

A Scoping Review of Mobile Apps in Plastic Surgery: Patient Care, Trainee Education, and Professional Development

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Background: Over the past 10 years, smartphones have become ubiquitous, and mobile apps serve a seemingly endless number of functions in our everyday lives. These functions have entered the realm of plastic surgery, impacting patient care, education, and delivery of services. This article reviews the current uses of plastic surgery mobile apps, app awareness within the plastic surgery community, and the ethical issues surrounding their use in patient care.

Methods: A scoping review of electronically available literature within PubMed, Embase, and Scopus databases was conducted in two waves in November and May 2022. Publications discussing mobile application use in plastic surgery were screened for inclusion.

Results: Of the 80 nonduplicate publications retrieved, 20 satisfied the inclusion criteria. Articles acquired from the references of these publications were reviewed and summarized when relevant. The average American Society of Plastic Surgeons evidence rating of the publications was 4.2. Applications could be categorized broadly into three categories: patient care and surgical applications, professional development and education, and marketing and practice development.

Conclusions: Mobile apps related to plastic surgery have become an abundant resource for patients, attending surgeons, and trainees. Many help bridge gaps in patient care and surgeon-patient communication, and facilitate marketing and practice development. Others make educational content more accessible to trainees and performance assessment more efficient and equitable. The extent of their impact on patient decision-making and expectations has not been completely elucidated. (*Plast Reconstr Surg Glob Open* 2023; 11:e4943; doi: 10.1097/GOX.0000000000004943; Published online 13 April 2023.)

INTRODUCTION

The smartphone has become a universal appliance, with applications for seemingly every aspect of our lives. Google Android and Apple iOS have been the leading mobile operating systems since 2007. By 2021, both platforms held over 99% of the global market share.¹ People

rely on smartphone apps for note keeping, scheduling, financial management, navigation, news, entertainment, communication, and much more. Apps have revolutionized the way we interact with each other and the internet, which has impacted educational technology and online learning.

Web-based learning systems have also become increasingly prevalent over the last two decades.² As smartphone technology has progressed, so too has their ability to deliver educational resources. Resource accessibility has led to widespread incorporation into work and academic environments.^{3,4} A recent survey of physicians found that 91% own a smartphone, and 88% report frequent use in the clinical setting.⁴ Residents are even more likely than attending physicians to use smartphones for learning

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and accessing patient care information, a finding consistent with younger generations' widespread embrace of technology.⁵

The breadth of plastic and reconstructive surgery makes it particularly amenable to app development and implementation in the clinical environment. A 2016 study identified 273 Apple App Store and 250 Google Play apps related to plastic surgery, noting a 62% and 580% increase within each app store, respectively, since 2013.⁶ Apps related to plastic surgery include those for practice development, academic literature, clinical tools, and guidelines, as well as anatomic and surgical education for both patients and professionals.⁶⁻⁸ As these apps become more abundant, they will continue to change our approach to patient care, patient and trainee education, marketing practices, and professional development. This article offers a timely review of the current uses of plastic surgery mobile apps and explores the ethics of employing technology for clinical, academic, and marketing purposes.

METHODS

An initial search of the PubMed, Embase, and Scopus databases was performed as of November 16, 2020. The search terms included: cell phone app, cell phone application, mobile app, mobile application, smartphone app, smartphone application, Apple App Store, Google Play, and plastic surgery. Article screening and data extraction was performed by two independent reviewers (T.J. and N.R.J.). Secondary literature, literature reviews, responses, commentary, viewpoints, and publications that did not discuss mobile apps in plastic surgery, were unavailable in English, or did not have full text access were excluded. Articles were included if content focused on the use of specific mobile applications in plastic surgery. Due to the limited number of publications returned, no restrictions were made based on quality, study methods, or risk of bias. Only published literature was included for review.

Due to the interval of time between the initial search and article composition, an updated search of all electronically available articles published between November 16, 2020 and May 3, 2022 was subsequently conducted. Articles included from the initial search were not re-screened. Article screening of the second search was performed by two independent reviewers (B.E.M. and N.R.J.) and data extraction was performed by two independent reviewers (E.M.V. and N.R.J.). In the case of disagreement, a third reviewer (C.M.T.) adjudicated the study. Article citations were also reviewed for relevance and included if criteria was met. A citation attrition diagram is displayed in Supplemental Digital Content 1. (See figure, Supplemental Digital Content 1, which summarizes the citation attrition diagram of the literature search. <http://links.lww.com/PRSGO/C509>.)

RESULTS

The initial literature search procured 115 articles. Of these, 80 were nonduplicates. After primary review of titles and abstracts, 31 articles were excluded. After full text

Takeaways

Question: What are the current uses of mobile apps in plastic surgery?

Findings: Applications used in plastic surgery are related to patient care and surgical applications; professional development and education; and marketing and practice development.

Meaning: Mobile apps related to plastic surgery have become significant resources for surgeons, trainees, and patients. The extent of their impact, however, needs further elucidation.

review of the remaining 49 articles, an additional 30 articles were excluded. The remaining 19 publications satisfied inclusion criteria and are listed below. (See Supplemental Digital Content 2, which summarizes the included articles and applications. <http://links.lww.com/PRSGO/C510>.) Upon review of the references within the 19 articles, an additional article was found to meet inclusion criteria, bringing the number of total articles included to 20.⁹ Categorization by article type is as follows: app design and integration,¹⁰⁻¹⁴ app store review,^{4,15-17} interventional study with control group,^{9,18-20} clinical case series,²¹⁻²⁴ and nonclinical case series of trainees.²⁵⁻²⁷ Of the four interventional studies with control groups, two explicitly used randomization.^{19,20} The level of evidence of each patient care article was determined using the American Society of Plastic Surgeons Evidence Rating Scale.²⁸ The levels of evidence ranged from III to V, with an average rating of 4.2. Five articles contained authors who were also listed as developers for publicly available apps discussed within the article.^{4,11,12,19,23} Although most applications discussed within the articles were free to download, the costs of paid applications varied from \$0.69 to \$213 (Supplemental Digital Content 2, <http://links.lww.com/PRSGO/C510>).

DISCUSSION

Over the past decade, smartphones have quickly become a personal necessity worldwide. Their hardware and software applications have advanced at an even faster pace. There have been several notable changes since the last systematic review on mobile apps in plastic surgery was published in 2016.⁶ Increased interest in artificial intelligence and the acceptance of mobile technology in education and productivity has led to an upsurge in both number and quality of mobile apps dedicated to plastic surgery. Additionally, the COVID-19 pandemic has demonstrated a need for virtual patient care and trainee education platforms. We find that these apps can be classified into three general categories: patient care and surgical applications, professional development and education, and marketing and practice development (Supplemental Digital Content 2, <http://links.lww.com/PRSGO/C510>). The following discussion will highlight trends in each general category and areas for further research and development.

Patient Care and Surgical Applications

Before undergoing surgery, indications for surgery, surgical protocols, recovery, and potential complications should be discussed with patients. This has traditionally been achieved through in-office consultations, printed materials, and online resources; however, Carvalho et al designed a mobile application to supplement the consent process, making this information more accessible to patients.¹⁰

Mobile applications have the potential to streamline surgical planning. Two applications, OR-Stencil and OsiriX, have been piloted and demonstrated high usability among surgeons.^{11,21} Although it has not been formally quantified, these applications could improve individual efficiency, especially for trainees and junior surgeons. Additionally, they suggest the possibility of real-time use in the intraoperative setting. Aoki et al specifically tested this with OsiriX and found it to be useful for confirming correct graft and implant placement in maxillofacial surgery.²¹

In the immediate postoperative period, free flaps must be regularly monitored for signs of vascular compromise necessitating re-intervention. Monitoring is typically completed by junior residents and nursing staff, and the process of reporting critical findings to consultants or senior residents can be inefficient. Hwang et al and Engel et al both describe the utility of applications for photographic documentation and team-based communication for flap monitoring.^{9,18} Their data suggest that designing a specific protocol for flap monitoring addresses the need for rapid decision-making in the face of flap compromise and shortens the interval between compromise and surgical intervention.^{9,18}

Postoperative follow-up traditionally involves a combination of outpatient clinic appointments and home self-care. Smartphone technology may facilitate virtual follow-up in a timely and cost-effective manner. This can be achieved in several different ways, with common themes being the provision of personalized wound care instructions, postsurgical pain questionnaires, medication instructions, decision-making tools for postoperative complications, and virtual wound assessment via mobile application.^{12,13,22-24} Blanquero et al found that improved outcomes could be achieved in hand surgery by augmenting traditional physiotherapy with feedback-guided app-based physiotherapy between in-person appointments.¹⁹ Further research regarding the effects of these applications on outcomes is needed, but their implementation represents the potential to improve patient care.

Professional Development and Education

Electronic learning has permeated medical student, resident, and consultant education. E-books, web-based question banks, and online libraries have become common learning tools, and the abundance of virtual resources became a lifeline for those restricted from accessing in-person education in light of the COVID-19 pandemic.

Zingaretti et al surveyed 115 plastic surgery residents at an Italian academic program. Over half of the residents cited a perceived lack of virtual simulation alternatives

to compensate for decreased surgical activities caused by COVID-19.¹⁴ Touch Surgery was instituted as a proposed solution, providing a virtual learning experience through real surgical videos, complete with step-by-step explanations and assessments of procedures across different specialties.¹⁴ Similar to patient education applications, Touch Surgery provides an efficient educational method that can be accessed on demand. Additionally, applications can be remotely updated to reflect new technical advancements and learning techniques in plastic surgery more frequently than traditional print resources.²⁰

Just as mobile messaging applications can expedite patient care discussions, they can also be used to provide didactic and discussion-based learning.^{25,29} Although this has become more commonplace during the COVID-19 pandemic, Justicz et al further studied this format and found positive outcomes on written, oral, and practical assessments with average scores increasing from 24.6% to 86.9% following the WhatsApp-based curriculum.²⁵ As many institutions work to find a balance between in-person and virtual learning, further research must be conducted to determine the efficacy of each format.

Mobile platforms have also been used to evaluate trainees. Anecdotally, trainee evaluation methods can be inefficient and lack utility. The System for Improving and Measuring Procedural Learning (SIMPL) is a mobile application that uses a competency-based framework to track surgery trainees' progress toward mandatory milestones.²⁶ Almufarrej et al utilized a similar framework to enhance their department's evaluation of resident operative skills.²⁷

Marketing and Practice Development

The rise of smartphones was quickly followed by that of social media. Relevant to plastic surgery is its impact on cosmetic surgery clientele. Plastic surgeons have begun marketing their practices through social media and individualized apps more frequently.¹⁵ This rise is demonstrated by a 75% increase in available plastic surgery apps from 2013 to 2019.^{15,16} Indeed, marketing and communication between plastic surgeons and their patients has become commonplace on platforms like Facebook, Instagram, and TikTok.³⁰

Workman et al suggested that practice-based applications will be the basis for marketing expansion in plastic surgery.¹⁵ They conducted a comprehensive search of applications related to plastic surgery in the Apple App Store. Their search returned 54 practice-based apps that were created by surgeons who provide cosmetic services. Common themes for applications included photo morphing software that "predicts" postoperative results for prospective patients, pre- and postoperative photo galleries of existing patients, and information about the surgeons and their clinics.¹⁵ As various applications provide marketing opportunities, plastic surgery practices should be aware of evolving methods of patient outreach. However, surgeons ought to maintain high standards for their marketing materials, as Om et al raise concerns regarding the overall quality of plastic surgery content on social media and the subsequent risk of patient misinformation.³¹

Table 1. Ethical Implications of the Use of Mobile Apps in Plastic Surgery

Ethical Issue	Description	Examples	References
Challenges to the doctor-patient relationship	Expansion of AI in patient care challenges the traditional doctor-patient relationship	<ul style="list-style-type: none"> • Use of AI to determine free flap vascular viability • Use of facial recognition software in patient identification 	16, 21, 22
Patient data safety	Concerns of data management within emerging patient care apps	<ul style="list-style-type: none"> • Use of personal smartphones to capture patient photographs • Use of non-HIPAA compliant communication apps 	23, 25, 29
Smartphone ownership discrepancies	Lack of universal smartphone ownership prevents access to this aspect of care	<ul style="list-style-type: none"> • Growing use of smartphone applications risks accentuating socioeconomic inequities 	25, 26, 29

Table 2. Plastic Surgery App Patient Data Safety Measures

Application	Data Safety Measures
OsiriX ²¹	<ul style="list-style-type: none"> • HTTPS communication
OR-Stencil ¹¹	<ul style="list-style-type: none"> • Unknown
Kakao Talk ¹⁸	<ul style="list-style-type: none"> • Optional end-to-end encryption
Flap Monitoring App ⁹	<ul style="list-style-type: none"> • Encrypted email communication
Patient Communication App ²²	<ul style="list-style-type: none"> • HIPAA-compliant mobile device • HIPAA-compliant photograph database
The Bridge ¹²	<ul style="list-style-type: none"> • HIPAA-compliant 256-bit SSL encryption
ReHand ¹⁹	<ul style="list-style-type: none"> • Pseudonymization • HTTPS communications • Encryption
WhatsApp ²⁵	<ul style="list-style-type: none"> • End-to-end encryption

HTTPS, Hyper Text Transfer Protocol Secure.

Data Safety and Ethical Considerations

As app use by patients and providers continues to rise, ethical concerns regarding patient data safety, confidentiality, and the physician–patient relationship have been raised (Table 1). Current smartphone technology should not supplant the shared decision-making process between patient and provider, but rather augment it.^{32–34}

As mobile applications for patient care evolve, so should patient data safety measures. Of the eight applications with the potential to handle patient data, seven demonstrated some degree of data safety measures (Table 2). Data encryption techniques vary widely, and not all are guaranteed to be compliant with institutional or legal data safety requirements.²⁹ Awareness of these requirements is especially crucial in plastic surgery.

The highly visual component of plastic surgery has led surgeons to capture photographs with their personal smartphones for patient care and educational purposes. A survey of 147 Canadian plastic surgeons revealed the need to address confidentiality pitfalls in this methodology.³⁵ With 89.1% of respondents using their personal smartphones to capture patient photographs, 21% of respondents deleted the photographs after fulfilling their intended use, and 26% of respondents reported accidentally showing a patient photograph to a friend or family member.³⁵ Considering that 75% of the respondents stated that verbal consent alone was sufficient, the authors suggest that written consent should be obtained similar to the process used by professional medical photographers.³⁵ Patel echoes shortcomings of smartphone technology in plastic surgery, highlighting the need to ensure that mobile applications are Health Insurance Portability and Accountability Act (HIPAA) compliant.³⁶ Kohli and Geis reaffirm this notion, underscoring the

importance of patient consent and third-party data use oversight.³⁷

Lastly, although smartphone access among the world’s population has sharply increased over the last decade, it is by no means universal; 76% and 45% of individuals in advanced and emerging economies, respectively, own smartphones.³⁸ With socioeconomic status driving discrepancies in smartphone ownership, clinicians must ensure that mobile app integration does not accentuate healthcare inequities among different demographics.

Limitations

This review has several limitations. First, there is a paucity of current literature on mobile applications in plastic surgery. Therefore, no restrictions were placed on article selection based on quality of research or potential bias. Second, this study is a scoping review rather than a systematic review; emphasis was placed on providing an overview of current concepts and trends regarding mobile apps in plastic surgery rather than quantitative statistics. Lastly, many of the apps discussed do not have accessible data on number of downloads and user ratings, or are not publicly available. Therefore, it was not feasible to analyze app popularity or perceived usability. Additional quantitative analysis will be warranted as high-quality research continues to be published.

CONCLUSIONS

In plastic surgery, mobile apps have become an abundant resource for patients, attending surgeons, and trainees alike. Apps that facilitate postoperative surgical care and patient education are becoming increasingly prevalent. However, this review reveals the need for additional randomized control trials to assess outcomes for app-based patient care. For the private-practice surgeon, practice-based apps have also become popular. These apps are bridging gaps in care and communication between the surgeon and patient while facilitating marketing and practice development. Many apps containing academic literature, reference texts, study materials, and evaluation tools are primed to make educational content more accessible and performance assessment more efficient and equitable for trainees.

Although plastic surgery mobile apps and their range of uses seem to be growing exponentially, app awareness among the professional community does not seem to be following.²⁹ Though the benefits offered by integrating

mobile apps into a plastic surgery practice and training program are numerous, steps need to be taken to ensure security, validity, and availability to their intended users.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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