MARKET OPPORTUNITIES IN SURGICAL TECHNOLOGY

TRENDS, INSIGHTS & OPPORTUNITIES

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HEALTH ENTERPRISE EAST LTD.

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Medtech Navigator

The Medtech Navigator, part-funded by the European Regional Development Fund (ERDF), is a three-year programme, delivered by Health Enterprise East Ltd., to facilitate knowledge exchange between the medtech industry, many of whom are small and medium sized enterprises (SMEs), the NHS, and academia. The programme seeks to enable companies to identify potential market opportunities in a variety of specific disease areas and apply for Innovation Grant funding through the programme, thereby engaging SMEs in new R&D projects that are both customer-focussed and collaborative in nature. This will allow the creation of partnerships between clinicians, academics and industry to develop novel medical technologies which will improve healthcare and quality of life for patients and the healthcare market of the future.

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Report Summary

This report discusses the potential of innovative technologies to transform patient outcomes, reduce complications, ease recovery and reduce costs across the surgical pathway. Globally**,** we are witnessing an ever-increasing disease burden associated with increasingly comorbid and ageing populations. Further, the impact of COVID-19 pandemic has underscored the importance of establishing a critical care system within the NHS that is more budget-efficient, personalised, and less invasive. Developments in technologies such as AI, genomics, VR/AR, imaging, and robotics can help address some of these challenges. Innovative UK SMEs are contributing to major breakthroughs that will lead to improvements in the surgical pathway over the next few years. The report will look at market opportunities in surgery, highlight the innovative SMEs operating in this area, and review the patent landscape.

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1. Background

Innovative technologies harbouring the potential to bolster the surgical landscape and the provision of care have been inquired into for more than half a century. This is best demonstrated in DeBakey's 1963 journal article "The Future of Surgery", laying bare his thesis as to why increased integration of research and clinical activities are essential for facilitating innovative breakthroughs in clinical care[1]. Since then, procedures once deemed unfathomable are now commonplace in surgical practice, leading to reductions in patient complications, length of stay, outcomes, and mortality rates.

Nevertheless, translation of these innovations into real-world surgical practice remains scarce - studies demonstrate that a meagre 9.8% of surgical innovations result in a first-in-human study within 10 years; however, in line with DeBakey's early indications, this probability drops off significantly (6x less likely) if the innovation was not developed in conjunction with a clinical collaborator early in the process (Figure 1)[2].

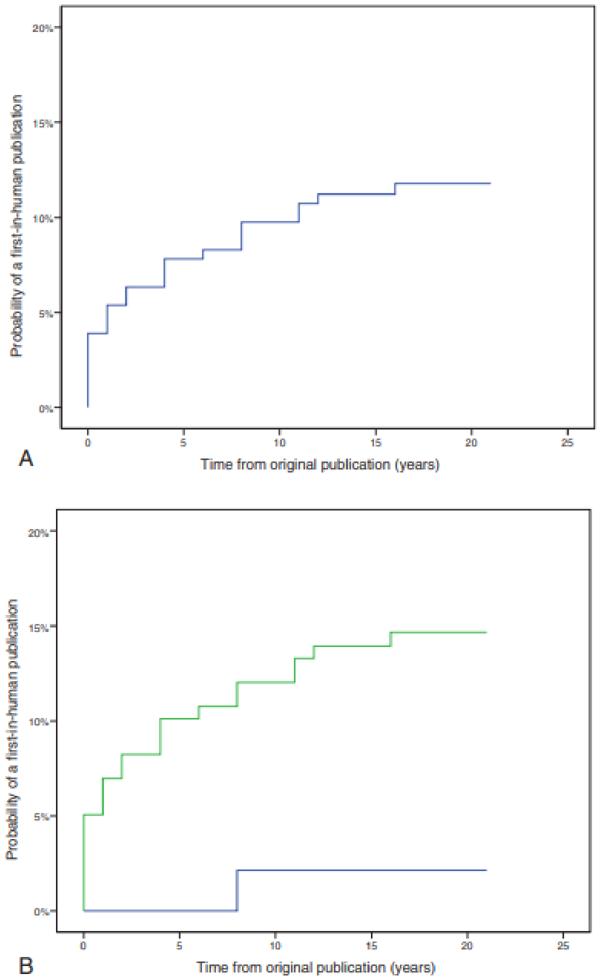


Figure 1 – Graphs demonstrating (A) overall first-in-human publication probability, and (B) first-in-human publication probability separated by clinical involvement (green) or not (blue).

Despite this, innovative opportunities are as abundant as ever and a unique set of challenges exist for MedTech innovators to tackle. On the global front, we are witnessing an ever-increasing uptick in the disease burden associated with increasingly comorbid and ageing populations, particularly in low-income and middle-income countries[3].

With regards to the UK, projections by the Office for National Statistics (ONS) estimate ~25% of the UK population will be 65 years of age and above by 2050, up from 20% in 2019[4]. Further, the impact of COVID-19 pandemic has underscored the importance of establishing a critical care system within the NHS that is more budget-efficient, personalised, and less invasive, be it through developments in technologies such as AI, genomics, VR/AR, imaging, and/or robotics[5,6]. Breakthroughs in these areas are expected to flourish within the next 20 years, as surmised by a 2018 report "Future of Surgery" by The Royal College of Surgeons of England, highlighting the importance of these innovations, particularly within pre and peri-operative care[7].

A focus on improvements to earlier stages in the surgical pathway are recommended due to the following:

- >5 million hospital admissions per year are now attributed to surgical procedures – a 35% increase since 2003/4[8,9].
- Surgical admissions now make up close to 40% of all total hospital admissions, up from ~32% in 2003/4[9,10].
- Latest Supporting Facilities Data from NHS England reports that there are 3,253 operating theatres in England, 608 (18.6%) of which are dedicated day case theatres[11]. Recent estimates from 2017 placed the annual cost of surgery in the UK at £11 billion, making up a sizeable proportion (7.5%) of the total 2017/18 NHS budget (£147.3 billion)(Figure 2)[12,13].
- In June 2020, over 50,000 patients waited more than 52 weeks for surgical treatment – a 30x increase since February 2020. The latest figures from October 2021 indicate this to now be 312,665 patients[14]. In addition, close to 2 million patients on the waiting list for NHS treatment waited more than legal waiting time of 18 weeks for their treatment[15], a number which has now risen to 3.9 million as of October 2021[14]. The 92% target for all patients to be seen within 18 weeks has not been met since February 2016 (Figure 3).

GOVERNMENT EXPENDITURE ON HEALTH SERVICES (UK): 2000/01 - 2018/19	
Year	Net Expenditure (£billion)
2000/01	54.2
2001/02	59.8
2002/03	66.2
2003/04	74.9
2004/05	82.9
2005/06	89.8
2006/07	94.7
2007/08	101.1
2008/09	108.7
2009/10	116.9
2010/11	119.9
2011/12	121.3
2012/13	124.3
2013/14	129.4
2014/15	134.1
2015/16	138.5
2016/17	142.6
2017/18	147.3
2018/19	152.9

Figure 2 - Adapted from House of Commons Library, Briefing Paper - NHS Funding and Expenditure (2019)

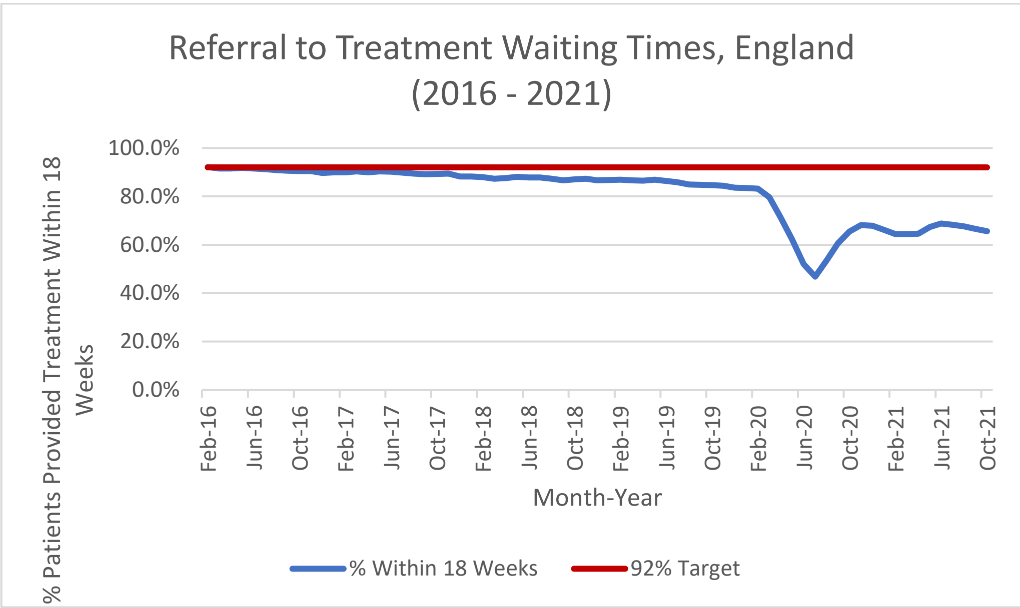


Figure 3 – Trend of patients waiting to start treatment since 2016 against the NHS constitution's 92% standard for elective treatment.

Unmet Needs

As evidenced by the NHS Long Term Plan, surgical services are to be focussed on providing the highest quality of service as close to a patients' residence as possible[16]. What's more, consolidating and strengthening networks to hospitals, NHS staff and patients and their families are seen as routes to ensure that patients can access both specialised and non-specialised services in planned, emergency, and urgent cases.

Additionally, the NHS has its sights set on minimising time-to-adoption and variation of innovations, techniques, and technologies. For example, 5-Aminolevulinic Acid (5-ALA - shown to promote higher rates of accurate malignant brain tumour resection – is now available across all treatment centres in the UK, as indicated by the 2019/20 annual report for The Brain Tumour Charity[17]. A number of new programmes, including the NHS Innovation Accelerator, have been set up in recent years to support innovators seeking to have their innovations adopted at scale across the NHS.

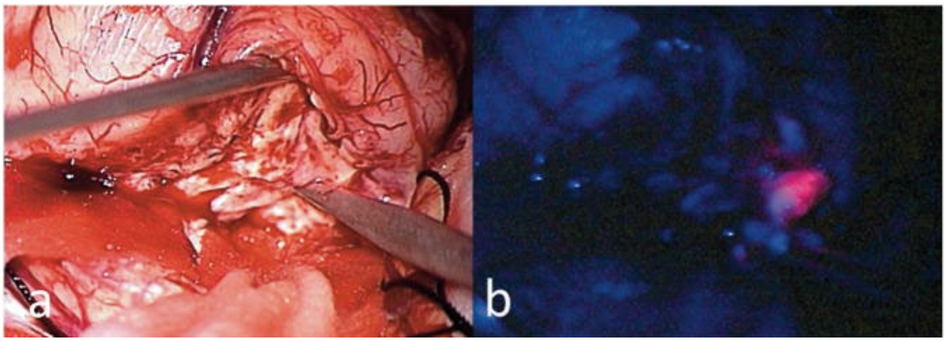


Figure 4 – (a) Glioma tissue during resection procedure demonstrates strong homogeneity under traditional white-light microscopy. (b) By comparison, a visibly clear intratumoural area is illuminated with 5-ALA induced PpIX fluorescence under violet-blue excitation light[18].

Finally, the NHS has highlighted the importance, particularly during the COVID pandemic, of curtailing wait times that patients experience when in need of an operation. This is demonstrated by the rising number of patients experiencing waits longer than 18 weeks as increases in treatment capacity have not mirrored those of patient need[16]. Overcoming this problem in the NHS will involve:

- Raising the number of planned surgeries per year.
- Reducing long wait times.
- Minimising the number of patients on the waiting list.

CASE STUDY:

Gloucestershire Hospital

Gloucestershire Hospitals NHS Foundation Trust faced significant challenges, with poor A&E performance and high numbers of cancellations and delays to planned operations. The Getting it Right First Time (GIRFT) programme supported the trust to split its 'hot' emergency work and 'cold' planned trauma and orthopaedics work onto two separate sites. Senior clinical decision makers were introduced at the A&E 'front door' to help ensure patients were managed more effectively. During the first six months the trust was able to achieve its 4-hour A&E target for the first time since 2010 and had halved the number of cancelled operations. There was a reduction in waiting times for surgeries, including for hip or knee replacements, and an 8% increase in the amount of elective surgery performed.

Figure 5 – Case study showcasing how surgical services at Gloucestershire Hospital were made more efficient through separation of urgent and planned services[16].

2. Market size

2.1 Analysing the market size and unmet needs of innovative surgical technologies

According to a modelling study published in 2008, approximately 235 million major surgical procedures are undertaken worldwide every year[19a]. An increase in the number of surgeries is attributed to the growing senior population and the increasing prevalence of chronic diseases. Moreover, surgical interventions are an effective treatment option in orthopaedic, cardiovascular, and ophthalmic disorders. As a result, the demand for various surgical procedures and interventional procedures is expected to increase with the rising geriatric population. In 2019, the global minimally invasive surgery (MIS) market reached a value of around 20.5 billion U.S. dollars and by 2030 is expected to increase to over 44 billion U.S. dollars, according to market research company NMSC[19b]. Figure 6 depicts the size of the minimally invasive surgery market worldwide in 2019 and 2030.

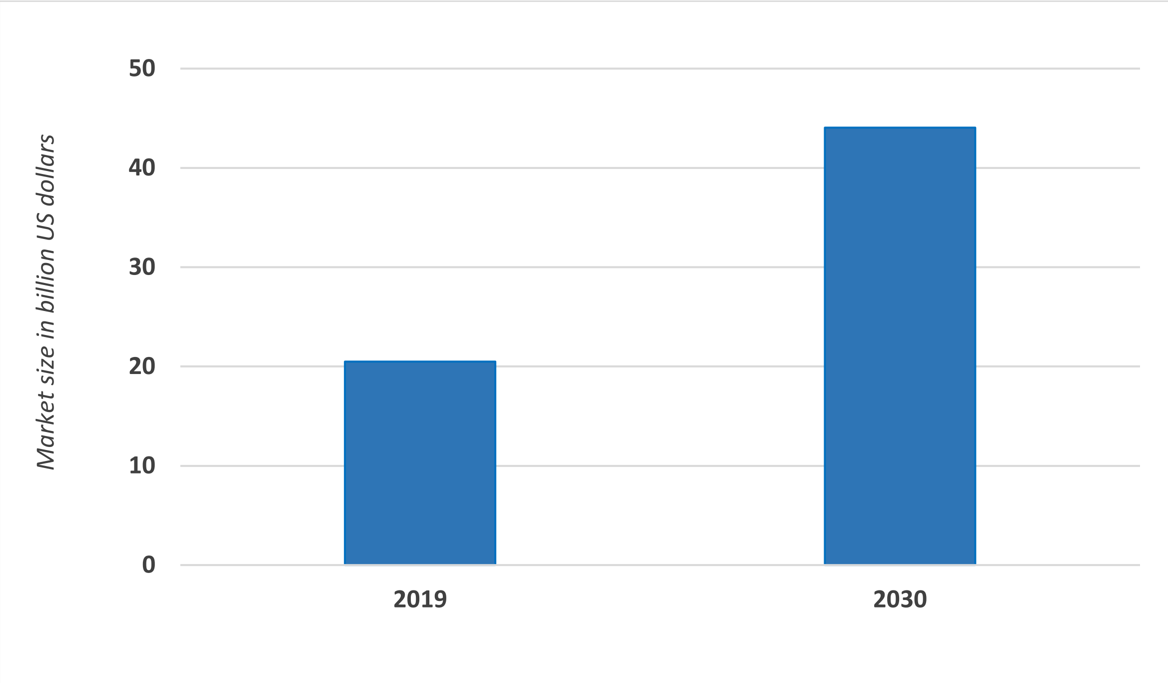


Figure 6. Size of the minimally invasive surgery market in 2019 and 2030 (in billion US dollars)

North America accounted for the largest share of the MIS instruments market in 2020. Although the increased pressure form COVID-19 pandemic led to the cancellation of many elective surgeries worldwide (COVIDSurg Collaborative, 2020), the procedural volume for surgery is expected to increase post-pandemic 2021 due to the backlog emerging from this delay, which could further drive the demand for minimally invasive surgical instruments market[20].

According to the research report published by Markets And Markets, in 2020 cardiothoracic surgery segment accounted for the largest share in the market, by type of surgery and handheld instruments segment accounted for the largest share of the minimally invasive surgical instruments market, by product[21]. Factors such as the increasing number of coronary and percutaneous cardiology interventions, growing adoption of MIS instruments in these surgical procedures, and the rising prevalence of cardiac diseases are driving the growth of this segment. The minimally invasive surgical instruments market is segmented into handheld instruments, inflation devices, surgical scopes, cutting instruments, guiding devices, electrosurgical & electrocautery instruments, and other instruments based on product. The low cost of articulating laparoscopic handheld surgical instruments, increasing number of surgical procedures, and rising technological innovations in handheld instruments enabled the handheld instruments to be accounted for the largest share of the minimally invasive surgical instruments market. A study conducted to compare the surgical outcomes between integrated robotic and conventional laparoscopic surgery for distal gastrectomy found higher success rate with robotic surgery with higher number of retrieved lymph nodes, less blood loss, and lower readmission rate in patients with early gastric cancer[22] .

The major market players in the surgical robot market are Intuitive Surgical (US), Stryker Corporation (US), Medtronic (Ireland), Smith & Nephew (UK), Zimmer Biomet (US), Asensus Surgical (Transenterix) (US), Corindus Vascular Robotics (US), Renishaw (UK), Auris Health (US), Medrobotics Corporation (US), Think Surgical (US), Verb Surgical (US), OMNIlife Science (US), CMR Surgical (UK), Preceyes BV (Netherlands), China National Scientific Instruments And Materials Corporation (CSIMC) (China), Microsure (Netherlands), Titan Medical (Canada), avateramedical Gmbh (Germany) and Medicaroid Corporation (Japan).

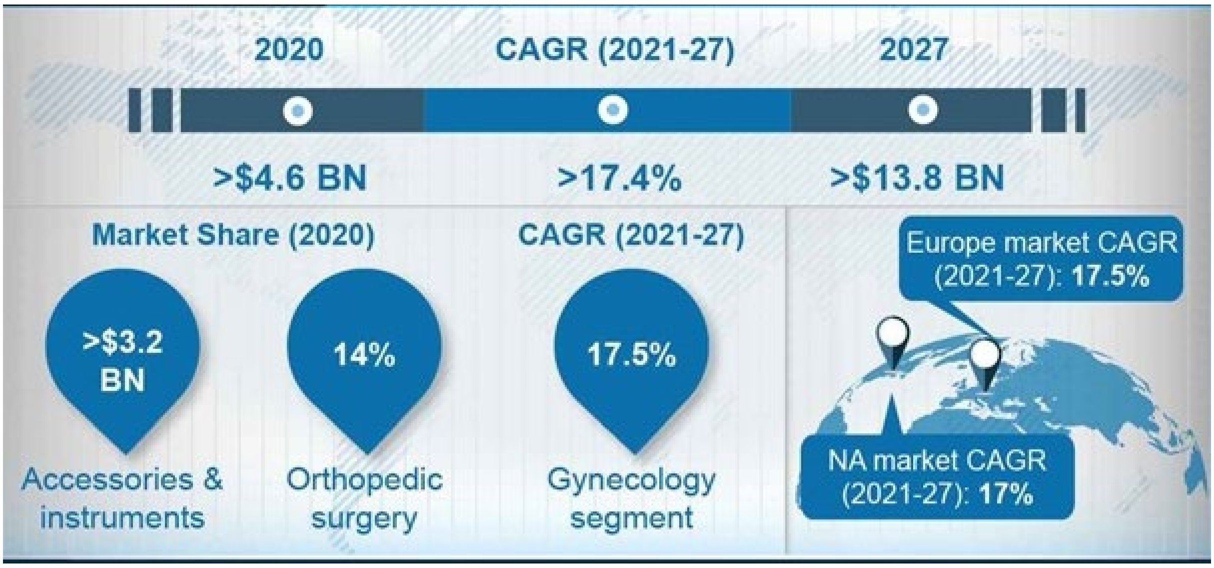


Figure 7. Surgical robot market (picture adopted from Global Market Insights)

A report published by the NIHR Surgical MedTech shows that only 9.8% of surgical innovations are translated into clinical trials globally, with the biggest hurdle to successful translation being the absence of early clinical involvement[23]. Nevertheless, the regulatory environment is extremely uncertain for medical device manufacturers. The time taken to approve the application and obtain a premarket approval has increased significantly. The US FDA requirements for more clinical data to prove the safety and efficacy of a product further leads to increased investments by companies in clinical trials, delays in the approval process, and additional capital requirements for in-depth post-marketing surveillance studies. Apart from the regulatory reforms, huge-capital investments, cost of R&D and manufacturing and high degree of competition among the market players also restrict small manufacturers from successfully entering the market.

The report "The future of surgery" considered likely future changes to the surgical workforce, to technology in diagnostics and in operating theatres, and to the patient experience[24]. In surgery, developments in robotics, big data, artificial intelligence, genomics, virtual and augmented reality, and imaging suggest a future where healthcare is even less invasive and more personalised[25-28]. Although the technology of robotic surgery is developing very fast and has attracted much attention recently, an unmet need identified here is the lack of high-quality training programmes for surgical care practitioners on the safe use of robots. The existing challenge also includes the amount of evidence regarding the use case and outcome of the surgery, excessive cost of surgical robots and low affordability in underdeveloped countries. The advantages of surgical robots such as superior visualization capabilities for surgeons, greater dexterity and manoeuvrability and provision to reach hard-to-access areas along with the rising demand for better, quicker healthcare services are expected to drive the growth of the overall surgical robots market in the coming years[29].

Developments in fields of genomics and artificial intelligence will improve our understanding of disease profiles, influence the type of surgery undertaken and enable a shift to preventative surgery by predicting the population at risk, screening and surveillance and early treatment. However, an issue that needs to be addressed is the safe, consented and transparent sharing of data[24]. The global genomics market size was valued at USD 20.1 billion in 2020 and is expected to expand at a compound annual growth rate (CAGR) of 15.35% from 2021 to 2028[30]. Functional genomics held the largest revenue share of 32.0% in 2020. The products segment dominated the market in 2020 with a revenue share of 69.3%. Real-time PCR was the dominant revenue generator within functional genomics 2028[30]. Launch of new PCR reagent kits and acquisition of smaller companies by the key players to advance their product pipeline drove revenue generation in this area. In June 2020, Illumina, Inc. acquired omics data analysis platform developer, Bluebee to accelerate processing, analysis and sharing of next generation sequencing data at scale[31].

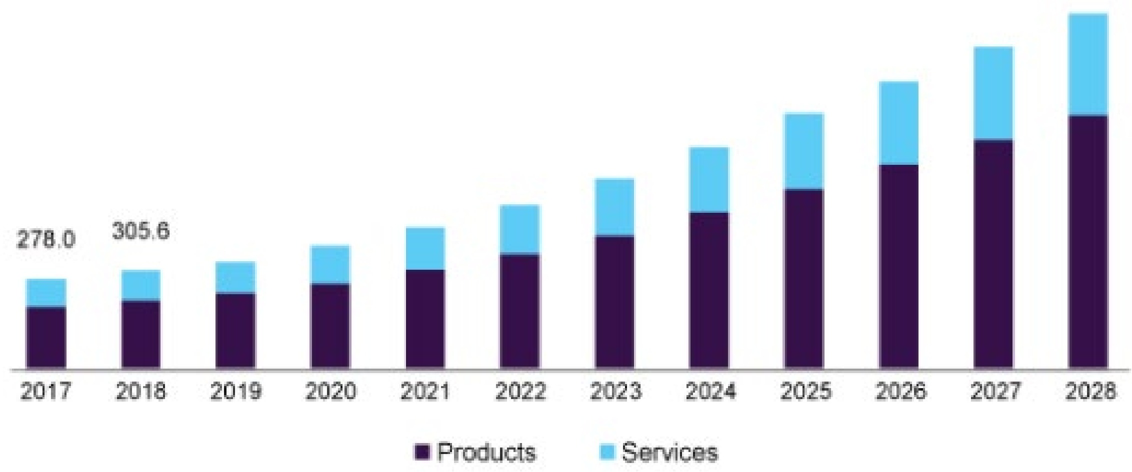


Figure 8. UK genomics market size, by deliverable, 2018-2028 (USD million) (picture adopted from GrandViewResearch report, 2021).

Pharmaceutical and biotechnology companies held the largest genomic market share of 60.3% in 2020[24]. Growing demand in genomic technologies, which owes to the possibility of low-cost sequencing has attracted many new players to the market. North America dominated the market with a share of 36.7% in 2020 owing to an increase in the number of research programs, a high number of strategic partnerships, and a rise in regulatory approvals by the U.S. FDA. Changing regulations for reimbursement and usage are anticipated to further propel the adoption of genetic tests in this region[30].

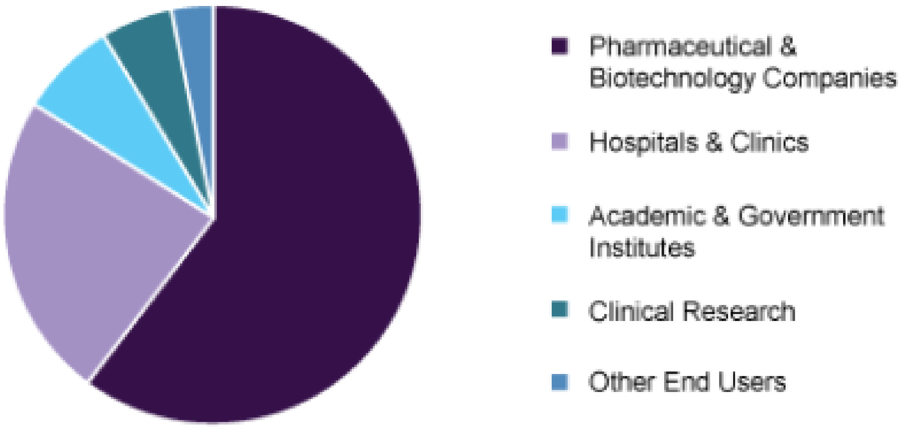


Figure 9. Global genomic market share, by end-use, 2020 (picture adopted from GrandViewResearch report, 2021).

Simulation tools, such as augmented reality (AR) and virtual reality (VR) platforms, are getting more interest as a training technique in the medical fields, unlocking significant benefits such as safety, repeatability and efficiency[32]. The use of these technologies can improve surgical training and outcomes, while standardising procedures and democratising access to training[24]. In surgical training VR/AR techniques find applications in surgical procedure diagnosis and planning, surgical education and training robotic and tele-surgery, sensor data and image visualization during the surgical operation[33]. VR and AR Dynamic imaging around a patient's organs by the use of virtual reality and augmented reality helps the surgical team both to plan an operation and to perform the procedure more accurately. In particular, the use of augmented reality, will also increasingly allow surgical teams to bring in remote expertise or remote mentoring by transmitting real-time information to a specialist surgeon and seek guidance in completing a complex surgical procedure[24].

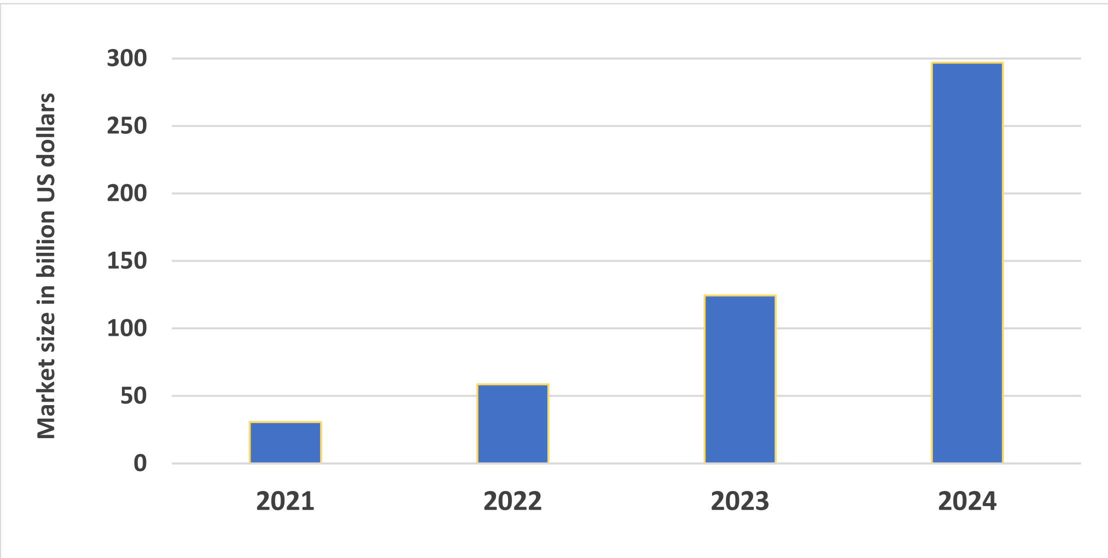


Figure 10. AR, VR and mixed reality market size worldwide from 2021 to 2024 (in billion US dollars) (picture adopted from Statista report, 2021).

The global augmented reality (AR), virtual reality (VR), and mixed reality (MR) market is forecast to reach 30.7 billion U.S. dollars in 2021, rising to close to 300 billion U.S. dollars by 2024[34]. The AR and

VR market size was valued at $14.84 billion in 2020, and is projected to reach $454.73 billion by 2030, registering a CAGR of 40.7%[35]. Growth of the mobile gaming industry, increase in internet connectivity and use of consumer electronic devices act as the key drivers of the global AR and VR market. Furthermore, remote training and consulting are considered as vital advantages of VR/AR based training methods during the COVID-19 pandemic[36]. Sony's PlayStation VR and Facebook's Oculus VR headsets are the major VR headset products being sold on the market now[34].

Advances in 3D printing technology have made tremendous contributions to fields throughout healthcare. 3D printing played a major role during the COVID-19 pandemic, with the development of different 3D printable objects from personal protective equipments, auxillary accessories, swabs for diagnosis, ventillators, splitters, valves to 3D printed lung model[37]. 3D printers are already used as training tools for surgeons at Alder Hey Innovation Hub[38] for example.

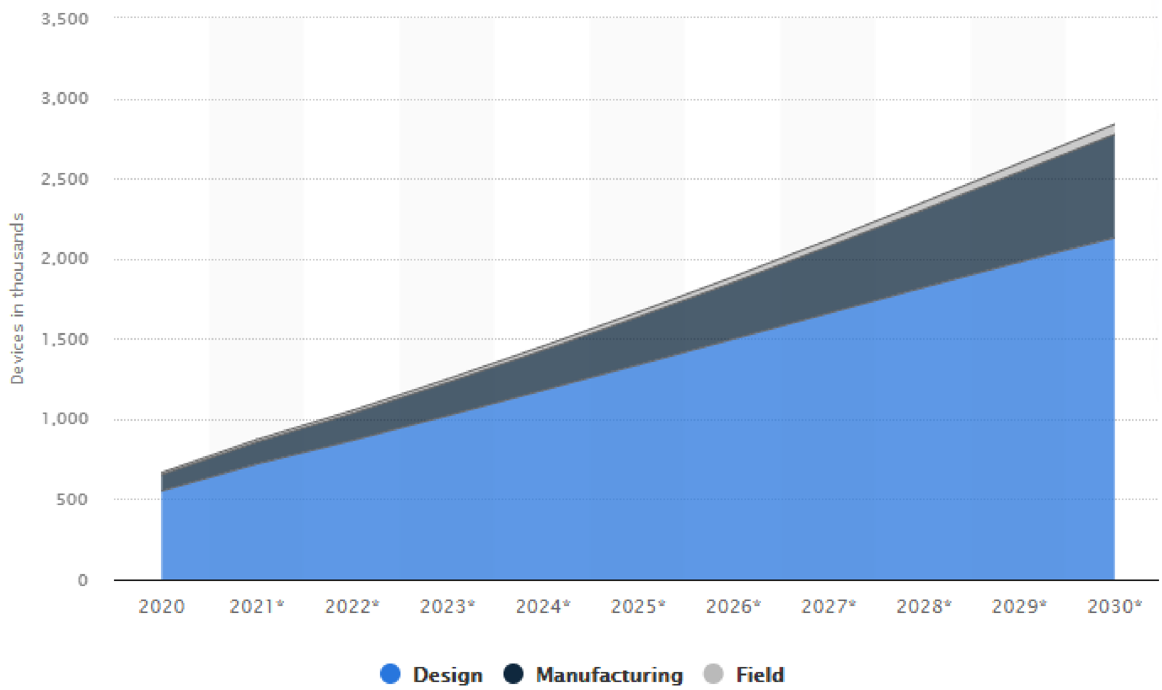


Figure 11. 3D printing & additive manufacturing devices worldwide 2020-2030, by context (picture adopted from Statista report, 2021).

The global 3D printing market has generated over USD 13 billion in 2020, expected to reach USD 35.38 billion with a CAGR of 14.6% for the forecast period of 2020 to2027[39]. Increased need and high adaptation of the advanced 3D technology drives growth however, the cost associated with the manufacturing needs to improve hardware, software, and material parts act as restraints. The number of 3D printing and additive manufacturing devices is forecast to grow to more than 2.7 million by 2030, an increase of more than two million compared to 2020. 3D printing and additive manufacturing devices for design purposes make up the largest share of the market in 2020 with 550 thousand devices, followed by the manufacturing and field contexts[40] (Statista report, 2021). Some of the key players operating in the market are Stratasys, Ltd., Materialise, EnvisionTec, Inc, 3D Systems, Inc., GE Additive and Autodesk Inc.

3. SMEs tackling unmet needs in surgical technology

A number of UK SMEs are at the forefront of surgical technology innovation, driven by a desire to improve patient outcomes, reduce complication rates and length of hospital stay, and decreased morbidity and mortality. We highlight some of them in this section.

Sapien Health: A solution for optimising around 5M patients (as of May 2021) on surgical waiting list could be solved by Sapien Health's with a mobile app-based behavioural intervention for patients undergoing elective surgery. According to Sapien Health, around 50% of people suffer from anxiety, depression and other mental health issues due to surgery[41]. The programme utilises personalised digital guidance and remote health coaching to optimise patients preoperatively and support their recovery during the postoperative phase. Technology has been shown to reduce surgery cancellations by 29%, outpatient DNAs by 29%, length of stay by 25%, A&E attendances by 47% and 30-day readmissions by 45%, representing a significant saving for the NHS[41].

TCC-CASEMIX Ltd: Optimising theatre schedules using a cloud service TCC-CASEMIX® overcomes the challenge of sub-optimal planning in surgery, which cause people to miss out on urgent surgery annually either through late starts, intra-surgery delays and early finishes. The system creates insights into surgical productivity and provides total traceability of medical devices used in their surgery[42].

Open Medical Ltd: Pathpoint SurgiCare from Open Medical Ltd is an interoperable cloud-based platform serving the full perioperative care pathway to tackle any waiting list backlog. The benefits of Pathpoint™ includes modern user interface designed by clinicians, minimisation of administration time, reduction of adverse incidents and complaints, fast digital recording of clinical workflows, automatic notifications and reporting, highly granular data analytics and modelling, maximisation of clinical efficiency and reduction of clinician burn-out, SNOMED CT end-user coding using natural language processing and effective clinical governance and internal communication[43].

CMR Surgical Ltd: Versius from CMR Surgical is a next-generation surgical robot. Designed to meet the needs of patients, surgeons, and surgical teams alike, Versius extends the surgeon's own dexterity and precision by mimicking the human arm. The systems' versatility and affordability mean it can be used across a wide range of minimal access surgery (MAS).

3D LifePrints (3DLP): 3DLP creates anatomical models for surgical pre-assessment and as educational/ training models. Created from MRI and CT scans, these help clinicians plan better, minimise invasive surgery plus shorten anaesthetise and rehabilitation times. Benefits include NHS productivity increase through adoption/use of emerging technologies, reduction of time/costs in pre-surgical planning/in theatre and better outcomes through planning/eliminating unknowns prior to surgery[45].

4. In-Progress Clinical Trials

To determine the number of clinical trials occurring within the sphere of surgery, data was sourced from the NIHR Clinical trials Database – repository harbouring the latest in health and social care research taking place across the UK. A complete rundown of the results is illustrated below in Figure 12.

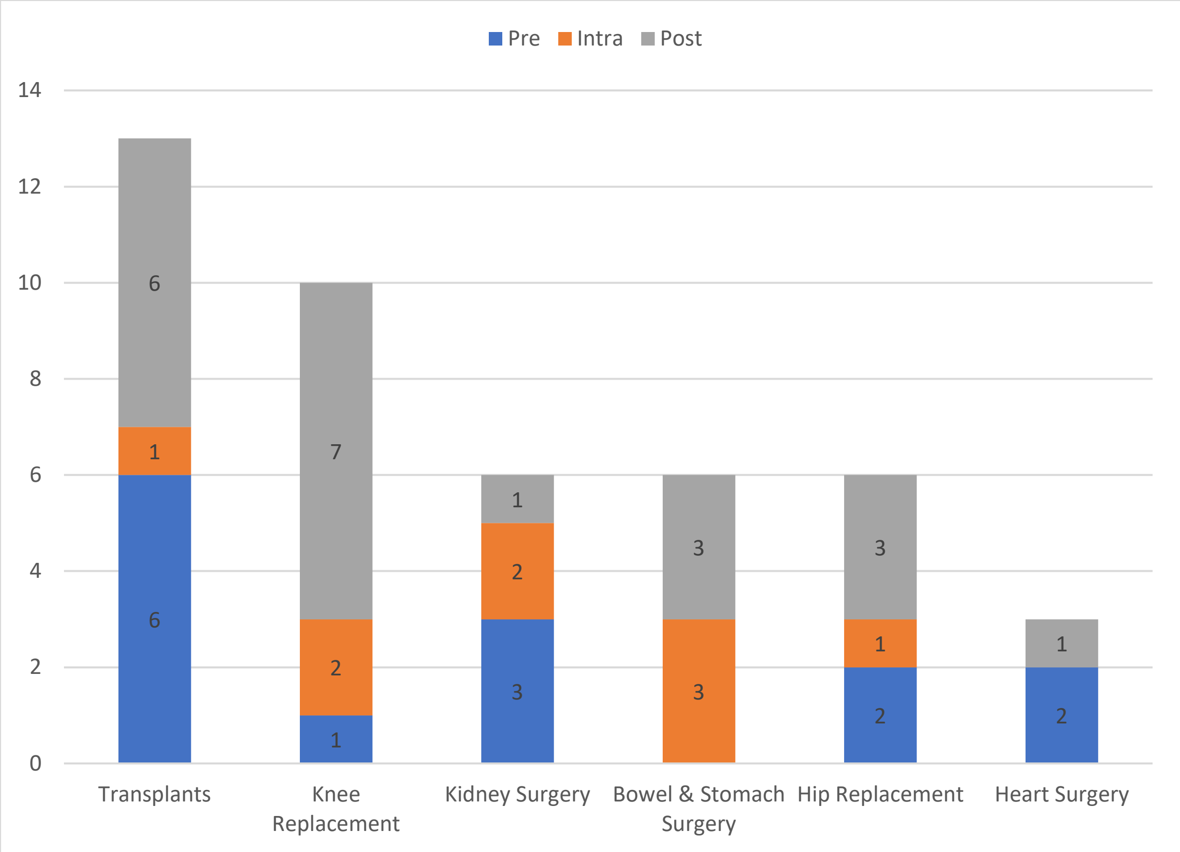


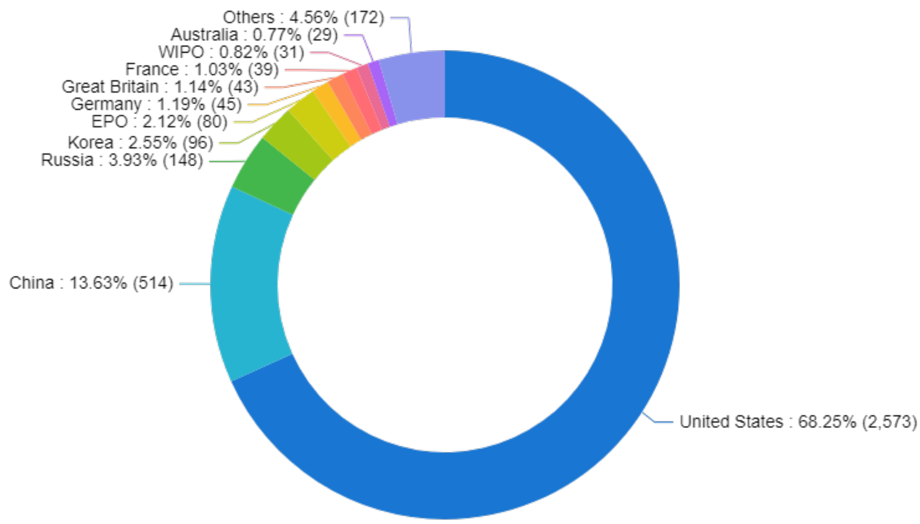
Figure 12. Clinical trials, split by stage in surgical pathway, actively recruiting for patient cohorts within specific surgical risk areas. Data adapted from NIHR Clinical Trials Database[46].

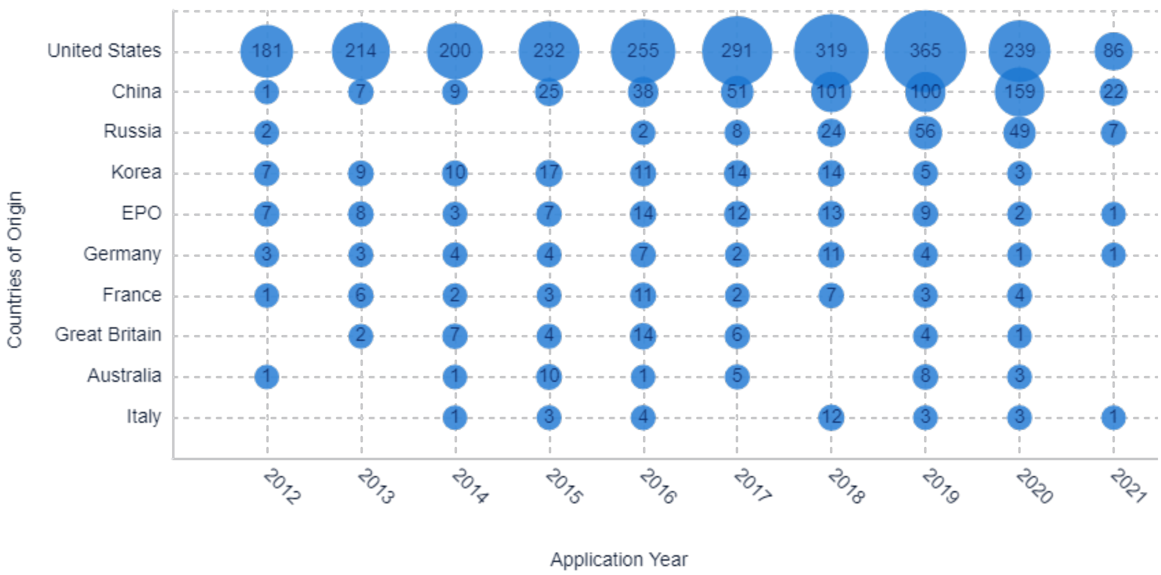
5. Patent landscape review

The patent landscaping was conducted for technologies over a period of ten years from 2011 till October 2021 in the following surgical specialties of vascular, cerebrovascular, paediatric, cardiac, cardiothoracic, orthopaedic, spinal, colon and rectal, neurology, ophthalmology, oral and maxillofacial, otorhinolaryngology, gynaecology and obstetrics, oncology, gastrointestinal, general surgery, gynaecology, oncology, genitourinary, plastic and maxillofacial and urology. Technologies such as surgical robots, artificial intelligence, three-dimensional printing and new imaging methods are already changing and will continue to change the way surgical care is delivered (Royal College of Surgeons of England). Therefore, this patent landscape reports on surgical innovations, with specific focus on simulation, virtual reality (VR), artificial reality (AR), 3D printing, 3D modelling, 3D imaging applicable to micro, keyhole, laparoscopic, emergency or minimally invasive surgeries. As a note, all charts displayed in patent landscaping section shows one document per application and is calculated using the latest publication.

5.1 Geographic territories and application trend in countries of origin

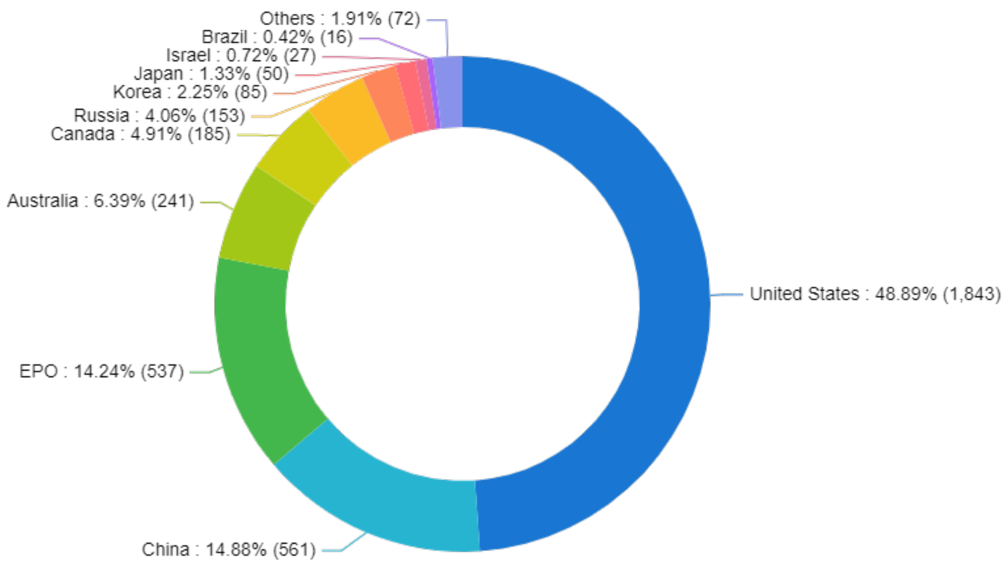
Around 68% of the earliest applications were filed in US, followed by 13% in China and early 4% in Russia. This indicates where the majority of organisations are based, or which countries companies want to first capitalise in. The yearly trend of earliest applications in the field of surgical technology shows the change in focus in different countries of origin for the surgical technology space (Figure 13).





5.2 Top countries and application trend in top countries

The geographic coverage of filed patent applications shows United States as the most targeted geographic market where the technology is most prominent and commercialized in, followed by China and Europe (Figure 14). The information available could be used by companies to plan their filing strategy – ensuring their portfolio covers the top jurisdictions, making them an attractive acquisition target. It might also help to identify untapped markets for this technology. A yearly application trend of the top countries within the surgical technology field gives an indication of the geographical markets targeted by the technology field and how direction changes over time, to help identify patenting trends and shifts in markets.



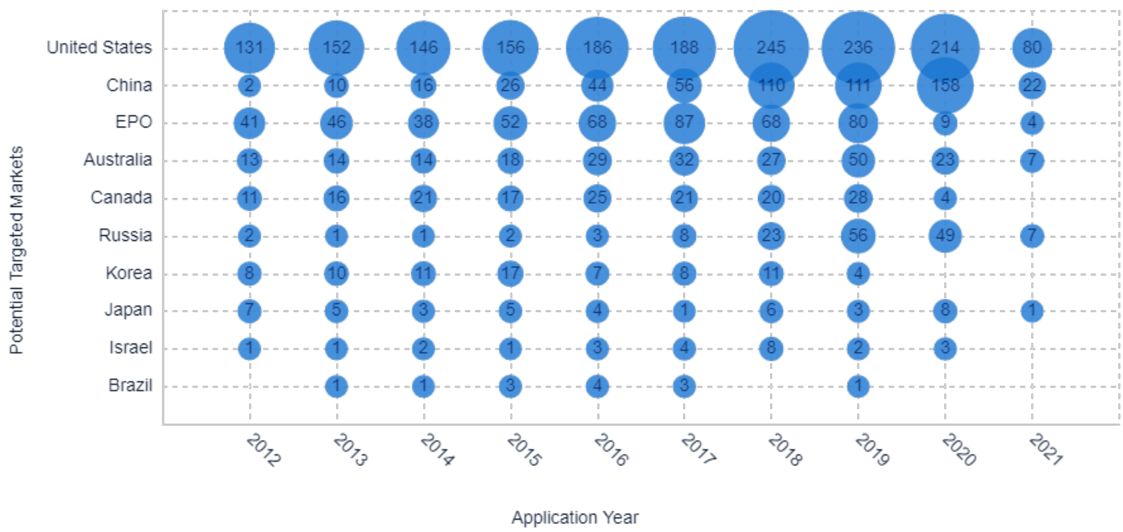


Figure 14. Top countries and application trend in top countries.

5.3 IP5 Territory distribution

Analysing the origin and protection of the surgical technology space in IP5 (EP, CN, JP, KR, US) as in gives a picture of which country, out of the top five largest intellectual property offices, the technology field originates from and is more heavily protected in (Figure 15). This helps to understand if organisations are typically protecting their invention in their own market or extending this to more profitable markets elsewhere.

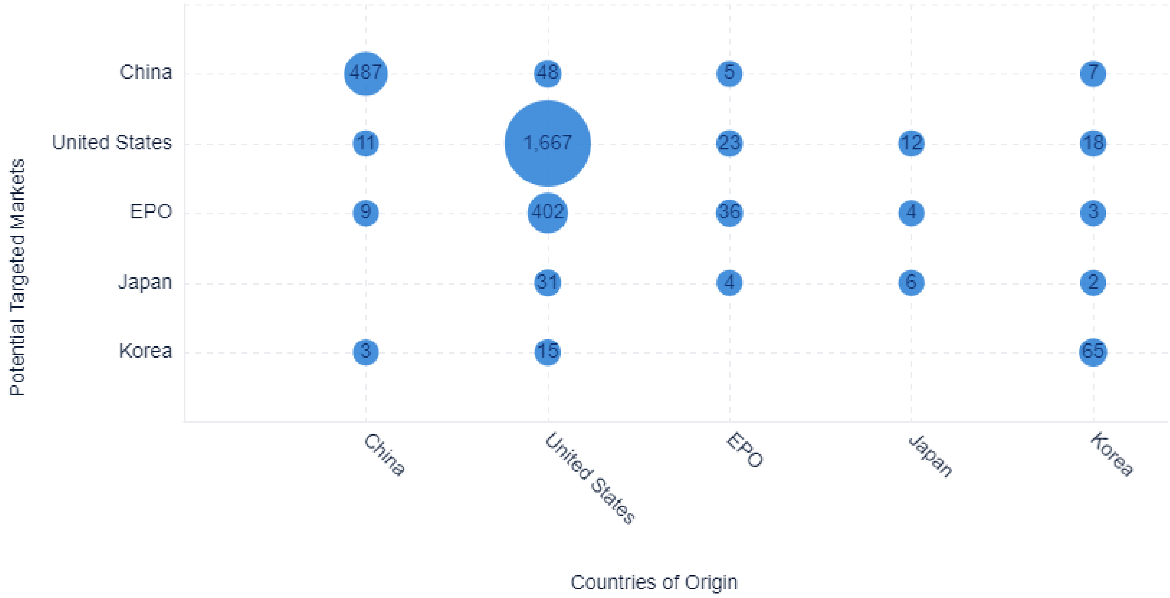


Figure 15. Surgical technology space in EP, CN, JP, KR and US

5.4 Key Technologies

Visualising the major technology areas helps to understand alternative applications of the technology and find potential opportunities for licensing and white space. To allow us to tap into the heart of the patent scene, data was extracted and tabulated using what is known as the Cooperative Patent Classification (CPC) system – an internationally recognised and implemented classification system for patent publications, born out of a collaboration between the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO). Description of all CPC codes used in this report can be found in table 5.1 and 5.2.

Table 5.1 Cooperative Patent Classification (CPC) sub system describing innovations in surgical technology

CPC	Description
A61B17	Surgical instruments, devices or methods, e.g. tourniquets (A61B 18/00 takes precedence; contraceptive devices, pessaries, or applicators therefor A61F 6/00; eye surgery A61F 9/007; ear surgery A61F 11/00) - When classifying in this group, classification is also made in group A61B 17/94 if the endoscopic features of the surgical instrument are of interest.
A61B34	Computer-aided surgery; Manipulators or robots specially adapted for use in surgery
A61F2	Filters implantable into blood vessels; Prostheses, i.e. artificial substitutes or replacements for parts of the body; Appliances for connecting them with the body; Devices providing patency to, or preventing collapsing of, tubular structures of the body, e.g. stents (as cosmetic articles, see the relevant subclasses, e.g. wigs, hair pieces, A41G

	3/00, A41G 5/00; artificial nails A45D 31/00; dental prostheses A61C 13/00; materials for prostheses A61L 27/00; artificial hearts A61M 60/00; artificial kidneys A61M 1/14)
A61B90	Instruments, implements or accessories specially adapted for surgery or diagnosis and not covered by any of the groups A61B1/00 - A61B50/00, e.g. for luxation treatment or for protecting wound edges (protective face masks A41D13/11; surgeon's or patient's gowns or dresses A41D13/12; devices for carrying-off, for treatment of, or for carrying-over, body liquids A61M1/00)
A61B5	Measuring for diagnostic purposes (radiation diagnosis A61B6/00; diagnosis by ultrasonic, sonic or infrasonic waves A61B8/00); Identification of persons
A61F9	Methods or devices for treatment of the eyes; Devices for putting-in contact lenses; Devices to correct squinting; Apparatus to guide the blind; Protective devices for the eyes, carried on the body or in the hand (caps with means for protecting the eyes A42B 1/018; visors for helmets A42B 3/22; {retractors A61B 17/02; manipulators specially adapted for use in surgery A61B 34/70}; appliances to aid invalids to move about A61H 3/00; {exercisers for the eyes A61H 5/00}; eye baths A61H 35/02; sunglasses or goggles having the same features as spectacles G02C)
A61B1	Instruments for performing medical examinations of the interior of cavities or tubes of the body by visual or photographical inspection, e.g. endoscopes (examination of body cavities or body tracts using ultrasonic, sonic or infrasonic waves A61B 8/12; instruments, e.g. endoscopes, for taking a cell sample A61B 10/00; endoscopic cutting instruments A61B 17/32; surgical instruments using a laser beam being directed along or through a flexible conduit A61B 18/22; technical endoscopes G02B 23/24); Illuminating arrangements therefor (for the eyes A61B 3/00)
A61B6	Apparatus for radiation diagnosis, e.g. combined with radiation therapy equipment (instruments measuring radiation intensity for application in the field of nuclear medicine, e.g. in vivo counting, G01T 1/161; apparatus for taking X-ray photographs G03B 42/02)
A61N1	Electrotherapy; Circuits therefor (A61N 2/00 takes precedence; irradiation apparatus A61N 5/00)
G09B 23/00	Models for scientific, medical, or mathematical purposes, e.g. full-sized devices for demonstration purposes (in the nature of toys A63H)
A61B 18/00	Surgical instruments, devices or methods for transferring non-mechanical forms of energy to or from the body (eye surgery A61F 9/007; ear surgery A61F 11/00)

A61M 25/00	Catheters; Hollow probes (dilators A61M 29/00; {peritoneal catheters A61M 1/285; tracheal tubes A61M 16/04; for drainage A61M 27/00; for uterus, vagina or rectum A61M 31/00} ; for measuring or testing A61B; {materials for catheters A61L 29/00})

The largest proportion of patents, over 36% lies in "surgical instruments, devices or methods" code of A61B17, followed by 17% of the patents fall in the category of "computer-aided surgery; manipulators or robots specially adapted for use in surgery" code of A61B34 (Figure 16).

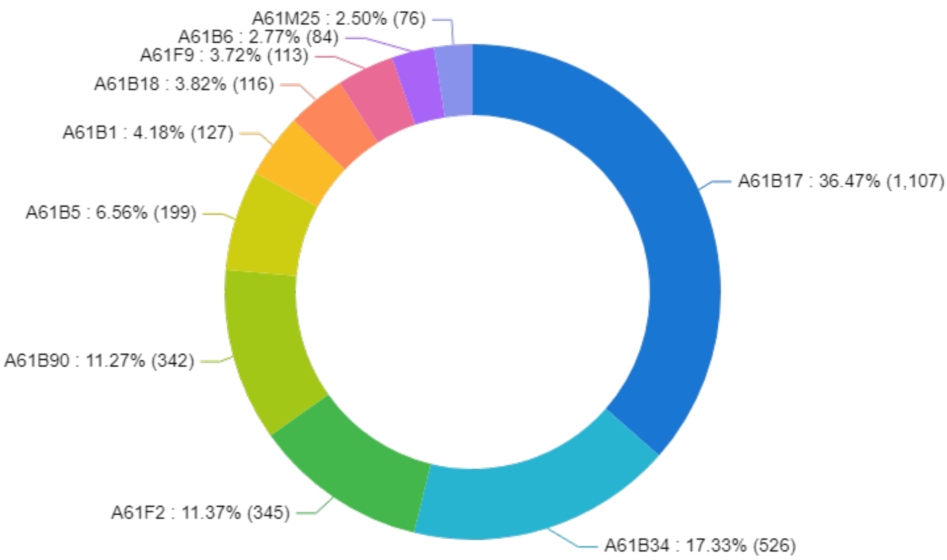


Figure 16. Top CPC codes depicting the proportion of filed patents in the Surgical technology space from 2011- 2021.

Table 5.2 Cooperative Patent Classification (CPC) system describing innovations in surgical technology

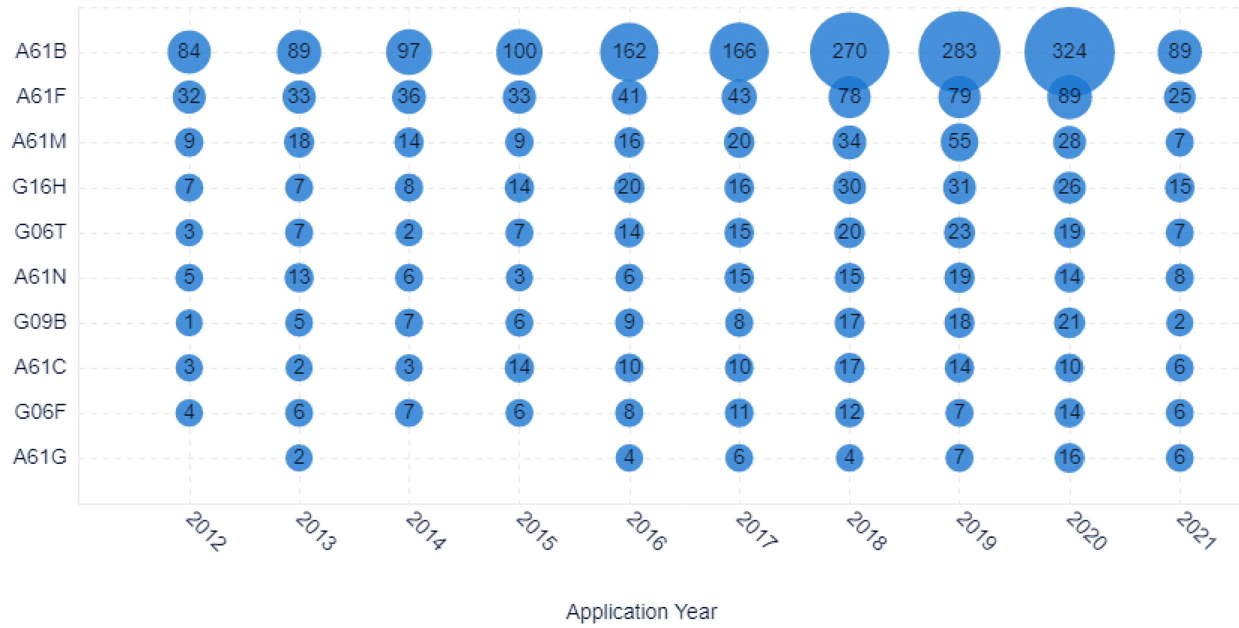
CPC	**Description**
A61B	Diagnosis; surgery; identification (analysing biological material G01N, e.g. G01N 33/48; obtaining records using waves other than optical waves, in general G03B 42/00)
A61F	Filters implantable into blood vessels; prostheses; devices providing patency to, or preventing collapsing of, tubular structures of the body, e.g. stents; orthopaedic, nursing or contraceptive devices; fomentation; treatment or protection of eyes or ears; bandages, dressings or absorbent pads; first-aid kits
A61M	devices for introducing media into, or onto, the body (introducing media into or onto the bodies of animals A61D 7/00; means for inserting tampons A61F 13/26; devices for administering food or medicines orally A61J; containers for collecting, storing or administering blood or medical fluids A61J 1/05); devices for transducing body media or for taking media from the body (surgery a61b; chemical aspects of surgical articles a61l); devices for producing or ending sleep or stupor {(electrotherapy, e.g. producing anaesthesia by the use of alternating or intermittent currents A61N 1/36021)}

G16H	Healthcare informatics, i.e. information and communication technology [ICT] specially adapted for the handling or processing of medical or healthcare data
G06T	Image data processing or generation, in general
A61N	Electrotherapy; Magnetotherapy; Radiation therapy; Ultrasound therapy (measurement of bioelectric currents A61B; surgical instruments, devices or methods for transferring non-mechanical forms of energy to or from the body A61B 18/00; anaesthetic apparatus in general A61M; incandescent lamps H01K; infra-red radiators for heating H05B)
G09B	Educational or demonstration appliances; appliances for teaching, or communicating with, the blind, deaf or mute; models; planetaria; globes; maps; diagrams (devices for psychotechnics or for testing reaction times A61B 5/16; games, sports, amusements A63; projectors, projector screens G03B)
A61C	Dentistry; apparatus or methods for oral or dental hygiene (non-driven toothbrushes A46B; {tongue scrapers A61B 17/24;} preparations for dentistry A61K 6/00; preparations for cleaning the teeth or mouth A61K 8/00, A61Q 11/00)
G06F	Electric digital data processing (computer systems based on specific computational models G06N)
A61G	Transport, personal conveyances, or accommodation specially adapted for patients or disabled persons (appliances for aiding patients or disabled persons to walk a61h 3/00); operating tables or chairs; chairs for dentistry; funeral devices (embalming corpses a01n 1/00)

5.5 Application trend of key technologies

Yearly application trend of the major technology areas over the last ten-year period represented here could be used to understand how investment into different technologies has changed over time

(Figure 17). The A61B category describing “Diagnosis; surgery; identification” tops the CPC class with increased activity over a period of nine years from 2012.



5.6 Geographic distribution of key technologies

To identify the top markets for commercialisation and the commercial potential of different countries, the distribution of key technologies across the top 10 countries is analysed (Figure 18). The top CPC code A61B17 which relates to surgical instruments, devices or methods in the surgical technology space accounts for the high proportion of the patents in US, China, EPO, Russia and Korea followed by A61B34 which represents patents in key technologies such as Computer-aided surgery; Manipulators or robots specially adapted for use in surgery.

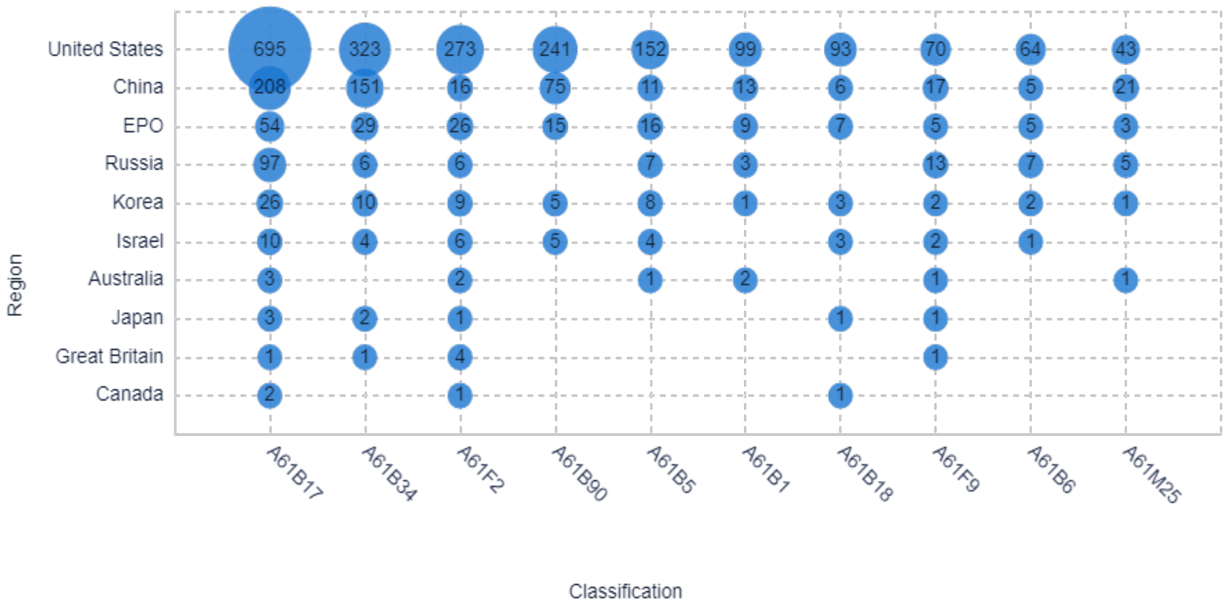
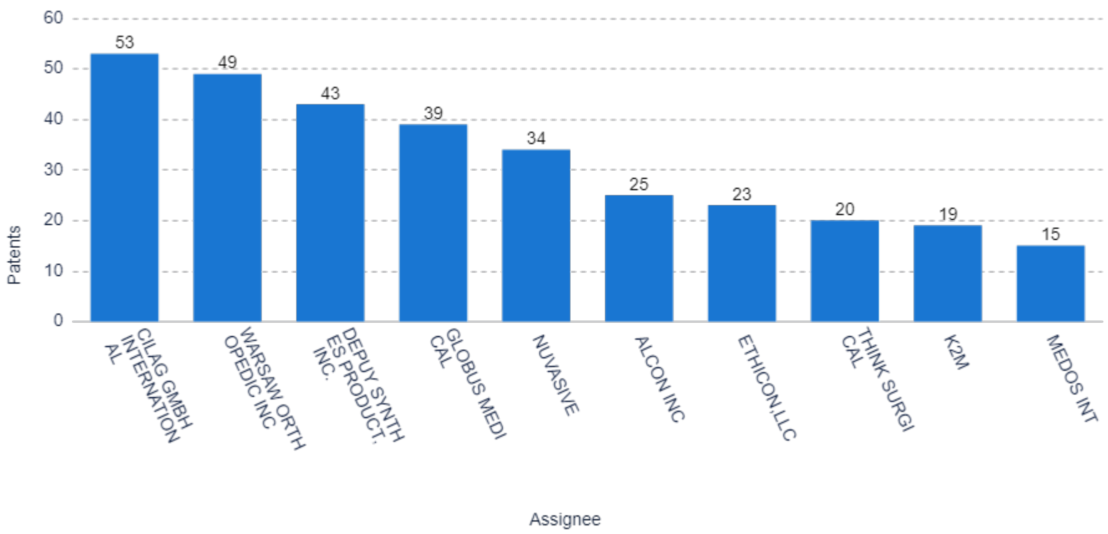


Figure 18. Geographic distribution of key technologies from 2011- 2021.

5.7 Major players in key surgical technologies & geographic distribution of top assignees

The top five assignees identified within different key surgical technology space (corresponds to the top CPC classes) are Cilag GmbH International, Globus medical, Depuy synthes Product Inc., Warsaw orthopedic Inc., and Nuvasive. The information regarding major players in key surgical technologies could help to locate potential partners for licensing, potential threats of litigation, and targets for invalidation. Figure 19 shows the geographic distribution of top assignees to understand if companies are competing in similar geographies or if their targeted markets are different.



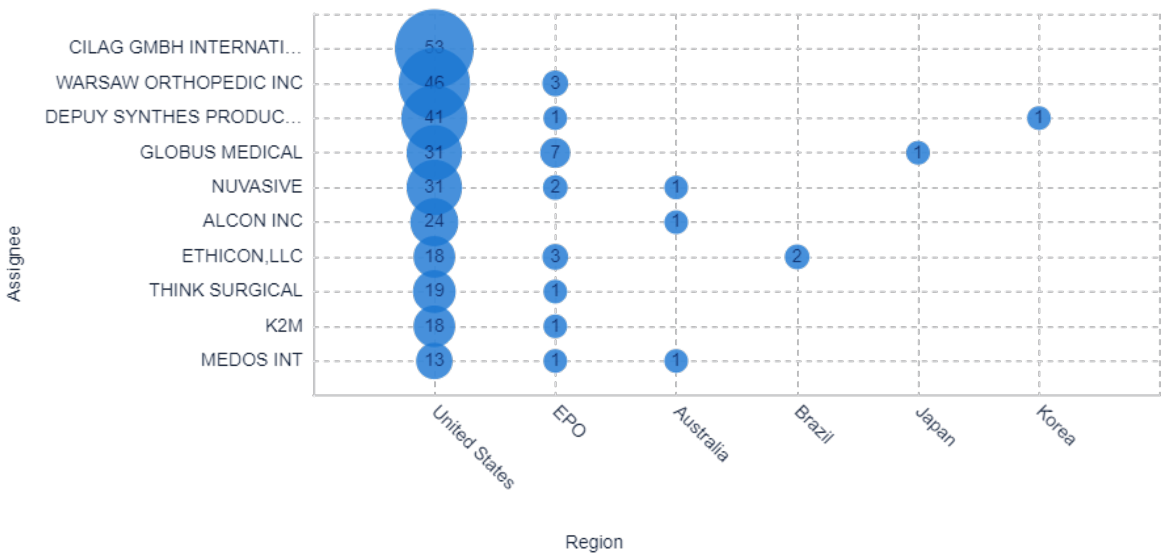


Figure 19. Major players in key surgical technologies & geographic distribution of top assignees from 2011- 2021.

5.8 New Entrants

Emerging entrants (applicants who have filed applications only in the past 5 years) in the technology field are identified to include any new competition in the technology space (Figure 20). Alternatively, they could also be considered as potential acquisition or partnership opportunities.

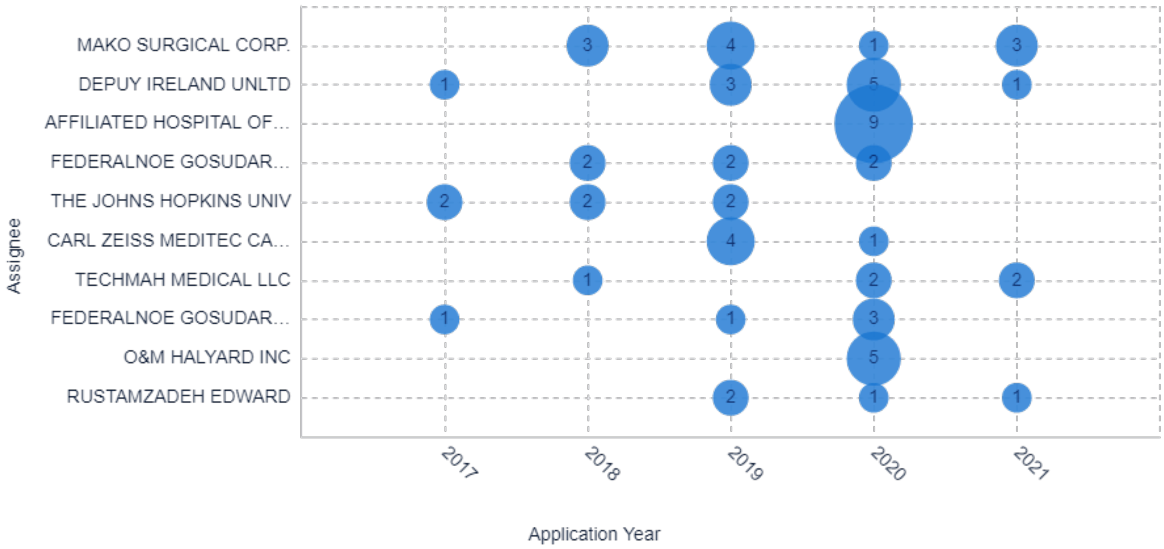


Figure 20. Emerging players in key surgical technology space.

6. Appendix

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