

Facial Rejuvenation: A Global Trend of Dermatological Procedures in the Last Decade

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Background: We aimed to track the global trend of cosmetic treatment outcomes for facial rejuvenation and the differences in modalities used in East Asian and Western populations.

Methods: Articles reporting on facial rejuvenation procedures (invasive/noninvasive) were identified in PubMed from 2013 to March 2023 and bibliometrically analyzed for type of published document, citation frequency, authors with most articles, author's affiliation, and frequency distribution of keywords.

Results: From 553 articles, most were published in 2021 (n = 86, 15.6%). Western countries (n = 323, 58.4%) contributed more than East Asian (n = 230, 41.6%), with more invasive interventions (n = 355, 64.2%) than noninvasive techniques (n = 198, 35.8%). Numbers of invasive techniques in West versus East Asian countries were 225 (40.7%) versus 135 (24.4%). Main indications were the reduction of facial wrinkles and antiageing treatments. Hyaluronic acid, fillers, and botulinum toxin were the main hotspots for invasive treatments, whereas laser, platelet-rich plasma, and radiofrequency were for noninvasive treatments. Nasolabial folds (13.4%) and glabellar lines (12.4%) were the top research hotspots in the East Asian and Western regions. Common adverse events were pain, erythema, swelling, and bruising. Approximately, 89.3% of publications were from single countries, whereas 10.7% of publications were from international collaborations. Most articles (n = 387; 69.95%) presented their findings using level II evidence. Dermatological surgery (IF = 2.914) had the greatest number of publications (n = 109; 19.71%).

Conclusions: The main hotspots were antiaging and youthfulness. This study provides a trend and a new perspective on the future research directions in the field of facial rejuvenation. (*Plast Reconstr Surg Glob Open* 2024; 12:e5801; doi: 10.1097/GOX.0000000000005801; Published online 4 June 2024.)

INTRODUCTION

Facial rejuvenation consists of treatment techniques that facilitates restoring the skin from any damage that is caused particularly by aging or sun exposure, including the restoration of damaged skin and the enhancement or elimination of sagging tissues through surgical interventions.¹ The valuation for global cosmetic surgery was at US \$63.4 billion in 2021, with a projected compound annual growth rate (CAGR) of 9.6% from 2022 to 2030.²

The global noninvasive aesthetic treatment is projected to expand at a CAGR of 15.40% from 2023 to 2030.³ North America is expected to be a key revenue-generating regional market, whereas East Asia, on the other hand, is currently the fastest growing region with a predicted CAGR of over 6.05% from 2019 to 2027.⁴⁻⁶

Facial aging is mainly caused by the loss of collagen and elastin, displacement of glycosaminoglycans, enlargement of fat in different locations, changes in muscle relaxation and length, and changes in the shape of bones.⁷ With this improved knowledge of facial anatomy, therapeutic strategies can be personalized to achieve more natural and harmonious treatment outcomes.⁸⁻¹² The main purpose of facial rejuvenation is to restore youthfulness either by noninvasive or invasive modalities.^{13,14}

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Noninvasive procedures are used for skin resurfacing, tissue tightening, rhytid reduction, and volume restoration. Several invasive and minimally invasive modalities are available for reversing the above changes associated with facial aging.^{15,16} Minimally noninvasive methods applied to reverse aging include botulinum toxin, dermal fillers, thread lifts, platelet concentrates, and radiofrequency waves. Invasive procedures include surgical procedures aimed to reposition facial soft tissues to achieve youthful and harmonious appearance include eyelid surgery, brow lift, face lift, and facial implants.^{16–19}

Ever since the first publication related to facial rejuvenation was published in 1912,²⁰ the literature on facial rejuvenation is increasing with the rapid development of invasive and new noninvasive procedures. In recent years, only one study regarding bibliometric analysis of facial rejuvenation has been published in 2022.²¹ In addition, most bibliometric analysis has focused on specific areas such as rhinoplasty²² and blepharoplasty.²³

Although the accessibility and affordability of aesthetic procedures have increased globally, the East Asian population differs from the Western (White) population in both facial appearance and baseline structural facial anatomy.^{24,25} Aesthetic procedures in East Asia have been influenced by Western procedures. However, understanding the similarities and differences in the usage of facial rejuvenation techniques between the two populations would enhance the development of targeted facial treatment based on ethnicity.

The present study aimed to identify the current trends and research hotspots related to facial rejuvenation globally as well as to identify the preferred procedures in Western population and East Asian population by conducting bibliometric analysis of the literature from 2013 to 2023.

METHODS

Data Sources and Search Strategy

PubMed articles from 2013 to March 2023 were analyzed for facial rejuvenation. PubMed, a search engine, was chosen for its accuracy. Preliminary analysis used article titles and specialized journals list. The search strategy is detailed in Table 1 and study design is illustrated in Figure 1.

Table 1. Search Terms and Inclusion and Exclusion Criteria

Search Terms
“facial plastic surgery,” “facial aesthetic surgery,” “facial cosmetic surgery,” “facial aesthetics,” “facial rejuvenation,” “eyelid rejuvenation,” “blepharoplasty,” “facelift,” “rhytidectomy,” “browlift,” “forehead lift,” “browplasty,” “endobrow,” “canthopexy,” “neck lift,” “platysmaplasty,” “botulinum toxin injections,” “dermal fillers,” “fillers,” “thread lifts,” “platelet concentrates,” “radiofrequency waves,” “laser lifts”
Inclusion
All “Journal” articles were included for screening from the PubMed search
Exclusion
Documents such as reviews, guidelines, letters, or editorials were excluded

Takeaways

Question: Identification of trends and research hotspots related to facial rejuvenation globally and to identify the preferred procedures in Western population and East Asian population.

Findings: This bibliometric analysis showed North America leading the market for facial rejuvenation techniques. The most-used invasive procedures include soft-tissue fillers, laser treatments, and radiofrequency- or ultrasound-based skin-tightening methodologies. Among noninvasive procedures, thermal approaches and topical applications were preferred.

Meaning: Although facial rejuvenation is prevalent around the world, an international collaboration for higher quality innovation in the future is warranted to achieve safer and effective techniques.

Data Collection and Statistical Methods

The articles were screened by two independent reviewers. Data collection strategy and methodological information are detailed in Table 2. Statistical analyses were conducted, and Microsoft Office Excel 2019 was used for graph preparation. VOSviewer (The Center for Science and Technology Studies, Leiden University, the Netherlands), a freely available Java-based software, is a widely used bibliometric tool that analyzes academic literature quantitatively.²⁶ VOSviewer was used to create network maps of co-authorship and co-occurrence analysis of author keywords using MEDLINE from the PubMed database. The resulting images consist of nodes and links in different colors. Nodes represent the analyzed elements such as authors, journals, or keywords, and their size indicates the number of citations or occurrences.²⁷ The links between the nodes reflected the relationship of co-citation or co-occurrence. The size of the node indicates the degree of co-occurrence or the frequency of citations, and the color of an item is determined by the cluster to which the item belongs. The attribute of the total link strength indicates the total strength of the co-authorship links of a given researcher with other researchers.²⁸

RESULTS

Publication Output

The bibliometric analysis of the literature of facial rejuvenation retrieved 553 articles from the PubMed database over the last 10 years (January 2013–July 2023), with an average of 50 publications per year. In 2021, the highest number of articles (86; 15.56%) was published. A polynomial curve fitting with an order of two suggested that the number of publications would reach 36 (6.51%) in 2023. However, the estimate was based on a lower correlation coefficient of 0.37 (Fig. 2). Among the total publications for invasive interventions (355; 64.2%), those published in the Western region (323; 58.4%) were higher than noninvasive (198; 35.8%) and East Asian regions (230; 41.6%). [See figure, Supplemental Digital

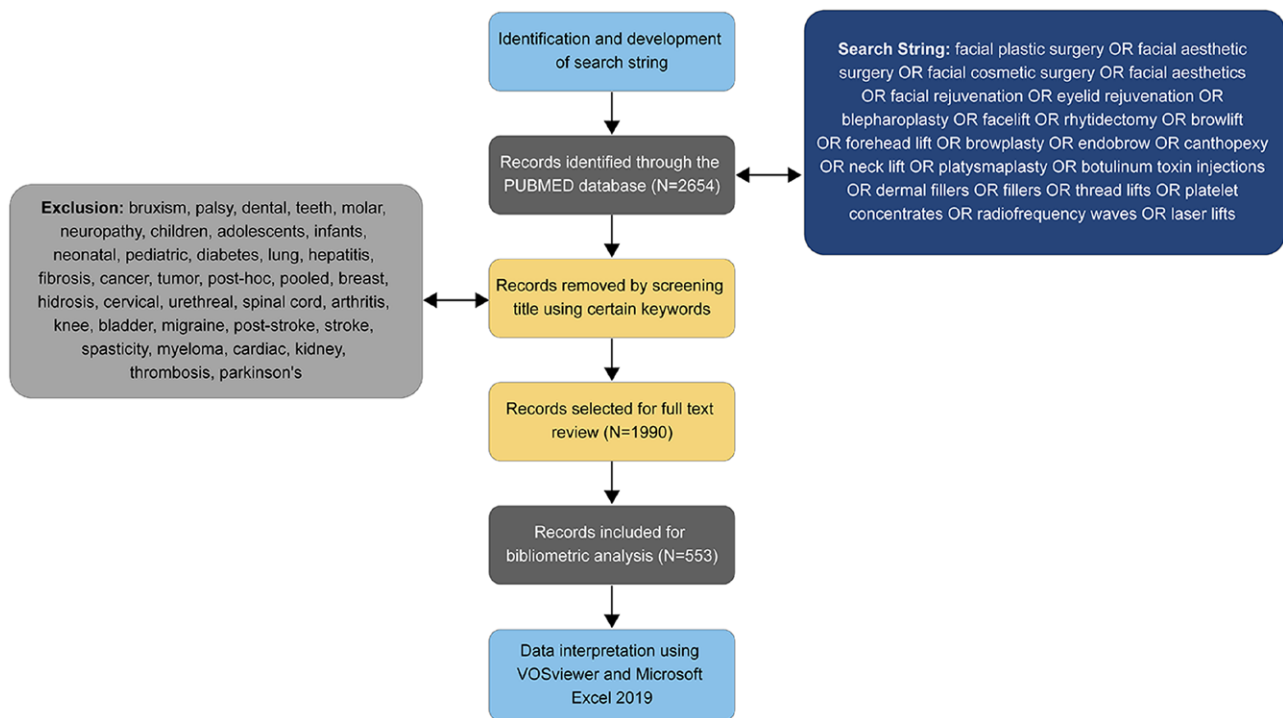


Fig. 1. Flow chart.

Table 2. Strategy for Data Collection and Full Methodological Information

Data Collection and Strategy
<ul style="list-style-type: none"> Articles were included only if their primary focus was facial rejuvenation. The retrieved articles were screened by two reviewers. Information on each included article was then extracted by two reviewers independently, including the title, month and year of publication, corresponding author with his/her address, publication type, and journal title, the affiliation of the corresponding author, and the source country (determined according to the affiliation of the corresponding author). The data were entered into Microsoft Office Excel 2019 (Microsoft Corporation). Any disagreements were resolved through discussion. Moreover, journal impact factors (JIF) were collected from the 2022 Journal Citation Reports and the citations were collected from PubMed.

Content 1, which displays publications (subgrouped). <http://links.lww.com/PRSGO/D194>. A year-wise distribution of publications based on these subgroups is illustrated in Supplemental Digital Content 2. [See figure, Supplemental Digital Content 2, which displays publications (year-wise). <http://links.lww.com/PRSGO/D195>.]

Countrywise Analysis

In total, 41 countries and two regions contributed to the published articles regarding facial rejuvenation. The top three contributing countries (Fig. 3), according to the number of publications, were the United States of America [USA; 148 (26.8%)], Republic of Korea [76 (13.7%)], and the People's Republic of China [62 (11.2%)]. The maximum number of publications (494; 89.3%) were from single countries. Western countries had a major number

of publications [323 (58.4%)], of which the USA contributed 45.8%. China and Korea contributed 52.2% of the total East Asian publications. [See figure, Supplemental Digital Content 3, which displays publications (country-wise). <http://links.lww.com/PRSGO/D196>]. A total of 59 (10.7%) studies were published in international collaborations. Maximum collaborations were in the Western region [50 (84.7%) publications], and 516 (93.2%) of the international collaboration studies were invasive in nature. The collaboration groups of North American and European (21), European (18), and USA and Canada (7) had the highest number of publications and were the most cited international groups with a total of 103 combined citations.

Analysis of Journals and Co-cited journals

Journal of the American Academy of Dermatology (IF = 15.487) was ranked the highest in the publications list. Table 3 shows the top 10 journals in terms of the number of publications, and the list of top 10 articles with the highest IF is presented in Table 4. *Dermatologic Surgery* was the top journal based on the total number of publications (n = 109; 19.7%) and combined citations (740), followed by the *Journal of Cosmetic Dermatology* (89; 16.1% publications; 470 combined citations) and *Journal of Drugs in Dermatology* (49; 8.9% publications; 167 combined citations; Table 5). The top three publications with the highest IF were published in *the Journal of the American Academy of Dermatology* and were based on skin rejuvenation and reduction of acne scars by using autologous PRP, polymethylmethacrylate (PMMA) microspheres and photodynamic therapy, respectively.

Overall Publications

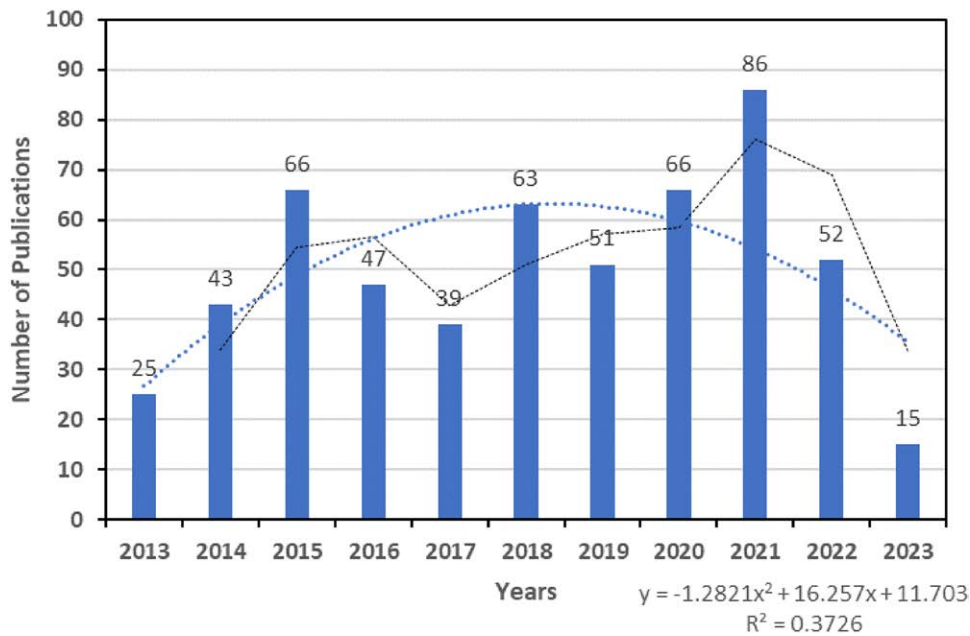


Fig. 2. Overall publications.

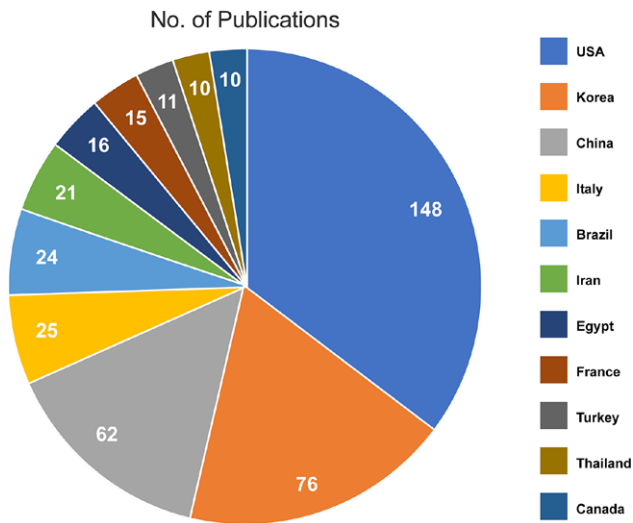


Fig. 3. Countrywise publications.

Analysis of Authors and Co-cited Authors

Co-authorship was analyzed by VOSviewer based on a minimum of five occurrences of authors in the publication list. A total of 50 authors were connected via links as per their occurrence strengths. Kim, Beom Joon was the most published author mentioned in 24 (4.3%) documents, followed by Cohen, Joel I. [14 (2.5%) publications; Table 6]. Kim explored various interventions primarily for nasolabial folds; facial volume defects; and facial wrinkles, including crow’s feet. This author extensively explored hyaluronic acid (HA) fillers and their application in facial volume defects and nasolabial folds, whereas botulinum toxin injections

were reported as interventions for wrinkles and crow’s feet. Supplemental Digital Content 4 shows the authors’ network, overlay, and density visualization obtained from VOSviewer. (See figure, Supplemental Digital Content 4, which displays the top cited authors analyzed from VosViewer. <http://links.lww.com/PRSGO/D197>.)

Most Cited Publications

A list of top 10 articles with the most citations is outlined in Table 7. All the top cited articles were published from 2014 to 2018. The top first, third, eighth, and ninth cited publications demonstrated the efficacy of PRP injections in facial wrinkles and rejuvenation. The second most cited (109) article focused on the reduction of unwanted submental fat with ATX-101 (deoxycholic acid) injection as an intervention. The usage of HA fillers was demonstrated in two publications for antiageing and lip enhancement.

Analysis of Author Keywords

The VOSviewer software was used to obtain visual maps of author keyword analysis. In total, 19 keywords met the threshold with a minimum frequency of seven occurrences and are listed in Table 8. The top five keywords with the most occurrences were HA, rejuvenation, facial rejuvenation, wrinkles and filler. HA had the largest node size with total link strength of 34. The network map colors indicate associations between keywords such as HA being linked to filler, nasolabial folds, wrinkles, and botulinum toxin. (See figure, Supplemental Digital Content 5, which displays the top author keywords analyzed from VosViewer. <http://links.lww.com/PRSGO/D198>.) In manual screening, HA and botulinum toxin

Table 3. Top 10 Journals as per Publications

Rank	Journal Name	Overall Occurrence	In Invasive Intervention	In Noninvasive Intervention	In East Region	In West Region
1	<i>Dermatologic Surgery</i>	109	85	24	23	86
2	<i>Journal of Cosmetic Dermatology</i>	89	48	41	46	43
3	<i>Journal of Drugs in Dermatology</i>	49	27	22	4	45
4	<i>Aesthetic Surgery Journal</i>	40	33	7	5	35
5	<i>Journal of Cosmetic & Laser Therapy</i>	26	15	11	18	8
6	<i>Aesthetic Plastic Surgery</i>	26	24	2	10	16
7	<i>Lasers in Medical Science</i>	21	5	16	16	5
8	<i>Lasers in Surgery and Medicine</i>	21	3	18	8	13
9	<i>Plastic and Reconstructive Surgery</i>	20	19	1	13	7
10	<i>JAMA Facial Plastic Surgery</i>	12	6	6	3	9

Table 4. Top 10 Publications with Highest IF

Rank	Title	Journal	Authors	IF	Year
1	Efficacy of autologous platelet-rich plasma combined with hyaluronic acid on skin facial rejuvenation: A prospective study	<i>Journal of the American Academy of Dermatology</i>	Hersant B, SidAhmed-Mezi M, Niddam J, La Padula S, Noel W, Ezzedine K, Rodriguez AM, Meningaud JP.	15.487	2017
2	A double-blind, randomized, multicenter, controlled trial of suspended polymethylmethacrylate microspheres for the correction of atrophic facial acne scars	<i>Journal of the American Academy of Dermatology</i>	Karnik J, Baumann L, Bruce S, Calender V, Cohen S, Grimes P, Joseph J, Shamban A, Spencer J, Tedaldi R, Werschler WP, Smith SR.	15.487	2014
3	Photodynamic therapy using chlorophyll-a in the treatment of acne vulgaris: a randomized, single-blind, split-face study	<i>Journal of the American Academy of Dermatology</i>	Song BH, Lee DH, Kim BC, Ku SH, Park EJ, Kwon IH, Kim KH, Kim KJ.	15.487	2014
4	Effect of platelet-rich plasma injection for rejuvenation of photoaged facial skin: a randomized clinical trial	<i>JAMA Dermatology</i>	Alam M, Hughart R, Champlain A, Geisler A, Paghdal K, Whiting D, Hammel JA, Maisel A, Rapcan MJ, West DP, Poon E.	11.82	2018
5	Efficacy of a needling device for the treatment of acne scars: a randomized clinical trial	<i>JAMA Dermatology</i>	Alam M, Han S, Pongprutthipan M, Disphanurat W, Kakar R, Nodzinski M, Pace N, Kim N, Yoo S, Veledar E, Poon E, West DP.	11.8	2014
6	Reduction of unwanted submental fat with ATX-101 (deoxycholic acid), an adipocytolytic injectable treatment: results from a phase III, randomized, placebo-controlled study	<i>British Journal of Dermatology</i>	Rzany B, Griffiths T, Walker P, Lippert S, McDiarmid J, Havlickova B.	11.113	2014
7	Randomized split-face, controlled comparison of treatment with 1565-nm nonablative fractional laser for enlarged facial pores	<i>British Journal of Dermatology</i>	Yu W, Zhu J, Ma G, Yang J, Qiu Y, Chen Y, Chen H, Jin Y, Yang X, Hu X, Wang T, Chang L, Lin X.	11.11	2018
8	Different injection patterns of incobotulinumtoxinA for crow's feet: a split-face comparative study	<i>Journal of the European Academy of Dermatology and Venereology</i>	Vachiramon V, Subpayasarn U, Triyangkulsri K, Jurairattanaporn N, Rattananukrom T.	9.228	2021
9	Efficacy, patient-reported outcomes and safety profile of ATX-101 (deoxycholic acid), an injectable drug for the reduction of unwanted submental fat: results from a phase III, randomized, placebo-controlled study	<i>Journal of the European Academy of Dermatology and Venereology</i>	Ascher B, Hoffmann K, Walker P, Lippert S, Wollina U, Havlickova B.	9.228	2014
10	Botulinum toxin type a injection for lateral canthal rhytids: effect on tear film stability and tear production	<i>JAMA Ophthalmology</i>	Ho MC, Hsu WC, Hsieh YT.	8.3	2014

Table 5. Top Journals Based on Combined Citations

Rank	Journal Name	No. Publications	IF	No. Citations Combined
1	<i>Dermatologic Surgery</i>	88	2.914	740
2	<i>Journal of Cosmetic Dermatology</i>	57	2.189	470
3	<i>Aesthetic Surgery Journal</i>	32	4.485	206
4	<i>Journal of Drugs in Dermatology</i>	32	1.527	167
5	<i>Lasers in Surgery and Medicine</i>	16	2.703	141

Table 6. Top Cited Authors Analyzed from VosViewer

Author	Documents	Total Link Strength	Region
Kim, Beom Joon	24	49	East
Cohen, Joel I	14	30	West
Kaufman-Janette, Joely	11	32	West
Choi, Sun Young	11	29	East
Goldman, Mitchel P	11	27	West
Shamban, Ava	10	28	West
Rzany, Berthold	9	29	West
Dayan, Steven	9	28	West
Baumann, Leslie	8	26	West
Ascher, Benjamin	6	27	West

injections constituted 19.5% and 16.1% of the total interventions, respectively. The PRP node (eight occurrences) was connected to the antiageing node, which was confirmed by manual screening (n = 15; 2.7%). Laser-based techniques were the most widely published noninvasive interventions (n = 70; 12.7%), followed by topical applications and radiofrequency (RF)-based interventions. Wrinkles had the maximum number of publications (56; 10.1%), followed by nasolabial folds and facial rejuvenation. Similar results were obtained from the network map illustrated by VOSviewer where rejuvenation and facial rejuvenation combined had 38 occurrences, followed by nasolabial folds (22; 4%) and wrinkles (16; 2.3%). Nasolabial folds, glabellar lines, and facial rejuvenation were the top-most treated conditions with invasive techniques, whereas wrinkles, facial rejuvenation, and acne-related indications were the top-most treated conditions with noninvasive techniques (Tables 8–10).

Analysis of Study Design

The published studies were evaluated as either level II (RCTs), level III (controlled trial without randomization), or level IV (case-control or cohort studies). Of the total 553 publications, 387 (70%) publications were RCTs and were assigned with level II evidence. Level III was assigned to 164 (29.7%) publications, and only two publications had level IV evidence. (See figure, Supplemental Digital Content 6, which displays the level of evidence based on the study design of publications. <http://links.lww.com/PRSGO/D199>.)

Adverse Events

The top ten instances of adverse events (AEs) are described in Table 11. Pain and pain-related events were the most prevalent type of AEs found in overall 103 (18.6%) publications. Of the 103 publications, 83 (80.6%) had invasive interventions. Therefore, pain can be further associated with invasive techniques where maximum occurrences were related to injection site. Overall, 96 (17.4%) publications reported erythema, which were equally distributed amongst invasive (45 publications) and noninvasive (51 publications) interventions. Swelling was reported by 72 publications, of which 63 (87.5%) publications were regarding invasive techniques. Fifty-two (9.4%) publications explicitly mentioned that no AEs were reported (Table 11).

Facial Rejuvenation in East Asian Population

A sizeable number of publications from the East Asian region [230 (41.6%)] makes it optimal for a direct comparison of publications between the geographical regions. (Supplemental Digital Content 1, <http://links.lww.com/PRSGO/D194>.) Maximum articles in the East Asian region were published between 2020 and 2022 (n = 98; 42.6% combined). (Supplemental Digital Content 2B, <http://links.lww.com/PRSGO/D195>.) China and Korea have dominated the publication landscape with a maximum number of publications, followed by Thailand (10 publications). Of the top 10 authors, only two were from the East Asian region (Table 6). This can be attributed to the fact that the USA has published more articles than articles of China and Korea combined. A total of 135 (58.7%) and 95 (41.3%) publications had invasive and noninvasive interventions, respectively (Supplemental Digital Content 2C, <http://links.lww.com/PRSGO/D195>.). The top five interventions administered in the East Asian region were laser (39), HA fillers (38), botulinum toxin injections (33), RF (15), and topical applications (15), whereas HA fillers (70) and botulinum toxin injections (56) were widely used in the Western region. The publications from the Western region combined are equal to the top five East Asian publications (Table 9). The top patient conditions were almost identical for the East Asian and Western regions with an exception of numerically higher acne- and scar-related indications (34 publications combined and 20 publications in the west, respectively; Table 10). Similarly, the incidence of AEs was nearly identical in both East Asian and Western publications, where erythema, pain, and swelling were the top AEs (Table 11). *The Journal of Cosmetic Dermatology* had the greatest number of publications for the East Asian region. *Dermatologic Surgery journal*, which had the most overall publications, had a very smaller number of publications from the East Asian region (23) when compared with the Western region (86; Table 3).

Risk of Bias and Funding Sources Assessment

We assessed the risk of bias in the included studies using the Jadad scale and the Agency for Healthcare Research and Quality assessment. The overall risk of bias was found to be 60%, indicating a moderate level of bias. Of the total 553 studies included in our analysis, 234 studies were funded. This represents approximately 42% of the studies reviewed. Notably, 30 studies among the funded ones were sponsored by Allergan, and 20 studies among the funded ones were sponsored by Galderma.

DISCUSSION

This study presents an overview of the current trends in the usage of facial rejuvenation procedures worldwide over the past decade. In addition, the study has brought out the differences and similarities in the use of aesthetic procedures between the Western and East Asian population.

Analysis Highlights

The year 2021 saw the largest number of articles published, as identified from the search with more publications

Table 7. Top 10 Cited Publications

Rank	Title	Key Indication	Journal	Author	Citations	Year
1	Assessment of efficacy of platelet-rich plasma (PRP) on infraorbital dark circles and crow's feet wrinkles	Dark circles and crow's feet wrinkles	<i>Journal of Cosmetic Dermatology</i>	Mehryan P, Zartab H, Rajabi A, Pazhoohi N, Firooz A.	123	2014
2	Efficacy, patient-reported outcomes and safety profile of ATX-101 (deoxycholic acid), an injectable drug for the reduction of unwanted submental fat: results from a phase III, randomized, placebo-controlled study	Unwanted submental fat	<i>Journal of the European Academy of Dermatology and Venereology</i>	Ascher B, Hoffmann K, Walker P, Lippert S, Wollina U, Havlickova B.	109	2014
3	Assessment of the efficacy and safety of single platelet-rich plasma injection on different types and grades of facial wrinkles	Facial wrinkle	<i>Journal of Cosmetic Dermatology</i>	Elnehrawy NY, Ibrahim ZA, Eltoukhy AM, Nagy HM.	68	2017
4	Noninsulated smooth motion, micro-needles RF fractional treatment for wrinkle reduction and lifting of the lower face: international study	Wrinkles	<i>Lasers in Surgery and Medicine</i>	Gold M, Taylor M, Rothaus K, Tanaka Y.	58	2016
5	Antiaging and filling efficacy of six types hyaluronic acid based dermo-cosmetic treatment: double-blind, randomized clinical trial of efficacy and safety	Antiaging	<i>Journal of Cosmetic Dermatology</i>	Nobile V, Buonocore D, Michelotti A, Marzatico F.	46	2014
6	Safety and effectiveness of VYC-15L, a hyaluronic acid filler for lip and perioral enhancement: one-year results from a randomized, controlled study	Lip and Perioral Enhancement	<i>Dermatologic Surgery</i>	Geronemus RG, Bank DE, Hardas B, Shamban A, Weichman BM, Murphy DK.	39	2017
7	Five-year safety and satisfaction study of PMMA-collagen in the correction of nasolabial folds	Nasolabial Folds	<i>Dermatologic Surgery</i>	Cohen S, Dover J, Monheit G, Narins R, Sadick N, Werschler WP, Karnik J, Smith SR.	38	2015
8	Effects of platelet-rich plasma on wrinkles and skin tone in Asian lower eyelid skin: preliminary results from a prospective, randomized, split-face trial	Wrinkles	<i>European Journal of Dermatology</i>	Kang BK, Shin MK, Lee JH, Kim NI.	36	2014
9	Expanded stem cells, stromal-vascular fraction, and platelet-rich plasma enriched fat: comparing results of different facial rejuvenation approaches in a clinical trial	Facial rejuvenation	<i>Aesthetic Surgery Journal</i>	Rigotti G, Charles-de-Sá L, Gontijo-de-Amorim NF, Takiya CM, Amable PR, Borojevic R, Benati D, Bernardi P, Sbarbati A.	35	2016
10	Three-dimensional volumetric analysis of 3 fat-processing techniques for facial fat grafting: a randomized clinical trial	Facial fat grafting	<i>JAMA Facial Plastic Surgery</i>	Wu R, Yang X, Jin X, Lu H, Jia Z, Li B, Jiang H, Qi Z.	32	2018
11	Preoperative use of dexamethasone in rhinoplasty: a randomized, double-blind, placebo-controlled clinical trial	Rhinoplasty	<i>JAMA Facial Plastic Surgery</i>	Valente DS, Steffen N, Carvalho LA, Borille GB, Zanella RK, Padoin AV.	32	2015

identifying invasive procedures. This trend can be attributed to a surge in the facial rejuvenation procedures during the COVID-19 pandemic.^{29,30} Approximately 12 countries published 10 or more articles, of which most were from the USA, followed by the Republic of Korea and China. Market country level analysis suggests that North America will lead the facial rejuvenation market closely followed by the East Asian countries.⁴⁻⁶ Most of the ongoing clinical trials as sourced by ClinicalTrials.gov registry (n = 26) were from single countries with the USA leading the list. (See figure, Supplemental Digital Content 7, which displays the ongoing clinical trials. <http://links.lww.com/PRSGO/D200>). Two trials were initiated from Asia Pacific, suggesting a need for registering the trials in international registry that would provide wider accessibility. However, international collaboration was few (10.7%), with the USA collaborating with Canada and major

European countries. As facial rejuvenation has been rapidly emerging in recent times, international collaboration associated with higher quality innovation would be beneficial in the future.

Furthermore, this analysis suggested that the percentage of level II/III studies was consistent till 2017 [219 (39.6%) publications combined] and has increased from 2018 till the present date [332 (60.1%) publications combined]. Level II studies are exponentially higher each year with a ratio of 2.7:1 (level II:level III). Moreover, 70% of the studies were RCTs, indicating significantly higher quality research throughout the timeline. Most research on facial rejuvenation has only been conducted in a few countries such as the USA, the Republic of Korea, and China. Articles from the top four journals (66.8% of the total searches; Table 3) in the research area of dermatology accounted for the maximum publications in both invasive

Table 8. Top 19 Author Keywords Analyzed from VosViewer

Rank	Keyword	Occurrences	Total Link Strength
1	Hyaluronic acid	33	34
2	Rejuvenation	21	18
3	Facial rejuvenation	17	13
4	Wrinkles	16	15
5	Filler	12	18
6	Nasolabial fold	11	14
7	Nasolabial folds	11	11
8	Botulinum toxin	11	3
9	Laser	10	5
10	Skin rejuvenation	9	4
11	Blepharoplasty	9	1
12	Platelet-rich plasma	8	5
13	Skin aging	8	5
14	Rhinoplasty	8	0
15	Antiaging	7	9
16	Wrinkle	7	7
17	Dermal filler	7	5
18	Radiofrequency	7	4
19	Acne vulgaris	7	1

Table 9. Top 10 Interventions (MS Excel Screening)

Rank	Intervention	No. Publications	East	West
1	Hyaluronic acid	108	38	70
2	Botox	89	33	56
3	Laser	70	39	31
4	Topical application	47	15	32
5	Radiofrequency	28	15	13
6	Fillers	23	8	15
7	Rhinoplasty	19	8	11
8	Surgical	17	8	9
9	Platelet-rich plasma	15	9	6
10	Light	12	5	7

and noninvasive procedures and were in the top citation list (Table 5). Publications from the Western region were more compared with the East Asian region, suggesting a need for publishing data from the East Asian counterpart to be accessible worldwide.

Current Trend in Invasive Techniques

Many of the invasive techniques, such as soft-tissue fillers, and noninvasive treatments, such as laser treatments and RF- or ultrasound-based skin-tightening methodologies used today were introduced within the last decade. The major key words identified among invasive techniques were HA, fillers, and botulin toxin, whereas PRP was discussed in the top cited articles. In addition to these research areas, trials related to blepharoplasty have been initiated. Dermal fillers have been used increasingly to improve facial appearance, as they can provide a long-lasting soft-tissue augmentation. However, complications such as intravascular occlusions may occur, which can be minimized using the clear understanding of anatomy of the face and injection techniques by the physicians.³¹ HA injectable formulations, the most commonly used fillers, are known to fill the wrinkles and add volume to the face. A recent systematic review by Akinbiy

et al, 2020, determined that injectable HA alone can improve hydration, skin texture, radiance, and elasticity.³¹ Other prominent long-acting fillers available are PMMA, poly L-lactic acid, and calcium hydroxyapatite. In addition, botulinum toxin A is a neuro toxin injection, which is widely used for the cosmetic indications to remove lines and wrinkles through the transitory and reversible paralysis of treated muscles.^{32,33} A recent meta-analysis including 9669 patients established the acceptable safety profile of botulinum toxin A injections for facial rejuvenation for patients from countries across the globe.³⁴ PRP, a mixture of highly concentrated platelets and growth factors derived from plasma, shows beneficial effects on the health of epidermal cells’ and efficient tissue damage recovery. Currently, PRP is routinely used by the plastic and cosmetic surgeons and dermatologists who have extensive experience in skin tissue repair.³⁵ A systematic review compiling social media marketing identified blepharoplasty (surgery to remove excess skin from the eyelids) to be most commonly performed in patients aged more than 70 years.³⁶ Our analysis identified nasolabial folds and glabellar lines as the commonly treated indications with invasive techniques.

Current Trend in Noninvasive Techniques

Thermal approaches (laser-based technique and RF-based intervention) and topical applications are widely preferred noninvasive techniques as per the current analysis. Thermal ablation methods deliver the drugs systematically through the skin by heating the skin surface without damaging deeper tissue,³⁷ whereas topical application is widely used to rejuvenate the skin surface. Recently, the demand for noninvasive facial rejuvenation is on the increase, making it imperative for plastic surgeons to master noninvasive techniques for restoring a youthful facial appearance.³⁸ This analysis identified that wrinkles and acne-related indications were commonly treated with noninvasive techniques.

AEs Associated with Aesthetic Procedures

Pain, pain-related events, and swelling were the most associated with invasive interventions at injection site, whereas erythema was observed across invasive and noninvasive interventions. Swelling was reported by 72 publications, of which 63 (87.5%) publications were invasive techniques. Bruising and swelling were associated with dermal fillers.³⁹ In particular, pain and swelling are the associated AEs with HA dermal filler.⁴⁰ However, headaches, eyelid ptosis, and heavy eyelids were associated with botulin toxin injections.⁴¹ Furthermore, ablative lasers are associated with few AEs.⁴²

Similarities and Differences in Current Trend between the Western and East Asian Population

The aesthetic procedures adapted by plastic physicians/surgeons will aim at the optimization of ethnic features, anatomical differences, and ideals of appearances from either the East Asian or Western population.²⁵ Our analysis identified that laser, HA fillers, botulinum toxin injections, RF, and topical applications administered

Table 10. Top 10 Indications (MS Excel Screening)

Rank	Indication	East	West	Invasive	Noninvasive	Total
1	Wrinkles	25	31	26	30	56
2	Nasolabial folds	30	23	50	3	53
3	Facial rejuvenation	21	29	29	21	50
4	Glabellar lines	5	38	41	2	43
5	Acne-related indications	18	10	8	20	28
6	Nasal shape	12	15	20	7	27
7	Scars	16	10	13	13	26
8	Face treatment	9	12	10	11	21
9	Photodamage	6	14	3	17	20
10	Skin aging	5	14	7	12	19

Table 11. Adverse Events

Rank	AE Name	Overall Occurrences	Invasive Intervention	Noninvasive Intervention	East Region	West Region
1	Pain	103	83	20	45	58
2	Erythema	96	45	51	55	41
3	Swelling	72	63	9	28	44
4	Edema	67	37	30	37	30
5	No AE	52	28	24	23	29
6	Bruising	52	47	5	17	35
7	Headache	35	34	1	2	33
8	Pigmentation	33	10	23	22	11
9	Redness	30	24	6	10	20
10	Tenderness	26	24	2	10	16

in the East Asian region demonstrate an equal balance between the invasive and noninvasive techniques, unlike the Western population, where HA fillers and botulinum toxin injections are widely used. To date, most of the studies regarding facial injection are related to the Western population, as observed by Cui et al.⁴³ However, contrary to the popular belief, invasive and noninvasive techniques are increasingly used in the East Asian region.⁴³ Numerically higher acne- and scar-related indications where treatment was sought were observed with the East Asian population compared with the Western region. In line with this observation, Lv et al observed that the Asian skin is more prone to hyperpigmentation and scarring.⁴⁴ Nasolabial folds and glabellar lines are the top research hotspots in the East Asian and Western regions, respectively. Furthermore, a similar incidence of AEs was observed between East Asian and Western populations.

CONCLUSIONS

Facial rejuvenation, particularly invasive procedures, has gained popularity, with North America and Asia Pacific leading the market. The most-used invasive procedures include soft-tissue fillers, laser treatments, and RF- or ultrasound-based skin-tightening methodologies. Among noninvasive procedures, thermal approaches and topical applications are preferred. AEs such as pain, swelling and erythema are commonly associated with these procedures. There is a need for international collaboration for higher quality innovation in the future; more research from the East Asian counterpart needs to be published, and the same should be accessible worldwide.

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