Review

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Use of Robotic Systems in Aesthetic/Cosmetic Plastic Surgery—A Review Article

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Use of Robotic Systems in Aesthetic/Cosmetic Plastic Surgery—A Review Article

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Abstract

Background: Robot-assisted surgery has become increasingly used across multiple specialties; however, its integration into aesthetic plastic surgery remains limited. Individualized patient requirements, such as concealed scar placement, superficial soft tissue dissection, and patient-specific docking angles, are major challenges to their adoption, unlike in other specialties. This review aimed to evaluate the current use of robotic systems in plastic surgery, with a particular focus on aesthetic procedures, operative outcomes, and existing technological limitations. Methods: Multiple databases, including PubMed, Scopus, and Google Scholar, were systematically searched to identify studies published between 2011 and 2026. Data on robotic platforms, operative duration, rehabilitation outcomes, and aesthetic indications were extracted and analyzed. Robotic systems such as da Vinci, Symani, MUSA, and ARTAS demonstrated feasibility across reconstructive subspecialties. However, their clinical application remains limited, as purely aesthetic procedures are rare, highlighting a significant lack of standardized docking methods and dedicated instruments. Results: The data showed that robotic platforms offer great advantages, such as precision and minimally invasive access; however, their high costs, bulky instrumentation, and limited docking methods are hurdles for their adoption in aesthetic surgery. Conclusions: Robot-assisted aesthetic plastic surgery remains in an early developmental stage. Further research is required to establish reproducible docking standards and expand its clinical indications. Advancements in single-port systems, artificial intelligence integration, and surgeon training will facilitate broader clinical implementation.

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1. Introduction

In recent years, the demand for aesthetic surgery has increased as more patients seek medical procedures to enhance their appearance through consultation with plastic surgeons. Contemporary standards of beauty continue to evolve, driving the development of new surgical methods and techniques aimed at constantly enhancing outcomes, minimizing complications, shortening recovery time, and concealing scars to achieve more natural results. Technologies such as lasers are increasingly used for soft tissue dissection and have demonstrated advantages over conventional techniques [1,2]. Although robotic systems are still in the early stages of development in aesthetic surgery, efforts are ongoing to expand their clinical application [3,4].

The progress of robotic systems in plastic surgery remains slower than that of other technologies because of the challenges associated with their clinical integration. The main limiting factors include the lack of standardized docking methods, high procedural costs, and the limited availability of specialized surgical instruments [5,6].

The main challenge lies in achieving proper docking of the robotic system to ensure a safe access angle, a clear field of view, and optimal cosmetic outcomes with minimal visible scarring. Patient anatomical factors must also be considered, including body mass index, age, excess skin, neck length, and breast size, as these variables may affect instrument rotation, particularly in procedures involving the neck region.

Currently, standardized docking methods for aesthetic plastic surgery are limited, except for those described in prior studies, which will be discussed later in this article [6].

This article aimed to analyze the use of robotic systems in plastic surgery, including the types of robotic applications, operative duration, hospital length of stay, and rehabilitation period, while providing context for the limited integration and research on robotic technology in aesthetic plastic surgery.

2. Materials and Methods

We conducted a literature review to evaluate the application of robotic systems in plastic surgery. Searches were performed in Scopus, PubMed, and Google Scholar for articles published between 2011 and 2026. Studies relevant to the objectives of this study were selected to provide context for the current state of robotic technology in aesthetic plastic surgery, including its reported advantages and future integration prospects. The following keywords were used: "robotic plastic surgery," "aesthetic robotic plastic surgery," "robot-assisted plastic surgery," "robotic docking methods," "minimally invasive robotic cosmetic surgery," and "docking methods in aesthetic surgery."

3. Robotic Systems Used in Plastic Surgery

Selecting the appropriate robotic system is a critical factor when determining its availability and effectiveness. Some systems are used more frequently than others due to their technological advantages or size.

Multiple robotic surgical systems are currently used in plastic surgery, including the da Vinci, Symani, MUSA, and ARTAS systems [7–37] (Table 1).

Other notable surgical robots, such as the Versius, Shurui Single Port, and Senhance Surgical System, have demonstrated distinct efficacy and advantages.

The Versius system has 5-mm articulated instruments, compact robotic arms, and integrated machine learning capabilities. The Shurui Single Port System has demonstrated low complication rates and minimal intraoperative blood loss. The Senhance Surgical System has shown clinical feasibility, low rates of adverse events, and shorter operative times [38–40].

Although these systems have not yet been applied in plastic surgery, elucidating their existence, technical advantages, and potential applications for guiding future research and innovation in the field is important.

Table 1. Types of robot use based on subspecialty and procedure.

Subspecialty/ Procedure	Primary robots used	Number of papers	Typical applications
Breast reconstruction	da Vinci (Xi, SP, Si)	8	Nipple-sparing mastectomy, DIEP/LD flap harvest, immediate reconstruction
Microsurgery	Symani Surgical System	8	Vascular anastomosis, nerve coaptation, and free flap inset
Lymphedema reconstruction/ Supermicrosurgery	Symani, MUSA/Microsure	3	Lymphovenous anastomosis, vascularized lymph node transfer

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Flap harvest/ flap-based reconstruction	da Vinci (Xi, SP, Si, S)	6	Latissimus dorsi, DIEP, rectus abdominis harvest for breast/chest wall
Head and neck reconstruction	da Vinci (Xi, Si)	3	TORS with free flaps, robotic neck dissection, facial/neck procedures
Facial aesthetic/ reconstructive	da Vinci (Xi, Si)	4	Rhytidectomy, platysmaplasty, retroauricular neck mass resection, abdominoplasty, browlift
Hair transplantation	ARTAS	3	Intelligent algorithms, optimized graft placement

Description: This table analyzes the use of different robotic systems based on the subspecialty, which is an important factor to consider when selecting robotic systems. DIEP, deep inferior epigastric perforator; LD, latissimus dorsi; TORS, transoral robotic surgery; MUSA, microsurgical as-sistant.

4. Length of Operation

The length of the operation is a critical consideration in evaluating robotic systems, as longer procedures may increase surgical costs and extend operating times. However, operating times tend to decrease with practice and experience. We analyzed the available literature on the surgical outcomes and discussed operative durations (Table 2).

In breast reconstruction, the mean operative time was 400.4 min, while the robotic time was only 85.8 min. The flap harvest time was decreased from 2 h to almost 1 h during the study period, as reported [41,42].

The median combined mastectomy and reconstruction operative time was 307.0 min. [7].

Endoscopic latissimus dorsi operating time was 34.5 ± 12.9 min, and robotic operating time was 75.9 ± 30.7 min, which decreased to a level comparable to the endoscopic method as the surgeon gained experience, while another study reported the console time for deep inferior epigastric perforator flap reconstruction to be 68.8 min with a decreasing pattern [10–26].

Microsurgical anastomosis takes a longer duration. One study reported that the average time for finishing the arterial anastomosis was 36.7 ± 10.9 min, while another paper reported 25.3 ± 12.3 mins when compared to conventional methods, but the time required to finish the anastomosis decreased with experience and time [13–21].

Lymphedema anastomosis time decreased from 33 to 16 min with increased practice and surgical experience, demonstrating a substantial improvement in procedural efficiency [23].

Transoral robotic surgery was associated with reduced operative time in selected settings. However, some studies reported total operative times ranging from 814 to 1,132 min, with a reconstruction time of approximately 591.2 min in patients with cancer who had free flap reconstruction. Other studies reported a total operative time of 710 min. Furthermore, robot-assisted neck dissection demonstrated a mean console time of 160 ± 15 min. [30,31,43,44].

Table 2. Operation duration based on subspecialty.

Subspecialty	Number of papers	Description
Breast reconstruction	5	Moderate to long operative time, decreases with experience, longer for complex flaps
Microsurgery/ Extremity	2	Longer anastomosis time, reasonable overall duration, and short setup for some harvests

Lymphedema/ Supermicrosurgery	1	Prolonged anastomosis vs manual, improves with experience
Head and neck reconstruction	4	Significantly longer operative times for complex cases, shorter for simpler dissections

Description: This table analyzes the outcomes of multiple papers discussing the length of operations based on the subspecialty.

5. Rehabilitation Period and Length of Stay

Rehabilitation outcomes vary by specialty but generally show favorable results, making this an important factor to consider when implementing new technologies. Several studies have shown promising results (Table 3).

In breast reconstruction, the robotic group demonstrated a shorter mean hospital stay (7.92 ± 1.20 days) compared with conventional methods (8.77 ± 1.74 days). Additionally, a mean follow-up period of 19.1 ± 15.6 months was reported without any postoperative complications [10,45].

Another study reported a median length of stay of 12 days. In comparison, the robotic group had a mean length of stay of 10.2 ± 1.5 days with a follow-up period of 18.4 ± 4.6 months, while the endoscopic group had a mean length of stay of 10.8 ± 2.0 days with a follow-up period of 23.0 ± 11.3 months [7,26].

In microsurgery, the length of stay was 15.5 ± 10.8 days with a follow-up duration of 66 ± 27 days [16].

In another study, no complications, such as flap loss, ischemia, or venous thrombosis, were noted during a 143-day follow-up, while in others the patient was discharged on day 6 without complications [12,17].

For lymphedema reconstruction, supermicrosurgical systems such as MUSA/Microsure showed symptom improvement within 1–3 months [23].

Head and neck reconstruction procedures reported a shorter hospital stay with fewer complications, while the average length of stay was 13.5 days, suggesting that this method may shorten the hospital stay. Other reports mentioned a length of stay of 5.6 days with a follow-up period of 6.4 and 12.8 months without any complications [30,31,43,44].

Table 3. Rehabilitation period and length of stay based on subspecialty.

Subspecialty	Number of papers	Results
Breast reconstruction	4	Moderate to long operative time, decreases with experience, longer for complex flaps
Microsurgery/ Extremity	3	Longer anastomosis time, reasonable overall duration, and short setup for some harvests
Lymphedema/ Supermicrosurgery	1	Prolonged anastomosis vs manual, improves with experience
Head and neck reconstruction	4	Significantly longer operative times for complex cases, shorter for simpler dissections

Description: This table discusses the results of multiple studies in different specialties regarding rehabilitation period outcomes in different subspecialties.

6. Aesthetic/Cosmetic Surgery

After reviewing the literature, only a few papers were found that focused specifically on robotic applications in aesthetic plastic surgery.4,22–28

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In 2014, Taghizadeh et al. evaluated the feasibility of using the da Vinci robotic system for platysmaplasty procedures using cadaveric models. The study demonstrated excellent surgical exposure, improved precision, tremor reduction, and easier suturing, indicating promising potential for the use of robotic systems in aesthetic plastic surgery [32].

In 2015, Mohamed et al. performed a retroauricular thyroidectomy combined with concomitant neck-lift surgery. The total operative time was 115 min, including 10 min for docking and 30 min for the neck-lift procedure. The authors reported that the approach was feasible and safe in a carefully selected group of patients with excess cervical skin [46].

Moreover, in 2015, Shin et al. used the ARTAS robotic system in 22 patients who underwent robotic follicular unit extraction for hair restoration. The study reported no significant adverse effects, infections, pain, or excessive scarring, thereby supporting the usefulness of robotic technology in hair restoration, particularly because the system improves harvesting efficiency for multiple hair follicles [35].

In 2016, Rybakin et al. performed upper facial rejuvenation procedures in four patients undergoing forehead lift using the da Vinci surgical system. The study highlighted several advantages of this approach, including high-resolution image display with scalable visualization, reduction of tremor effects, improved instrument maneuverability, ease of instrument switching, and enhanced surgeon comfort [33].

In 2017, Correa et al. performed diastasis recti plication procedures in five mini-abdominoplasty cases. Conventional surgical instruments were initially used to dissect abdominal wall tissues, after which the da Vinci robotic system was introduced. The authors reported that robotic surgery offered advantages over conventional methods, including high-definition three-dimensional surgical visualization, superior precision, a wider range of instrument motion of the robotic instruments, and improved surgical stability, while allowing the surgeon to operate comfortably in a seated position at the console [47].

In 2024, Borisenko et al. performed the world's first simultaneous robot-assisted lipoabdominoplasty and cholecystectomy using the da Vinci surgical system. In this procedure, trocars were inserted through the flap scheduled for excision after abdominoplasty, eliminating the need for a separate cholecystectomy scar, thereby improving cosmetic outcomes and enabling successful suturing of the diastasis recti [34].

In 2025, the same group established the first reported robotic docking standards for facial aesthetic plastic surgery. Robot-assisted browlift, facelift, and platysmaplasty procedures were performed using the da Vinci system, with multiple access points defined for each procedure based on patient-specific anatomical characteristics. These protocols aimed to ensure safe access to target structures, maintain clear visualization, and improve instrument maneuverability. To date, these remain the only published docking standards for such operations [6].

A comparative study on the application of robotic hair restoration technology versus traditional follicular unit excision (FUE) methods for male androgenetic alopecia was published in 2024 by Zhu et al. [36].

The study compared the ARTAS robotic system with conventional FUE techniques and found no significant differences in efficacy, adverse effects, or complication rates, indicating that robotic hair transplantation is a safe and effective approach for androgenic alopecia management.

Research and development in robotic hair transplantation technology are ongoing, as discussed in studies by Bae and Thuangtong [37,48,49].

However, current advancements are largely limited to hair transplantation procedures and are not transferable to other robot-assisted aesthetic surgeries involving the face or body. This limitation highlights the need for further research to expand the clinical applicability of robotic technology in aesthetic plastic surgery.

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7. Discussion

The use of robotic systems in plastic surgery is progressing; however, several challenges continue to limit their wider adoption in aesthetic procedures.

Previous attempts to apply robotic technology in plastic surgery were primarily performed in open surgical procedures, where the robotic system was introduced only after incisions were made and the operative field was exposed using conventional surgical methods.

Robotic systems are designed for use in closed surgical systems through small incisions, under camera guidance with gas insufflation to enhance the field of view for the surgeon, which represents their primary advantage.

The absence of standardized docking algorithms remains a major limitation, as few docking protocols currently exist for aesthetic surgical procedures; further development of docking standards is therefore necessary to advance robotic surgery [6].

The existing instruments are bulky and expensive; therefore, single-port robotic systems offer significant potential for aesthetic surgery applications, including platforms such as the da Vinci SP and Shurui Single Port.

The lack of specialized instruments for aesthetic surgical procedures also remains a concern. Further miniaturization and optimization of surgical tools may enhance procedural feasibility and clinical outcomes in this field [33].

Based on the analysis of Giuseppe Turchetti et al., robotic systems are associated with high acquisition and maintenance costs, which limit their accessibility for many hospitals and patients [50].

Finally, surgeons must carefully select appropriate access points, maintain a clear field of view, minimize visible scarring, and consider patient-specific anatomical factors to ensure safe surgery and optimal clinical outcomes.

8. Future Directions

Future research will play a crucial role in advancing aesthetic plastic surgery by enhancing the precision, safety, and clinical effectiveness of robotic systems. Continued technological development is expected to improve surgical outcomes while maintaining superior cosmetic results.

Single-port robotic platforms, such as the da Vinci Single Port and Shurui Single Port systems, are particularly suitable for aesthetic plastic surgery because they provide a single access point, thereby minimizing visible scarring while preserving favorable cosmetic outcomes through minimally invasive surgical techniques.

The Shurui single-port platform has been shown to be feasible and safe, demonstrating low intraoperative complication rates, minimal blood loss, no surgical conversions, favorable postoperative pain scores, and shorter hospital stays, indicating strong clinical potential [39].

The da Vinci SP system has also demonstrated promising safety and feasibility. Its advantages include improved cosmetic outcomes, reduced postoperative pain, and faster recovery [51].

The integration of artificial intelligence (AI) may enhance preoperative planning by enabling faster and more accurate surgical decision-making. AI models and predictive analytics can support real-time perfusion assessment, assist in correct flap selection, and enhance imaging interpretation [52].

Augmented reality and haptic feedback technologies may reduce procedural complexity while improving integration with tissues by providing enhanced sensory feedback for surgeons. The development of user-friendly training systems for plastic surgeons may also improve the accessibility and adoption of robotic technology [53,54].

Furthermore, telemedicine represents a promising application of robotic surgical technology. Remote robot-assisted surgery may allow surgeons to operate on patients across different geographic locations, thereby helping to overcome access barriers. Because robotic surgery is minimally invasive,

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integrating telemedicine may improve patient outcomes, reduce surgeon cognitive load, increase satisfaction levels, and enhance collaboration between hospitals and surgeons [21,55].

9. Conclusions

The use of robotic systems in plastic surgery is still in the early stages of development, and only a limited number of studies have examined their application in aesthetic plastic surgery.

The advantages of robotic systems have been highlighted in the literature, including minimal visible scarring, lower complication rates, shorter rehabilitation periods, and the ability to operate in anatomically challenging regions with high precision, making robotic technology an important consideration for future implementation in the field.

However, due to the absence of standardized docking methods, further investigation is required, with particular emphasis on developing safe, reliable, and reproducible robotic docking protocols for aesthetic plastic surgery.

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