

Innovation in Surgical Technology - Minimally Invasive Surgery (MIS)

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Introduction

Surgical technology is continually advancing, propelled by the integration of novel technologies, cutting-edge equipment, and innovative devices. Among the myriad advancements in surgical technologies and techniques, minimally invasive surgery (MIS) takes a revolutionary approach that involves conducting surgical procedures through small incisions or body openings, aiming to minimize bodily trauma, alleviate pain, expedite recovery, and optimize patient outcomes (Gomes, 2012). The essence of such procedures requires a minimal viable product to accurately visualize the operative site and delicately manipulate tissues.

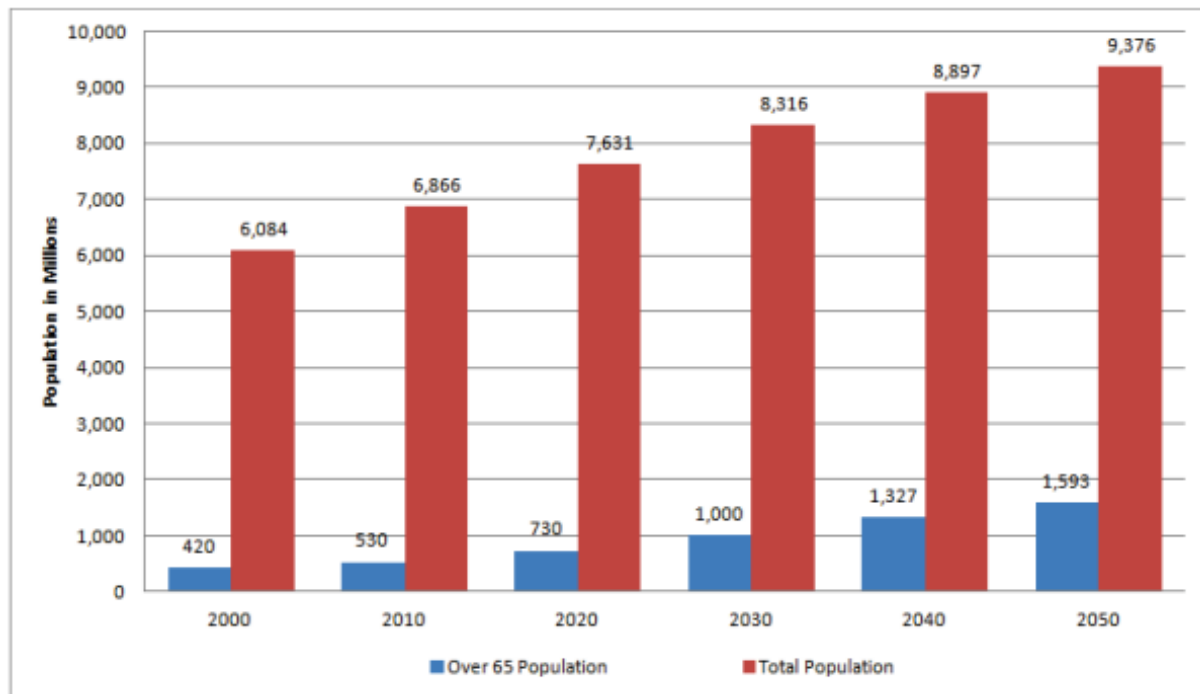
The emergence of MIS procedures is significantly attributed to the availability of endoscopy, insufflation, and specialized surgical instruments. In the 1970s, the laparoscope gained prominence in gynecological surgery, while the first balloon angioplasty marked a milestone in treating clogged arteries (Kottapenta, 2023). The widespread acceptance and adoption of these techniques paved the way for computer assisted surgery technologies, introduced in the 1990s by pioneering companies like Integrated Surgical Systems and the ZEUS Robotic Surgical System (Shah, 2014) (Kottapenta, 2023).

As MIS technologies continue to evolve, subsequent generations of surgical systems have emerged—smaller, lighter, more flexible, and smarter. This progression has not only widened the application of MIS techniques across various surgical domains, including general, cardiac, cosmetic, orthopedic, and more, but has also accentuated the substantial growth of the market. The expanding scope of MIS applications has attracted a growing number of companies poised to play pivotal roles in this market.

Market Conditions

In examining the landscape of MIS market, it is crucial to consider context of population dynamics, global health, and socio-political changes. In the realm of population as it relates to health, projections indicate a significant rise in the aging population until 2050, necessitating an increased demand for medical technology to address a spectrum of health conditions (Kalorama

Information, 2022). This global phenomenon is reflected in a projected 118% increase in the population aged 65 and older from 2020 to 2050, as shown below.



Source: Kalorama Information

The escalating demand for healthcare services, coupled with an aging demographic, will also lead to a surge in global healthcare expenditures. This trend is expected to persist as the population grows older. Therefore, the forecasts for the MIS market anticipate a growth rate of 3.2% from 2022 to 2027 (Kalorama Information, 2022). Nonetheless, despite the increasing need for medical technologies, healthcare systems face constraints on unlimited spending. As a result, the pricing growth of medical devices has exhibited a measured pace, remaining constant as a share of total national health expenditures. The development of new tools and tests is another factor contributing to this gradual price growth. This will require not only innovation, but also competitive business strategies to survive in the market.

Thriving in this dynamic market requires not only innovation of products to meet demand for growing population but also strategic competitiveness for both major players and specialized firms. The impact of external factors, such as the COVID-19 pandemic and geopolitical events

like the Russia-Ukraine War, has influenced market dynamics. While the pandemic initially led to a decrease in surgical procedures and disrupted supply chains, there is an upward trend of 3.4% in the demand for innovative technologies and solutions from 2021 to 2022 (Kalorama Information, 2022) (Kottapenta, 2023). Additionally, the aftermath of the Russia-Ukraine War has introduced challenges, contributing to a global economic slowdown and inflation, particularly in fuel, food, and commodity prices. Stringent sanctions imposed by the EU and the US further underscore the complex landscape (Kottapenta, 2023). Navigating these multifaceted challenges requires agility and adaptability, solidifying the importance of strategic resilience in the ever-evolving market landscape.

In navigating the MIS market, considerations of price, quality, reliability, innovation, and regulatory compliance are paramount (Technavio, 2022). The adaptation of MIS procedures to novel surgical techniques, including lumbar decompression, thoracic aortic endografts, neurosurgeries, endoscopic submucosal dissection, and submucosal tunneling endoscopic resection, showcases the versatility and evolution of this field (Kottapenta, 2023). Moreover, emerging technologies such as nonvisual imaging techniques, robotically assisted surgery, transcatheter surgery, computer-assisted surgery, and percutaneous ablation have the potential to disrupt and reshape the landscape of MIS innovations.

Current Innovations

As technology continues to drive medical advancement, the field of MIS takes center stage, transforming patient outcomes and procedural methodologies. Notable innovations in this arena encompass laparoscopy, endoscopy, and computer assisted minimally invasive surgeries. The integration of environmental, social, and governance (ESG) standards, along with the progression into industry 4.0, has elevated MIS technologies into a realm where advanced imaging, technological enhancements, and robotic assistance seamlessly come together. With this transformative landscape, innovations align to meet unique needs and preferences of different patient demographics. MIS technologies have proven to be particularly well-suited for

elderly patients facing the challenges of enduring prolonged surgeries and extended recovery periods. Simultaneously, individuals with limited time for recuperation have come to appreciate MIS technologies as a significant advantage. This optimization of patient outcomes resonates harmoniously with the contemporary lifestyle preference of minimizing downtime. Moreover, in an era where aesthetics and body image are valued, MIS technologies, with their focus on small incisions, align perfectly with prevailing societal norms, where individuals prefer procedures that leave minimal scarring. In embracing these advancements, the healthcare landscape evolves to offer solutions that prioritize patient well-being and harmonize with cultural ideals of our time.

At the forefront of this revolution are robotic surgeries, exemplifying the pinnacle of minimally invasive techniques. Selected companies of major key places in MIS landscape are analyzed to offers a glimpse into the dynamic of the market in the table below. It's important to note that the product featured in the table is just one among many offerings by the company, chosen for its alignment with MIS and recognition as a prominent product within the company's portfolio. The application highlighted in the table serves as a representative example, recognizing that the actual applications of these products extend across various fields and surgical specialties. The factual information provided in the table is derived from company product information, annual reports, and market research reports, all of which are referenced. In term of innovation strategy, these products were specifically chosen for their impactful contributions to surgical procedures, reflecting a strategic alignment with the evolving industry landscape driven by technological advancements. The selection took into account of the impact on both the industry and the market, carefully considering timelines and the progression of technology.

Company	Intuitive Surgical	Zimmer Biomet	Stryker	Stereotaxis	Medtronic
Product	da Vinci	ROSA	Mako	Genesis RMN	Hugo RAS
Applications	General Surgery	Arthroscopy	Arthroscopy	Cardiology	General Surgery
Market Shares	80.9%	2%	9.6%	~1.5%	3.5%
Innovation Strategy	Disruptive	Continuous	Continuous	Breakthrough	Disruptive
Excitement Features	Enhanced visualization with high accessibility	Mobile health app to improve patient experience	Includes haptics feedback assistance system	Instantaneous responsive to physician control	Open console for direct contact with staff
Strategy	<p>Increase utilization of surgical system</p> <p>Expand innovation and launch platforms</p> <p>Increase productivity and continue supply</p>	<p>Expand portfolio and business area</p> <p>Enable solution to new products</p> <p>Continuous supply and efficiency</p>	<p>Intense customer commitment</p> <p>Expand innovation via investment</p> <p>Strengthen alignment among franchise</p>	<p>Create collaborative open ecosystem</p> <p>Enhance customer experience</p> <p>Increase access and affordability</p>	<p>Optimize customer experience</p> <p>Expand market and business area</p>
Competitors	Medtronic, Johnson & Johnson, Titan Medical, CMR	Stryker, Smith & Nephew, NuVasive, Globus Medical	Zimmer Biomet, Medtronic, Smith & Nephew, MicroPort	Siemens Healthineers - Corindus, Robocath	Intuitive Surgical, Johnson & Johnson CMR, Vicarious

Industrial Paradigm

In the landscape of MIS, the advent of Industry 4.0 is poised to catalyze a transformative shift. MIS technologies epitomize the capability to visualize and operate equipment or machines remotely. As industrial automation ascends with the proliferation of robots and remote control, the control of real machines remotely through virtual and master interfaces becomes a reality. Consequently, IoT platforms and software leverage digital representations of physical objects or assets, enabling the monitoring, simulation, and control of physical assets with virtual objects. This integration extends to haptic internet technologies and virtual reality, democratizing user interfaces and eliminating the need for specific equipment controls. The connection of physical machines with the digital world triggers software analytics, processing massive volumes of data to unveil valuable insights and intelligence. The convergence of the Internet of Things, big data, sensors, controllers, RTUs, PLCs, and standard communication stacks with security protocols further defines this transformative era (Mind Commerce, 2022).

This paradigm shift has given rise to emerging technologies, including nonvisual imaging techniques that seamlessly integrate optical and nonoptical systems. This shift has paved the way for augmented reality, where data overlays objects to enhance spatial relationships, minimizing the need for surgeons to divert their attention from the surgical site. The industry has enabled remote surgery, facilitating the delivery of focused energy for ablation without incisions. Consequently, the role of MIS robotics extends beyond enhancing surgical assistance, dexterity, and image-guided therapy; it acts as a catalyst for futuristic innovations. Envisage a future where cameras are ingested, implantable sensors facilitate real-time monitoring, microbots conduct intricate surgical procedures, and magnetically controlled implants are navigated remotely. This progression promises outcomes such as an augmented visual field, superior dexterity, improved accessibility, AI and data-enabled precision, and telesurgery. Moreover, the wealth of visual and nonvisual data stored in databases, encompassing patient histories, test results, and preoperative planning, will determine optimal surgical strategies (Kottapenta, 2023).

This reservoir of information empowers surgeons to select optimal surgical strategies, aiming for the eventual goal of achieving autonomous actions in surgery and the realization of independent robotic interventions. Furthermore, the integration of Industry 4.0 into MIS not only amplifies current capabilities but also propels the field toward unprecedented frontiers of innovation and efficiency. This synergy between technological evolution and surgical methodologies holds the promise of revolutionizing surgical practices, pushing the boundaries of what is achievable in current MIS market.

Conclusion

As the Minimally Invasive Surgery (MIS) market solidifies its presence in the mainstream market, the landscape is becoming increasingly competitive. Notable players like Moon Surgical, Noah Medical, Penumbra, and others contribute to a continuous surge in competition, amplifying the market's dynamism. The growing supply and emergence of new competitors underscore the need for seamless integration and synergy among instrument, equipment, software, and imaging technology companies, underscoring a pivotal requirement for industry advancement.

In navigating the future of MIS, cybersecurity solutions are imperative (Frost & Sullivan, 2022). Therefore, multifaceted challenge lies not only in technological innovation but also in compliance with stringent regulations, including those set by the FDA, Health Canada, EUMDR, and PMDA. Ethical considerations surrounding the increasing role of robotics in surgery, coupled with ongoing training requirements for medical professionals, add additional layers of complexity (Gomes, 2012). Consequently, a delicate balance between costs and benefits must be carefully weighed in the pursuit of innovative designs and production. As we look ahead, the evolution of MIS intersects with the broader transformation of healthcare delivery. All-in-one MedTech solutions and the digitization of care delivery become crucial for hospital efficiency, especially as equipment and technologies enable comprehensive data collection and guidance.

This integration aligns with an emphasis on adopting efficient, integrated solutions for the evolving healthcare landscape (Frost & Sullivan, 2022).

Furthermore, the horizon of MIS is dotted with disruptive emerging technologies, including personalized medicine, miniaturized surgery, and targeted customization with real-time technologies. The incorporation of 3D printing adds another layer of customization, tailoring solutions to individual patients. As technology advances, the consideration for collaborative platforms, big data utilization, and predictive analytics becomes paramount. The trajectory of MIS points toward a future where seamless integration, compliance with regulations, and strategic adaptation to emerging technologies will be key determinants of success in this dynamic and evolving field.

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