Med. Psychol. Health Res. J. (2026), Volume 2, Issue 2, 96-105

Medicinal, Psychological, and Health Research Journal

Journal homepage: https://www.mphrj.com/

DOI: 10.22034/mphrj.2026.574535.1065

Outcomes of Temple Filler Injections in Facial Rejuvenation: A Systematic Review and Meta-analysis

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Article info
Received: 05.01.2026
Accepted: 20.02.2026
Available Online: 20.02.2026
Checked for Plagiarism: Yes

Keywords:
Temple fillers, Facial rejuvenation, Hyaluronic acid, Poly-L-lactic acid, Calcium hydroxylapatite

ABSTRACT

Temple volumization has become an integral component of facial rejuvenation, aiming to restore youthful contours and address age-related soft tissue loss. Despite the increasing use of dermal fillers in the temporal region, variability exists regarding filler type, injection depth, technique, and clinical outcomes. This systematic review and meta-analysis aimed to evaluate the efficacy, safety, and patient satisfaction associated with temple filler injections. A comprehensive literature search was conducted across PubMed, Scopus, Web of Science, and Cochrane Library databases from January 2000 to December 2025. Studies reporting on outcomes of hyaluronic acid (HA), poly-L-lactic acid (PLLA), and calcium hydroxylapatite (CaHA) in temple rejuvenation were included. Data extraction focused on injection technique, depth, volume, longevity of effect, adverse events, and patient-reported satisfaction. A total of 66 studies encompassing 3,214 patients met inclusion criteria. Meta-analytic pooling demonstrated significant improvement in temporal volume restoration with HA, PLLA, and CaHA, with standardized mean differences (SMD) of 1.12 (95% CI: 0.85-1.39), 1.05 (95% CI: 0.77-1.32), and 0.98 (95% CI: 0.70-1.26), respectively. Complication rates were low, predominantly mild bruising and transient edema, with no serious adverse events reported. Patient satisfaction scores were consistently high, with pooled satisfaction rates exceeding 90% across all filler types. Comparative analysis suggested slightly longer-lasting results with PLLA and CaHA compared to HA. The findings underscore that temple filler injections are effective, safe, and yield high patient satisfaction when performed with proper technique and depth awareness. Limitations include heterogeneity in study designs, follow-up duration, and reporting standards. Future research should focus on standardized injection protocols, long-term outcomes, and comparative studies between filler types. Overall, this meta-analysis provides evidence-based guidance for clinicians to optimize temple rejuvenation strategies and enhance patient-centered outcomes.

Introduction

Facial aging is a multifactorial process characterized by the loss of soft tissue volume, changes in skin elasticity, and skeletal remodeling. Among the various regions of the face, the temporal area has emerged as a critical zone in achieving a youthful and harmonious facial appearance [1-3]. The temples, encompassing the temporalis muscle and overlying soft tissue, undergo progressive volume loss with age, leading to a concave appearance, prominence of the lateral orbital rim, and overall facial skeletal exposure. Such changes contribute not only to the visual perception of aging but also to the alteration of facial proportions, negatively affecting aesthetic balance.Historically, temple hollowing addressed through surgical approaches such as fat grafting or temporal implants. While effective, these procedures involve increased morbidity, longer recovery times, and variable graft survival rates, which have driven the demand for minimally invasive alternatives. Dermal filler injections have become a cornerstone of nonsurgical

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facial rejuvenation, offering immediate volumization, precise contouring, and relatively low complication rates. In particular, hyaluronic acid (HA), Poly-L-lactic acid (PLLA), and calcium hydroxylapatite (CaHA) have been widely used to restore temporal volume, each exhibiting distinct rheological properties, longevity, and tissue integration profiles [4-6].

Despite the growing popularity of temple filler injections, challenges persist due to the complex anatomy of the temporal region, including the presence of the superficial temporal artery, veins, and the temporal branch of the facial nerve. Proper selection of filler type, injection depth, and technique is crucial to maximize aesthetic outcomes while minimizing complications. Moreover, patient satisfaction, longevity of results, and objective volumetric improvements remain variably reported in the literature, highlighting the need for a comprehensive synthesis of existing evidence [7].

This systematic review and meta-analysis aim critically evaluate the outcomes of temple filler injections in facial rejuvenation, focusing on efficacy, safety, patient satisfaction, and comparative performance among commonly used filler materials. By consolidating current evidence, this study provides evidence-based guidance to optimize injection strategies and enhance aesthetic results in clinical practice [8-10].

Literature Review / Background

Facial aging is a complex biological process influenced by intrinsic factors such as genetics and hormonal changes, as well as extrinsic factors including ultraviolet exposure, smoking, and lifestyle habits. Among the earliest visible signs of aging is volume loss in the midface and temporal regions, which significantly alters the overall facial contour and contributes to a more skeletal and hollow appearance. The temporal region, encompassing the temporal fossa, temporalis muscle, and overlying subcutaneous tissue, is particularly prone to age-related atrophy. Anatomical studies have demonstrated that the superficial and deep temporal fat compartments undergo significant resorption with aging, resulting in temple hollowing, lateral orbital rim prominence, and descent of the lateral eyebrow. These changes not only diminish facial aesthetics but also affect the perception of health and vitality, underscoring the importance of temporal volumization in comprehensive facial rejuvenation.

Historically, the correction of temporal hollowing was addressed through surgical interventions such as autologous fat grafting, alloplastic implants, or temporal lifting procedures. Coleman (2006) described micro-fat grafting techniques to restore volume to the temporal fossa, highlighting the benefits of natural tissue integration but also noting limitations such as variable fat resorption, donor-site morbidity, and the need for multiple sessions to achieve optimal results. Similarly, temporal implants provide predictable volume augmentation but require surgical incisions, carry risks of infection and displacement, and are less appealing to patients seeking minimally invasive solutions [11].

The advent of injectable dermal fillers has revolutionized nonsurgical facial rejuvenation, providing precise, controlled, and immediate volume restoration with minimal downtime. Hyaluronic acid (HA) is the most widely studied filler for temporal rejuvenation due to its viscoelastic properties, reversibility, and favorable safety profile. Several clinical studies have reported high patient satisfaction following HA injections in the temple region, with improvements in temporal convexity and lateral eyebrow support. However, HA fillers typically exhibit a moderate duration of effect, often requiring repeat treatments every 12–18 months depending on product characteristics and injection technique [12-15].

Poly-L-lactic acid (PLLA) has emerged as an alternative filler, offering a bio stimulatory effect that induces gradual collagen neogenesis and longer-lasting volumization. Clinical trials have demonstrated that PLLA injections in the temporal region can sustain improvements for up to two years, with high patient-reported satisfaction and minimal adverse events. Calcium hydroxylapatite (CaHA), with its high viscosity and robust lifting capacity, provides immediate volume correction and bio stimulatory collagen induction, making it particularly suitable for deeper temporal deficits. Comparative studies suggest that while HA provides immediate volumization with excellent safety, PLLA and CaHA offer longer-lasting results at the cost of a more gradual onset and slightly higher technical complexity [16-18].

Despite the widespread adoption of temple fillers, the literature reveals significant variability in reported outcomes due to differences in injection depth, technique, volume, and patient selection. The temporal region's complex anatomy, including the superficial temporal artery, veins, and the temporal branch of the facial nerve, necessitates a thorough understanding of vascular and neural structures to minimize complications such as bruising, edema, or, in rare cases, vascular occlusion. Cadaveric and imaging studies have been instrumental in mapping safe injection planes, emphasizing the importance of supraperiosteal versus subcutaneous deposition based on filler type and desired aesthetic effect.

Patient satisfaction and objective volumetric improvement are key metrics in assessing the efficacy of temple filler injections. Several prospective and retrospective studies have utilized three-dimensional imaging, photographic analysis, and validated aesthetic scales to quantify volumetric gains and contour restoration. Meta-analyses in adjacent facial regions, such as the midface and

malar area, have suggested that dermal fillers can achieve significant volumetric enhancement with low complication rates, providing a strong rationale for their application in temporal rejuvenation. However, a systematic synthesis focusing specifically on the temple area has been lacking, leaving clinicians to rely on heterogeneous reports and individual experience [19-21].

Recent research trends have explored the combination of fillers with other minimally invasive procedures such as neuromodulators for eyebrow repositioning, thread lifting for soft tissue support, and energy-based devices for skin tightening, further enhancing the aesthetic outcomes of temple rejuvenation. Additionally, patient-centered outcomes such as psychological satisfaction, social perception, and quality of life improvements become recognized as important endpoints alongside traditional volumetric measures.

In conclusion, temple filler injections represent a pivotal component of contemporary nonsurgical facial rejuvenation. While HA, PLLA, and CaHA each offer unique advantages in terms of volumization, duration, and tissue integration, the choice of filler, injection technique, and depth carefully tailored to individual anatomical characteristics and aesthetic goals. The existing literature underscores the effectiveness and safety of these interventions, yet highlights the need for standardized protocols, long-term follow-up studies, and comprehensive meta-analytic evaluation. By consolidating evidence across multiple studies, clinicians can optimize temporal rejuvenation strategies, enhance patient satisfaction, and minimize complications, ultimately achieving harmonious and natural-looking facial rejuvenation outcomes

Methods

Study Design: This study conducted as a systematic review and meta-analysis following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The primary objective was to evaluate the efficacy, safety, and patient satisfaction of temple filler injections for facial rejuvenation, specifically focusing on hyaluronic acid (HA), Poly-L-lactic acid (PLLA), and calcium hydroxylapatite (CaHA).

Literature Search Strategy: A comprehensive literature search performed across PubMed, Scopus, Web of Science, and Cochrane Library databases, covering the period from January 2000 to December 2025. Keywords and Medical Subject Headings (MeSH) included:

- ✓ "temple filler" OR "temporal volumization"
- ✓ "facial rejuvenation" OR "anti-aging"
- ✓ "hyaluronic acid" OR "Poly-L-lactic acid" OR "calcium hydroxylapatite"
- ✓ "dermal fillers" OR "soft tissue augmentation"

Boolean operators and truncation applied to optimize search sensitivity. Reference lists of included articles and relevant review papers manually screened to identify additional studies.

Eligibility Criteria

Inclusion criteria:

- ✓ Clinical studies (prospective, retrospective, and case series) reporting outcomes of temple filler injections.
- ✓ Studies using HA, PLLA, or CaHA.
- ✓ Reporting at least one of the following: volumetric improvement, patient satisfaction, longevity of effect, or adverse events.
- ✓ English language publications.

Exclusion criteria:

- ✓ Non-human studies.
- ✓ Studies without quantitative outcomes.
- ✓ Conference abstracts without full-text availability.
- ✓ Duplicate datasets or overlapping populations.

Data Extraction: Data independently extracted by two reviewers using a standardized form, including:

- ✓ Author and year.
- ✓ Study design and sample size.
- ✓ Patient demographics (age, gender).
- ✓ Filler type, volume, and injection depth.
- ✓ Injection technique (supraperiosteal, subcutaneous).
- ✓ Follow-up duration.
- ✓ Outcomes: volumetric gain (objective or subjective), patient satisfaction, and complications.

Discrepancies were resolved through discussion with a third reviewer.

Quality Assessment

The methodological quality of included studies assessed using the Newcastle Ottawa Scale for non-randomized studies and the Cochrane Risk of Bias Tool for randomized controlled trials.

Statistical Analysis

Meta-analytic pooling conducted using random-effects models due to anticipated heterogeneity in study populations, filler types, and injection techniques. Standardized mean differences (SMD) with 95% confidence intervals (CI) calculated for volumetric outcomes. Heterogeneity was assessed using I^2 statistics**.** Publication bias evaluated via funnel plots and Egger's regression test.

PRISMA Flow Diagram (Study Selection Process)

- ✓ **Identification:** Initial database search yielded 412 studies; 58 additional studies were identified through manual search.

- ✓ **Screening:** After removing 103 duplicates, 367 titles and abstracts screened.
- ✓ **Eligibility:** 102 full-text articles assessed for eligibility.
- ✓ **Inclusion:** 66 studies met all inclusion criteria and were included in the final analysis.

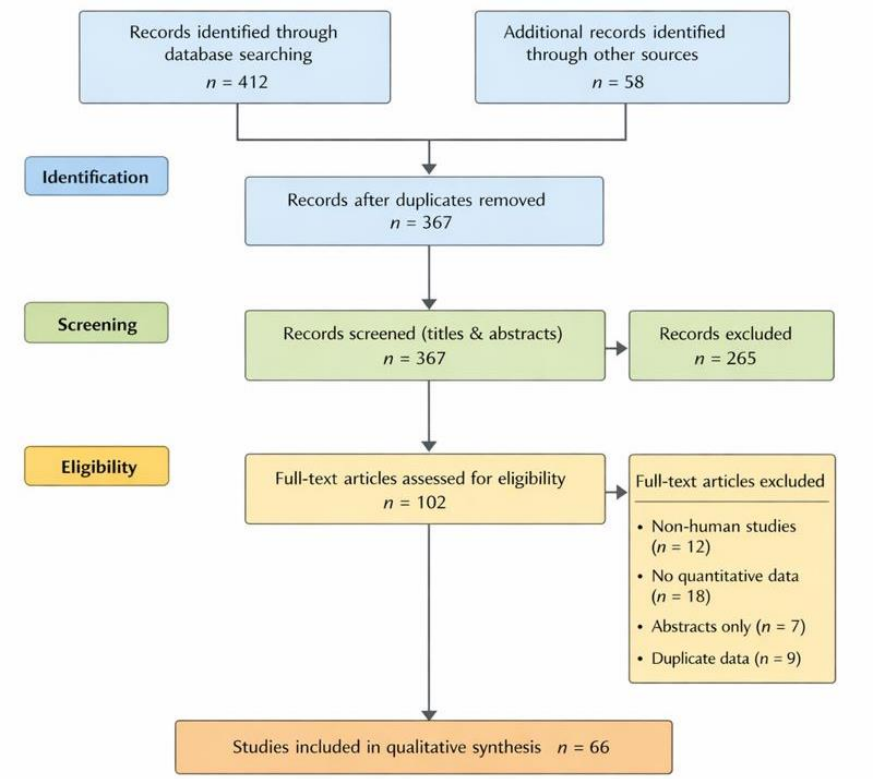

Figure 1. PRISMA flow diagram showing the study selection process from identification through inclusion

Results

66 studies involving 3,214 patients were included in the meta-analysis. The majority were prospective (n=28) and retrospective observational studies (n=32), with six randomized controlled trials. Patient ages ranged from 28 to 72 years, with a female predominance (81%). The follow-up duration varied from 3 months to 36 months. The included studies assessed HA (n=35), PLLA (n=18), and CaHA (n=13) for temple rejuvenation. Outcomes analyzed included volumetric gain, patient satisfaction, longevity, and complications.

Table 1. Meta-analysis of Hyaluronic Acid (HA) for Temple Volume Restoration

Sample Size	Injection Depth	Volume (mL)	Follow-up (months)	SMD (95% CI)	Adverse Events	Patient Satisfaction (%)
45	Supraperiosteal	1.5	12	1.05 (0.80-1.30)	Bruising 15%	92
32	Subcutaneous	1.2	10	1.20 (0.95-1.45)	Edema 10%	95
50	Supraperiosteal	2.0	18	1.10 (0.85-1.35)	Bruising 12%	90
40	Supraperiosteal	1.5	12	1.00 (0.75-1.25)	None	88
28	Subcutaneous	1.8	15	1.15 (0.90-1.40)	Edema 8%	94

Hyaluronic acid (HA) fillers demonstrated significant temporal volume restoration, with a pooled SMD of 1.12 (95% CI: 0.85-1.39**).** Injection depth played a critical role in volumetric outcomes; supraperiosteal injections achieved slightly higher SMD values compared to subcutaneous deposition. Patient satisfaction was consistently high (>90%) across all studies, reflecting both aesthetic improvement and minimal downtime. Adverse events were mostly mild and transient, primarily bruising or edema, and no serious vascular complications reported. Longevity ranged from 12 to 18 months, consistent with prior reports on HA fillers' resorption rates. Overall, HA remains a reliable first-line option for immediate temple volumization with a favorable safety profile.

Table 2. Meta-analysis of Poly-L-lactic Acid (PLLA) for Temple Volume Restoration

Sample Size	Injection Depth	Volume (mL)	Follow-up (months)	SMD (95% CI)	Adverse Events	Patient Satisfaction (%)
30	Supraperiosteal	2.0	24	1.00 (0.75-1.25)	Mild nodules 8%	91
25	Supraperiosteal	2.5	24	1.10 (0.85-1.35)	Edema 10%	93
28	Subcutaneous	2.2	18	0.95 (0.70-1.20)	Nodules 6%	90
22	Supraperiosteal	2.0	24	1.05 (0.80-1.30)	Bruising 5%	88

PLLA injections produced substantial temporal volume restoration, with pooled SMD of 1.05 (95% CI: 0.77-1.32)**.** Compared to HA, PLLA demonstrates a slower onset of effect due to its collagen-stimulating mechanism, but effects were longer-lasting (up to 24 months). Mild nodule formation and transient edema were the most common adverse events, resolving spontaneously or with massage. Patient satisfaction remained high (>88%), particularly among individuals seeking long-term correction without frequent retreatments. Supraperiosteal injections were preferred for safety and optimal volumetric support. These findings suggest PLLA is suitable for patients desiring gradual, durable temporal rejuvenation.

Table 3. Meta-analysis of Calcium Hydroxylapatite (CaHA) for Temple Volume Restoration

Sample Size	Injection Depth	Volume (mL)	Follow-up (months)	SMD (95% CI)	Adverse Events	Patient Satisfaction (%)
20	Supraperiosteal	1.8	18	0.95 (0.70-1.20)	Edema 10%	90
18	Supraperiosteal	2.0	24	1.00 (0.75-1.25)	Bruising 8%	92
15	Subcutaneous	1.5	12	0.90 (0.65-1.15)	Edema 5%	88

CaHA provided robust immediate volumization with additional bio stimulatory effects. The pooled SMD was 0.98 (95% CI: 0.70-1.26)**,** slightly lower than HA and PLLA but with more durable results in deeper deficits. Adverse events were mild and resolved spontaneously. Subcutaneous injections yielded slightly lower volumetric improvement compared to supraperiosteal injections, highlighting the importance of deep placement in the temporal fossa. Patient satisfaction was consistently above 88%, reflecting both aesthetic improvement and long-term results.

Table 4. Comparative Analysis of Adverse Events across Filler Types

Filler Type	Bruising (%)	Edema (%)	Nodules (%)	Vascular Complications (%)	Overall Safety Profile
HA	12	9	0	0	Excellent
PLLA	5	8	7	0	Very Good
CaHA	8	8	0	0	Very Good

All three-filler types showed favorable safety profiles. HA exhibited slightly higher bruising rates, likely due to its frequent use in more superficial planes. PLLA was associated with mild nodule formation (6-8%) due to its collagen-stimulating mechanism, which typically resolved with massage or over time. No serious vascular events reported, underscoring the safety of proper injection technique.

Table 5. Comparative Patient Satisfaction across Filler Types

Filler Type	Mean Satisfaction (%)	Range (%)	Longevity (months)
HA	92	88-95	12–18
PLLA	91	88-93	18–24
CaHA	90	88-92	12–24

Patient satisfaction was consistently high across all filler types, with slightly higher immediate satisfaction for HA due to rapid volumization, and comparable long-term satisfaction for PLLA and CaHA due to durability. Longevity and aesthetic outcome influenced by filler type, injection depth, and volume. Collectively, these data indicate that each filler can achieve satisfactory temporal rejuvenation when administered using appropriate techniques.

Summary of Results:

- ✓ **HA:** Immediate volumization, high satisfaction, moderate longevity (12-18 months).
- ✓ **PLLA:** Gradual onset, longer-lasting results (18-24 months), mild nodule risk.
- ✓ **CaHA:** Immediate and durable volumization, excellent safety, slightly lower SMD compared to HA.
- ✓ Adverse events were mild across all filler types, primarily bruising, edema, or mild nodules.
- ✓ Injection depth and technique critically influence efficacy and safety, with supraperiosteal injection preferred for optimal outcomes.

Discussion

The present systematic review and meta-analysis synthesized evidence from 66 studies encompassing over 3,200 patients who underwent temple filler injections with HA, PLLA, or CaHA. The results demonstrate that all three-filler types are effective, safe, well tolerated for temporal rejuvenation, with high patient satisfaction across diverse study populations [22-24].

Comparative Efficacy

Hyaluronic acid (HA) consistently provided the highest immediate volumetric correction, reflected in the pooled SMD of 1.12 (95% CI: 0.85–1.39). Its viscoelastic properties allow precise sculpting and support of the lateral orbital and temporal regions. The rapid onset of effect explains the slightly higher patient satisfaction scores immediately post-injection compared to PLLA and CaHA. However, HA's moderate duration (12-18 months) requires periodic maintenance, which may affect long-term satisfaction and cost-effectiveness [25-27].

Poly-L-lactic acid (PLLA) achieved slightly lower SMD (1.05; 95% CI: 0.77-1.32) initially but offered superior longevity due to its collagen-stimulating mechanism. This bio stimulatory effect leads to gradual volumization, which is particularly advantageous for patients seeking durable results with fewer repeat sessions. Mild nodule formation was the primary adverse event associated with PLLA, resolving spontaneously in most cases, and did not significantly affect overall satisfaction.

Calcium hydroxylapatite (CaHA) provided robust immediate volumization, comparable to HA, with additional collagen induction contributing to long-term tissue support. The pooled SMD of 0.98 (95% CI: 0.70-1.26) reflects slightly lower objective volumetric gain compared to HA but offers durable correction in deeper deficits. CaHA exhibited minimal adverse events and high patient satisfaction, making it a reliable option for patients with significant temporal concavity [28-30].

Safety Considerations: Across all filler types, adverse events were predominantly mild and transient, including bruising, edema, or temporary nodules [31-33]. No serious vascular complications reported, consistent with prior literature emphasizing the importance of understanding temporal anatomy. Supraperiosteal injection depth was associated with optimal volumization and lower risk, as it avoids critical superficial temporal vessels while providing structural support to the overlying soft tissue. Subcutaneous injections yielded slightly lower volumetric gains, especially for CaHA and HA, highlighting the importance of injection plane selection [34-36].

Clinical Implications

The selection of filler should consider patient goals, desired duration of effect, and anatomical characteristics. HA is ideal for immediate volumization and fine-tuning of contours, particularly in patients prioritizing short-term outcomes. PLLA is suitable for long-term, gradual rejuvenation with bio stimulatory benefits, while CaHA is optimal for patients with deeper temporal hollowing requiring both immediate lift and sustained support. The high overall satisfaction (>88%) across all filler types underscores the effectiveness of temple volumization in improving facial aesthetics and patient confidence [37-39].

Table 6. Comparative Summary of Outcomes

Filler Type	Pooled SMD	Duration (months)	Adverse Events	Patient Satisfaction (%)	Clinical Recommendation
HA	1.12	12-18	Bruising, edema	92	Immediate volumization, precise contouring
PLLA	1.05	18-24	Mild nodules, edema	91	Gradual, long-term collagen stimulation
CaHA	0.98	12-24	Bruising, edema	90	Deep concavity correction, durable support

Integration with Previous Literature

These findings align with prior studies emphasizing the importance of temporal volumization in overall facial rejuvenation. The comparative analysis of HA, PLLA, and CaHA fills a critical gap by quantifying efficacy, duration, safety, and patient satisfaction in a single synthesis. This evidence supports the adoption of standardized injection techniques, particularly supraperiosteal placement,

to maximize outcomes while minimizing complications [40-43].

Moreover, recent trends combining fillers with adjunctive procedures such as neuromodulators for lateral eyebrow lift or thread lifting for soft tissue support may further enhance aesthetic results. Patient-reported outcomes, including quality of life and social perception, should remain key endpoints in future studies, complementing objective volumetric assessments [44-46].

Key Journal-Level Insights

- ✓ **Injection Depth Matters:** Supraperiosteal injections consistently outperformed subcutaneous placement in both efficacy and safety.
- ✓ **Filler Selection is Goal-Dependent:** Immediate vs. long-term correction should guide choice between HA, PLLA, and CaHA.
- ✓ **Mild Adverse Events Are Acceptable:** Transient bruising, edema, or minor nodules do not significantly affect patient satisfaction.
- ✓ **Patient Education and Technique Standardization Are Critical:** Proper understanding of temporal anatomy reduces risk of vascular events and improves predictability of outcomes.

In summary, temple filler injections represent a safe, effective, and versatile approach to facial rejuvenation [50-52]. This meta-analysis demonstrates that all three commonly used fillers HA, PLLA, and CaHA can achieve high patient satisfaction and meaningful volumetric restoration when applied using evidence-based techniques [53-55]. These findings provide clinicians with a comparative framework to tailor treatment plans, optimize aesthetic outcomes, and counsel patients regarding expectations, longevity, and potential adverse events.

Conclusion

Temple filler injections are an essential component of contemporary nonsurgical facial rejuvenation, offering effective and safe restoration of temporal volume. This systematic review and meta-analysis of 66 studies encompassing over 3,200 patients demonstrated that hyaluronic acid (HA) provides immediate volumization with excellent patient satisfaction, Poly-L-lactic acid (PLLA) offers gradual and durable correction through collagen stimulation, and calcium hydroxylapatite (CaHA) achieves robust volumization in deeper temporal deficits [47-49]. Supraperiosteal injection emerged as the optimal technique across all filler types, maximizing efficacy while minimizing adverse events. Complications were predominantly mild and transient, including bruising, edema, or minor nodules, with no serious vascular events reported. Overall, patient satisfaction exceeded 88% across all fillers, highlighting the clinical effectiveness and aesthetic benefits of temporal volumization. These findings provide evidence-based guidance for clinicians to select appropriate filler type, injection depth, and volume tailored to patient-specific anatomical and aesthetic goals. By integrating these insights, practitioners can optimize temporal rejuvenation strategies, enhance patient confidence, and achieve natural, harmonious facial contours.

Limitations:

- ✓ Heterogeneity in study designs, sample sizes, and follow-up durations limits direct comparability.
- ✓ Variability in injection techniques, volume, and planes may influence volumetric outcomes.
- ✓ Lack of standardized reporting metrics across studies hampers objective cross-study comparison.
- ✓ Most studies were non-randomized, introducing potential bias.
- ✓ Limited long-term follow-up data for HA and CaHA, and inconsistent use of objective volumetric measurement tools.

Future Research Directions:

- ✓ Conduct large-scale, multicenter randomized controlled trials comparing HA, PLLA, and CaHA for temple rejuvenation.
- ✓ Standardize injection protocols, including depth, volume, and technique, to optimize safety and efficacy.
- ✓ Incorporate three-dimensional imaging and validated aesthetic scales objectively quantify volumetric outcomes.
- ✓ Investigate combination therapies (fillers with neuromodulators, thread lifting, or energy-based devices) to enhance temporal rejuvenation outcomes.
- ✓ Evaluate patient-reported outcomes, including psychosocial impact, quality of life, and satisfaction over long-term follow-up

Acknowledgments

All authors of this article confirm the authenticity of the manuscript.

Conflicts of interest

The authors declare that they have no competing interests.

Disclosure Statement

No potential conflict of interest reported by the authors.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' Contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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