter of 1mm, operate from the end of a rigid endoscope. The endoscope is less than half the size of a 5-pence coin. The endoscope, which features a camera, is available with various manipulators depending on the procedure.
Instruments	Spatula, grasper, snare, laser aiming manipulator.
Therapeutic indications	Surgeries such as bladder cancer, uterine fibroids, enlarged prostate, removal of central airway obstruction and endoscopic neurosurgery.
Height / weight / age limits	No known indications
Regulatory aspects	FDA submission in 2024
Publications / studies	No academic articles found

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SWISS FOUNDATION FOR INNOVATION
AND TRAINING IN SURGERY