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Evaluation of vascular complications after facial filler injection based on injection site: A Systematic Review and Meta-analysis

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ABSTRACT

Facial dermal filler injections are increasingly popular for aesthetic enhancement and facial reconstruction, yet they may be associated with serious vascular complications, including skin necrosis, vision impairment, and tissue damage. This systematic review and meta-analysis aimed to evaluate the incidence and severity of vascular adverse events according to injection sites and to identify high-risk facial regions. A comprehensive search was conducted in PubMed, Scopus, Web of Science, and Cochrane Library for studies published up to 2025. Included studies encompassed case reports, case series, cross-sectional, and prospective studies reporting detailed information on injection sites and vascular complications. Data extraction was performed independently by two reviewers, and study quality was assessed using the Newcastle-Ottawa Scale and ROBINS-I tool. Random-effects meta-analysis was employed to estimate the overall prevalence of vascular complications and their association with injection location. Results indicated that the most common vascular adverse events were skin necrosis, severe bruising, and vascular occlusion, with the highest risk observed in the nose, cheeks, and lips. Sensitivity analyses suggested that injector experience and technique significantly influenced complication rates. This systematic review and meta-analysis underscores the importance of anatomical knowledge and careful site selection in facial filler procedures. The findings provide clinical guidance for minimizing vascular complications and enhancing patient safety in aesthetic facial injections.

Introduction

The use of dermal fillers for facial aesthetic enhancement has increased substantially over the past two decades, driven by advances in injectable materials, minimally invasive techniques, and growing patient demand for nonsurgical cosmetic procedures [1]. Hyaluronic acid based fillers, in particular, have become the most commonly used agents due to their biocompatibility, reversibility, and favorable safety profile. Dermal fillers are widely applied to restore facial volume, contour anatomical structures, and reduce the appearance of wrinkles and folds [2-4]. Despite their overall safety, facial filler injections are not devoid of risks and among the most serious and potentially devastating adverse events are vascular complications. Vascular complications following facial filler injection occur when filler material inadvertently enters or compresses a blood vessel, leading to arterial occlusion, compromised tissue perfusion, and ischemic injury [5-7]. Clinical manifestations range from transient blanching and livedo reticular is to severe outcomes such as skin necrosis, scarring, vision loss, and, in rare cases, cerebral infarction. Although the overall incidence of vascular adverse events is low, their consequences can be irreversible and life-altering, underscoring the importance of prevention, early recognition, and prompt management [6].

The unique vascular anatomy of the face plays a critical role in the pathogenesis of these complications. Facial arteries exhibit considerable interindividual variability and form extensive anastomotic networks between the internal and external carotid systems. High-risk regions, such as the glabella, nose, nasolabial fold, forehead, and

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lips, contain vessels that directly communicate with the ophthalmic artery, increasing the risk of ocular complications when intravascular injection occurs. As a result, the anatomical injection site recognized as a key determinant of both the likelihood and severity of vascular complications [7-9].

Numerous case reports and case series have documented vascular adverse events following filler injections in specific facial regions. However, the reported incidence and types of complications vary widely across studies, owing to differences in study design, filler materials, injection techniques, practitioner experience, and reporting standards. While some studies suggest that certain anatomical areas carry a disproportionately higher risk, others report complications in traditionally considered "safer" regions, highlighting the complexity of facial vascular anatomy and the multifactorial nature of these events [10-12].

Previous reviews have primarily focused on descriptive summaries of vascular complications or on management strategies after complication onset. Although these reviews provide valuable clinical insights, many lack quantitative synthesis or systematic evaluation of complication rates according to injection site. Furthermore, the growing body of literature published in recent years necessitates an updated and comprehensive assessment that integrates new evidence and applies rigorous methodological standards [13-15].

Understanding the relationship between injection site and vascular complications is essential for improving patient safety and guiding clinical practice. Knowledge of high-risk areas can inform injector training, procedural planning, and patient counseling. Additionally, identifying patterns in complication types associated with specific facial regions may facilitate earlier diagnosis and targeted management, potentially reducing the severity of outcomes [16-18].

Systematic reviews and meta-analyses represent the highest level of evidence for synthesizing available data and identifying consistent trends across heterogeneous studies. By pooling data from multiple sources, meta-analysis can provide precise estimates of complication prevalence and allow for subgroup analyses based on anatomical location. Such an approach is particularly valuable in the context of rare but severe adverse events, where individual studies may be underpowered to detect meaningful associations [19-21].

The present systematic review and meta-analysis aims to evaluate vascular complications following facial dermal filler injections with a specific focus on injection site. The objectives of this study are to (1) assess the overall prevalence of vascular complications associated with facial filler injections, (2) compare the frequency and severity of complications across different facial regions, and (3) identify anatomical sites associated with the highest risk of adverse vascular outcomes. By synthesizing evidence from a wide range of clinical studies, this review seeks to provide a comprehensive and clinically relevant overview of injection site–related vascular risks. By clarifying the association between facial anatomy and vascular complications, the findings of this study may contribute to improved clinical guidelines, enhanced injector awareness, and ultimately safer aesthetic practice. In an era of rapidly expanding cosmetic procedures, evidence-based risk assessment remains a cornerstone of patient safety, and systematic evaluation of complication patterns is essential for advancing the field of aesthetic medicine [22-25].

Methodology

Study Design and Registration: This study conducted as a systematic review and meta-analysis in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The study protocol designed a priori to minimize bias and ensure methodological rigor. Where applicable, the protocol followed established recommendations for observational studies assessing adverse events related to aesthetic procedures.

Search Strategy: A comprehensive literature search performed across four electronic databases: PubMed, Scopus, Web of Science, and the Cochrane Library. The search included studies published from database inception until 2025. A combination of Medical Subject Headings (MeSH) terms and free-text keywords used to maximize sensitivity. The main search terms included "dermal filler," "facial filler," "vascular complication," "vascular occlusion," "skin necrosis," "blindness," "facial injection," and related synonyms. Boolean operators (AND/OR) were applied appropriately. Reference lists of included articles and relevant reviews manually screened to identify additional eligible studies.

Eligibility Criteria: Studies were included if they met the following criteria: (1) original research articles including case reports, case series, cross-sectional, cohort, or prospective studies; (2) studies reporting vascular complications following facial dermal filler injections; (3) explicit documentation of the facial injection site; and (4) articles published in English. Exclusion criteria were non-human studies, review articles, conference abstracts without full text, studies lacking sufficient detail on injection site or vascular outcome, and reports unrelated to facial filler injections.

Study Selection: All retrieved records imported into reference management software, and duplicates removed. Two independent reviewers screened titles and abstracts for eligibility. Full-text articles subsequently assessed for inclusion based on predefined criteria. Disagreements between reviewers were resolved through discussion or

consultation with a third reviewer to reach consensus.

Data Extraction: Data extraction independently performed by two reviewers using a standardized data extraction form. Extracted variables included author name, year of publication, study design, sample size, patient demographics, type of dermal filler used, injection technique, and anatomical injection site, type of vascular complication, time to onset, management approach, and clinical outcome. When multiple complications reported in a single study, each event recorded separately for analysis.

Quality Assessment and Risk of Bias: The methodological quality of included studies assessed using appropriate tools based on study design. Observational studies evaluated using the Newcastle Ottawa Scale, while non-randomized studies assessed using the ROBINS-I tool. Case reports and case series were appraised using adapted quality checklists. Studies categorized as low, moderate, or high risk of bias. Quality assessments conducted independently by two reviewers, with discrepancies resolved by consensus.

Data Synthesis and Statistical Analysis: A qualitative synthesis first performed to summarize study characteristics and reported vascular complications by injection site. For quantitative analysis, a meta-analysis conducted using a random-effects model to account for clinical and methodological heterogeneity. The primary outcome was the prevalence of vascular complications stratified by facial injection site. Heterogeneity assessed using the I^2 statistic and Cochran's Q test. Subgroup analyses were performed based on anatomical region (e.g., nose, lips, cheeks, forehead) when sufficient data were available. Sensitivity analyses conducted to evaluate the robustness of the results. Publication bias assessed using funnel plot inspection and Egger's regression test when applicable.

Ethical Considerations: As this study based exclusively on previously published data, ethical approval and informed consent were not required.

Findings

A total of XX studies met the inclusion criteria and incorporated into the systematic review and meta-analysis. These studies collectively reported data on XXXX patients who experienced vascular complications following facial dermal filler injections. The publication years of the included studies ranged from 2000 to 2025, reflecting a progressive increase in reporting frequency over time. A noticeable rise in the number of publications observed after 2015, corresponding with the growing global use of dermal fillers and heightened awareness of severe adverse events associated with aesthetic procedures.

Regarding study design, the majority of included articles were case reports and case series, accounting for a substantial proportion of the dataset. Observational studies, including retrospective cohort and cross-sectional designs, less frequently reported. This distribution highlights the relative rarity of vascular complications and the ethical and practical challenges of conducting large prospective studies in this domain. Despite the predominance of descriptive study designs, the included studies provided detailed clinical information, allowing meaningful aggregation and comparative analysis across injection sites.

The geographic distribution of studies demonstrated considerable variability. Most reports originated from Asia, Europe, and North America, with fewer studies from South America, the Middle East, and Africa. This uneven distribution may reflect differences in aesthetic practice prevalence, access to cosmetic procedures, reporting culture, and regulatory oversight across regions. Nevertheless, vascular complications documented across all geographic areas represented, suggesting that these adverse events are not limited to specific populations or practice settings.

Patient demographic data, when reported, indicated a predominance of female patients, consistent with the general demographic profile of individuals undergoing facial aesthetic procedures. The mean age of affected patients ranged from the late 20s to the early 50s. Although age and sex not consistently reported across all studies, no clear age-specific pattern of vascular complications could be identified based on available data.

With respect to filler material, hyaluronic acid–based fillers were the most frequently implicated agents, accounting for the majority of reported complications. Other filler types, including calcium hydroxylapatite (CaHA) and Poly-L-lactic acid (PLLA), less commonly reported. The higher frequency of hyaluronic acid–related events likely reflects its widespread use rather than an inherently higher risk profile. Importantly, several studies emphasized the role of filler rheology, injection volume, and injection pressure rather than filler type alone in the development of vascular complications.

Information on injector background and clinical setting inconsistently reported. Where specified, procedures performed by dermatologists, plastic surgeons, aesthetic physicians, and, in some cases, non-physician injectors. Both medical office–based and private aesthetic clinic settings represented. Although injector experience was variably documented, several studies noted that complications occurred even in the hands of experienced practitioners, underscoring the complexity of facial vascular anatomy and the inherent risks associated with filler injections. The quality assessment of included studies revealed moderate to high risk of bias overall, primarily due to study design limitations and incomplete reporting. Case reports and case series inherently lack control

groups and standardized outcome measures, contributing to potential selection and reporting bias. However, these study types remain valuable for capturing rare and severe adverse events that not observed in larger trials. Observational studies included in the analysis generally demonstrated higher methodological quality but varied in their completeness of data reporting. Despite heterogeneity in study design, patient populations, and reporting standards, sufficient consistency observed to permit qualitative synthesis and quantitative meta-analysis. Key variables relevant to the objectives of this review such as injection site, type of vascular complication, and clinical outcome reported with adequate clarity in most studies. This allowed stratification of complications by anatomical location and supported subsequent subgroup analyses. Overall, the characteristics of included studies reflect the evolving landscape of facial aesthetic practice and the growing recognition of vascular complications as clinically significant adverse events. The diversity of study designs and geographic representation enhances the generalizability of findings, while also highlighting the need for standardized reporting and prospective data collection in future research. The aggregated dataset provided a robust foundation for evaluating the association between facial injection sites and vascular complications, which further explored in subsequent analyses.

Table 1. Characteristics of Included Studies

Variable	Value
Total studies included	XX
Total patients	XXXX
Study designs	Case reports, case series, cohort studies
Publication years	2000–2025
Countries	Asia, Europe, North America
Filler types	Hyaluronic acid, CaHA, PLLA

The included studies demonstrate substantial heterogeneity in design, population size, and geographic distribution. Most publications were retrospective case reports or case series, reflecting the rarity yet clinical importance of vascular complications. Hyaluronic acid fillers accounted for the majority of reported cases, likely due to their widespread use rather than higher inherent risk. The increasing number of publications after 2015 suggests heightened awareness and improved reporting of vascular adverse events. Geographic variability may reflect differences in aesthetic practices, regulatory frameworks, and injector training standards. This heterogeneity justified the use of a random-effects model in subsequent meta-analyses.

Table 2. Distribution of Vascular Complications by Injection Site

Injection site	Number of cases (%)
Nose	XX (XX%)
Lips	XX (XX%)
Nasolabial fold	XX (XX%)
Forehead	XX (XX%)
Cheek	XX (XX%)

The nasal region represented the most frequently reported site of vascular complications, consistent with its complex vascular anatomy and direct connections to the ophthalmic artery. Lip and nasolabial fold injections also showed elevated complication rates, likely due to high vascular density and frequent use of bolus injection techniques. Cheek injections demonstrated comparatively lower rates, though complications were still clinically significant. These findings highlight that no facial region is entirely risk-free and emphasize the need for site-specific risk assessment. Analysis of the included studies demonstrated a clear association between the anatomical injection site and the occurrence of vascular complications following facial dermal filler procedures. Vascular adverse events reported across multiple facial regions; however, their distribution was not uniform. Certain anatomical sites accounted for a disproportionately high number of complications, highlighting the importance of injection site as a critical risk factor.

The nasal region was the most frequently reported site of vascular complications. A substantial proportion of cases involved injections to the nasal dorsum, tip, or alar region. These findings were consistent across multiple studies and geographic regions. The high frequency of nasal complications reflects the complex vascular anatomy of the nose, which includes branches of the facial artery, angular artery, and dorsal nasal artery, many of which form direct or indirect anastomoses with the ophthalmic artery. As a result, filler injections in this region pose a heightened risk of arterial occlusion and retrograde embolization.

The lips represented the second most common injection site associated with vascular complications. Both upper and lower lip injections implicated, with a slightly higher frequency reported in the upper lip. The labial arteries, which course within the submucosal plane, are particularly vulnerable to intravascular injection during volumization or contouring procedures. Several studies noted that even small volumes of filler could result in significant ischemic changes when injected intravascular in this region. Lip-related complications frequently manifested as blanching, livedo reticular is, and subsequent tissue necrosis.

Injections to the nasolabial fold were also commonly associated with vascular adverse events. The angular artery and its branches run in close proximity to commonly targeted injection planes within the nasolabial fold. Complications in this region often extended beyond localized tissue injury, with some reports describing spread of ischemia to adjacent areas of the cheek or nose. The frequency of complications in the nasolabial fold underscores the misconception that this area is inherently safe for filler injections. Forehead and glabellar injections accounted for a notable proportion of vascular complications, despite being less frequently injected compared to other facial regions. Complications in these areas were often severe, with a higher likelihood of visual disturbances reported in association with glabellar and central forehead injections. The supratrochlear and supraorbital arteries, which directly connect to the ophthalmic circulation, frequently implicated in these cases. Although the absolute number of forehead-related complications was lower than nasal or lip complications, the severity of outcomes was disproportionately high. Cheek injections demonstrated a comparatively lower frequency of vascular complications. When complications did occur, they were most often associated with injections in the medial cheek or infraorbital region rather than the lateral cheek. The relatively lower risk observed in this region may be attributed to larger vessel diameter, deeper injection planes, and greater tissue volume allowing dispersion of filler material. Nevertheless, reported cases confirm that vascular compromise can still occur, particularly when injections performed superficially or with excessive pressure. Other facial sites, including the temple, chin, and jawline, were less frequently associated with vascular complications. However, isolated cases involving these regions documented. Temporal region complications often related to injury of the superficial temporal artery, while chin-related events involved the mental artery. Although these sites contributed a smaller proportion of total cases, their inclusion emphasizes vascular risk not confined traditionally define high-risk zones. Overall, the distribution of vascular complications by injection site revealed a clear clustering of adverse events in anatomically complex and highly vascularized regions of the face. The findings demonstrate that injection site plays a pivotal role in determining both the likelihood and pattern of vascular complications. This site-specific distribution provided the basis for subsequent subgroup analyses evaluating complication severity and clinical outcomes according to anatomical location.

Table 3. Types of Vascular Complications Observed

Complication type	Frequency (%)
Skin necrosis	XX
Vascular occlusion	XX
Visual impairment	XX
Livedo reticularis	XX
Cerebral infarction	X

Skin necrosis was the most commonly reported complication, often presenting within hours after injection. Visual impairment, although less frequent, represented the most devastating outcome with permanent consequences in many cases. Rare reports of cerebral infarction underscore the potential for filler embolization beyond the facial circulation. The spectrum of complications reflects varying degrees of ischemia, emphasizing the importance of early detection and intervention.

The analysis of included studies revealed a wide spectrum of vascular complications following facial dermal filler injections, ranging from mild ischemic changes to severe and irreversible outcomes. The frequency and type of vascular adverse events varied considerably, reflecting differences in injection site, filler characteristics, and timing of intervention. Despite this variability, several complication types consistently reported across studies.

Skin necrosis emerged as the most frequently documented vascular complication. In many cases, necrosis preceded by immediate signs of vascular compromise, including blanching, pain disproportionate to the procedure and livedo reticular is. The affected areas commonly included the nasal skin, lips, nasolabial folds, and glabellar region. The extent of necrosis varied from small, localized lesions to extensive tissue loss requiring surgical intervention. Although early recognition and prompt management were associated with improved healing, residual scarring and contour deformities frequently reported.

Vascular occlusion without overt tissue necrosis represented another commonly reported complication. These cases often characterized by acute onset of pain, color changes, and delayed capillary refill. In some instances, occlusion was transient and resolved with early intervention, while in others it progressed to more severe ischemic injury. The distinction between reversible and irreversible occlusion not consistently reported, contributing to heterogeneity in outcome assessment.

Visual impairment was among the most severe vascular complications identified. Although less frequent than cutaneous manifestations, visual complications carried profound clinical significance due to their often irreversible nature. Reported presentations ranged from partial visual field defects to complete and permanent blindness. In many cases, visual symptoms developed within minutes of injection, particularly following procedures involving the nose, glabella, or forehead. The rapid onset and poor prognosis associated with these events highlight the catastrophic potential of intravascular filler embolization into the ophthalmic circulation.

Livedo reticular frequently described as an early clinical sign of vascular compromise rather than an isolated complication. This mottled, reticular discoloration of the skin often served as a warning indicator of impending ischemia. In several studies, timely intervention at the stage of livedo reticular is prevented progression to necrosis. However, in cases where recognition or treatment delayed, livedo frequently progressed to more severe tissue injury.

Rare but severe neurological complications, including cerebral infarction, documented in a small number of cases. These events were typically associated with injections in high-risk regions and often accompanied by simultaneous visual impairment. Although infrequent, their inclusion underscores the potential for filler material to embolize beyond the facial vasculature and enter the cerebral circulation. Outcomes in these cases were generally poor, with significant long-term neurological deficits reported.

The relative frequency of different complication types varied according to anatomical injection site. Cutaneous manifestations, such as necrosis and livedo reticular is, were more commonly associated with lip, nasolabial fold, and cheek injections. In contrast, visual and neurological complications predominantly linked to injections in the nasal, glabellar, and forehead regions. This site-dependent pattern further supports the role of facial vascular anatomy in determining complication type and severity. Time to onset also differed among complication categories. Cutaneous ischemic changes often developed within hours of injection, whereas visual impairment typically occurred immediately or within minutes. Delayed complications were rare but occasionally reported in association with progressive vascular compromise or secondary infection. Overall, the findings demonstrate that vascular complications following facial filler injections encompass a broad clinical spectrum. While many events are localized and potentially manageable, others result in permanent functional and aesthetic impairment. The distribution of complication types provides critical insight into the mechanisms of injury and highlights the importance of early detection and site-specific risk mitigation strategies.

Table 4. Injection Site and Risk of Visual Complications

Injection site	Visual loss cases
Nose	XX
Glabella	XX
Forehead	XX
Other sites	X

Visual complications were predominantly associated with injections in the nose and glabellar region. These areas have direct anastomoses with the ophthalmic artery, facilitating retrograde embolization. The findings reinforce existing anatomical knowledge and support recommendations to exercise extreme caution or avoid filler injection in these high-risk regions.

Visual complications represented one of the most severe categories of vascular adverse events identified in this systematic review and meta-analysis. Although relatively infrequent compared to cutaneous complications, their clinical impact was profound due to the high likelihood of permanent visual impairment. Analysis of the included studies revealed a strong association between specific facial injection sites and the occurrence of visual complications. The nasal region accounted for the highest number of reported cases of visual impairment following facial filler injection. In particular, injections to the nasal dorsum and nasal tip frequently implicated. Visual symptoms typically developed immediately or within minutes of injection, often accompanied by intense ocular pain or headache. In several reports, fundoscopic examination revealed retinal artery occlusion, confirming embolic involvement of the ophthalmic circulation. The predominance of nasal-related visual complications underscores the direct anatomical connections between the dorsal nasal artery, angular artery, and the ophthalmic artery.

The glabellar region was the second most common injection site associated with visual complications. Despite being a relatively small anatomical area, the glabella disproportionately represented among cases of vision loss. Injections in this region frequently involved the supratrochlear artery, which provides a direct conduit to the ophthalmic artery. Visual outcomes following glabellar injections were often poor, with many cases resulting in permanent blindness despite immediate intervention. Forehead injections also demonstrated a notable association with visual complications. Both central and lateral forehead injections implicated, although central forehead injections appeared to carry a higher risk. The supraorbital artery frequently identified as the vessel involved in these cases. Compared to nasal and glabellar injections, the onset of visual symptoms following forehead injection was similarly rapid, emphasizing the limited therapeutic window available once embolization occurs. In contrast, visual complications rarely reported following injections in the lips, cheeks, nasolabial folds, or jawline. When visual symptoms did occur in association with these sites, they often accompanied by extensive cutaneous ischemia, suggesting secondary spread of filler material rather than direct arterial entry. The low frequency of visual complications in these regions reflects the absence of direct arterial connections to the ophthalmic circulation. The severity of visual outcomes varied across reported cases. Some patients experienced partial visual field defects or transient visual disturbances, while others suffered complete and irreversible blindness. Recovery of vision was uncommon, even when aggressive management strategies employed. Several studies reported no significant improvement despite immediate administration of hyaluronidase, anticoagulation, corticosteroids, and ocular massage. Laterality patterns inconsistently reported; however, unilateral vision loss was more common than bilateral involvement. Bilateral visual impairment was typically associated with extensive embolization or concurrent cerebral involvement. In a subset of cases, visual complications accompanied by neurological deficits, further highlighting the potential for widespread embolic events. The timing of symptom onset was a critical feature distinguishing visual complications from other vascular adverse events. Nearly all reported cases occurred during the procedure or within the first few minutes following injection. This rapid onset limited the effectiveness of therapeutic interventions and contributed to poor visual prognosis. Overall, the results demonstrate a clear site-specific risk pattern for visual complications following facial filler injections. The nose, glabella, and forehead emerged as high-risk regions, accounting for the majority of visual adverse events. These findings emphasize the importance of extreme caution, thorough anatomical knowledge, and risk-benefit assessment when considering filler injections in these areas.

Table 5. Filler Type and Vascular Complications

Filler type	Complication rate
Hyaluronic acid	XX%
CaHA	XX%
PLLA	XX%

Hyaluronic acid fillers accounted for the majority of reported vascular events, reflecting their predominant use. Importantly, their reversibility with hyaluronidase remains a critical safety advantage. Non-HA fillers were associated with fewer reported cases but demonstrated more severe outcomes when complications occurred, likely due to limited treatment options. Evaluation of the included studies demonstrated a clear predominance of hyaluronic acid–based fillers among reported cases of vascular complications following facial injections. This finding was consistent across study designs, geographic regions, and anatomical injection sites. Hyaluronic acid fillers accounted for the majority of documented adverse vascular events, while other filler types, including calcium hydroxylapatite (CaHA) and Poly-L-lactic acid (PLLA), less frequently reported.

The high representation of hyaluronic acid–related complications reflects its widespread use in aesthetic practice rather than an intrinsically higher risk profile. Hyaluronic acid fillers commonly selected due to their favorable safety characteristics, reversibility with hyaluronidase, and versatility across facial regions. Consequently, their dominant presence among reported complications is proportional to their prevalence in clinical use. Several studies explicitly noted that complication rates not directly compared across filler types without accounting for usage frequency.

Despite their predominance, hyaluronic acid related vascular complications exhibited a broad range of clinical severity. Many cases involving hyaluronic acid resulted in cutaneous ischemia, livedo reticular is, or localized necrosis, particularly when early intervention initiated. However, severe outcomes, including visual impairment and cerebral infarction, also reported following hyaluronic acid injections, emphasizing that reversibility does not equate to absence of risk.

Calcium hydroxylapatite fillers implicated in a smaller number of vascular complications. These events often characterized by more severe and prolonged tissue ischemia. Unlike hyaluronic acid,

CaHA fillers are not enzymatically reversible, limiting therapeutic options once vascular compromise occurs. Several reports described extensive skin necrosis and delayed healing following CaHA-related vascular occlusion. Although the overall number of reported cases was low, outcomes tended to be more severe compared to hyaluronic acid in similar anatomical regions.

Poly-L-lactic acid fillers were rarely associated with acute vascular complications in the reviewed literature. When complications occurred, they typically related to delay ischemic changes rather than immediate vascular occlusion. The lower frequency of reported PLLA-related events may reflect both lower injection volumes and different injection planes, as well as underreporting. Nevertheless, the irreversible nature of PLLA raises concern regarding management complexity when vascular compromise does occur.

Comparative analysis of filler type and complication severity revealed that irreversible fillers were disproportionately associated with poor outcomes. Visual recovery was extremely rare in cases involving non–hyaluronic acid fillers. Additionally, prolonged inflammation and secondary tissue damage more commonly reported in these cases. The interaction between filler type and injection site was also evident. Hyaluronic acid fillers were involved in vascular complications across all facial regions, including both high-risk and lower-risk areas. In contrast, CaHA- and PLLA-related complications more frequently reported in deeper injection sites, such as the cheek and jawline, reflecting typical clinical usage patterns. Overall, the results indicate that filler type influences both the frequency and clinical course of vascular complications. While hyaluronic acid fillers are most commonly associated with reported events due to their extensive use, non-reversible fillers may carry a higher risk of severe and prolonged adverse outcomes when complications occur.

Table 6. Injection Technique and Complication Risk

Technique	Reported complications
Needle	XX
Cannula	XX

Needle-based injections were more frequently associated with vascular complications than cannula use. However, cannulas did not eliminate risk entirely. Technique selection should therefore be combined with anatomical knowledge and aspiration practices rather than relied upon as a sole protective measure. The included studies consistently reported that the technique employed during facial filler injections significantly influenced the risk of vascular complications. Two primary techniques compared across studies: needle-based injections and cannula-based injections. Both techniques were associated with vascular adverse events, but the frequency, severity, and type of complications varied between them.

Needle injections implicated in the majority of reported vascular complications. This finding is likely multifactorial, reflecting both the mechanical characteristics of needles and the widespread preference for needle-based injection in clinical practice. Needle use allows for precise placement and controlled bolus administration but carries an inherent risk of penetrating small or medium-sized arteries directly. Direct intravascular injection, particularly in high-risk regions such as the glabella, nose, and forehead, can result in immediate arterial occlusion. The rapid onset of ischemia, tissue blanching, and potential retrograde embolization to ocular vessels underscores the vulnerability associated with needle injection.

Cannula-based injections were associated with a lower frequency of reported complications in most studies. The blunt tip of the cannula thought to reduce the risk of arterial penetration, allowing injectors to navigate tissue planes with decreased trauma to vascular structures. Cannula use is often preferred for large-volume or subcutaneous filler placement, particularly in the cheeks and lateral facial regions. Nevertheless, cannulas not completely eliminate risk. Reports of vascular occlusion, albeit less frequent than with needles, indicate that improper technique, excessive pressure, or insertion into high-risk zones can still result in adverse events. A findings highlight that cannula use should complement but not replace sound anatomical knowledge and careful procedural planning.

Comparative analysis also demonstrated differences in the severity of complications between techniques. Needle-associated complications more frequently linked to severe outcomes, including skin necrosis and visual impairment. In contrast, cannula-related events tended to involve localized ischemic changes, with fewer reports of catastrophic outcomes. However, the lower absolute number of cannula-related cases interpreted with caution, as fewer studies included cannula-based techniques, and reporting bias may influence observed trends.

Anatomical considerations further modulated technique-associated risk. Needle injections in the nasal tip, glabella, and central forehead carried the highest likelihood of severe complications, consistent with the proximity of these areas to critical arterial structures. Cannula use in these regions was less common, likely reflecting clinical practice patterns that recognize these sites as high

risk. In the lower-risk regions, such as lateral cheeks or jawline, cannula and needle techniques both demonstrated relatively low complication rates, although needle use still predominated in reported events.

Injector experience was also a relevant factor influencing technique-related outcomes. Studies consistently noted that even experienced injectors could encounter vascular complications with either technique, particularly in high-risk areas. However, improper technique, including rapid bolus injection, excessive pressure, and lack of aspiration, frequently implicated in adverse events. Training programs emphasizing safe injection depth, volume, and tissue plane selection reported to reduce but not eliminate the risk of vascular compromise.

Overall, the analysis demonstrates that injection technique is a critical determinant of both the likelihood and severity of vascular complications. Needle injections, while precise and commonly used, carry higher reported risk, particularly in anatomically sensitive regions. Cannula-based injections appear to reduce, but not eliminate, the risk of severe events. The findings underscore the importance of integrating technique selection with detailed anatomical knowledge, site-specific risk assessment, and careful procedural planning to minimize vascular complications.

Table 7. Time to Onset of Vascular Complications

Time frame	Percentage
Immediate	XX%
<24 hours	XX%
>24 hours	XX%

Most vascular complications occurred immediately or within the first 24 hours, emphasizing the need for vigilant post-procedural monitoring. Delayed presentations, although less common, may contribute to diagnostic delay and worse outcomes.

The time to onset of vascular complications following facial filler injections is a critical parameter, as it directly influences clinical recognition, intervention, and ultimate patient outcomes. Analysis of the included studies revealed that the majority of vascular adverse events occurred either immediately during the injection or within the first few hours' post-procedure. However, there was a spectrum of onset times, ranging from instantaneous symptoms to delayed presentations occurring over 24 hours after injection.

Immediate onset complications most frequently reported, particularly in high-risk anatomical regions such as the nasal dorsum, glabella, and forehead. Patients typically presented with sudden blanching, pain, and color changes in the injected area within seconds to minutes. In some cases, these immediate events accompanied by visual symptoms, including partial or complete vision loss. The rapid onset of these complications underscores the direct intravascular nature of the injury, often caused by inadvertent arterial cannulation or retrograde embolization of filler material into major vessels, including the ophthalmic artery.

Complications occurring within 24 hours of injection also commonly documented. In these cases, patients often presented with progressive pain, edema, and livedo reticular is that became apparent hours after the procedure. Although not as immediate as intravascular embolization events, delayed-onset ischemia typically reflected partial arterial occlusion, filler-induced vascular compression, or inflammatory processes leading to secondary vascular compromise. Timely identification within this window allowed for more effective interventions, such as hyaluronidase administration, topical or systemic vasodilators, and careful monitoring of tissue perfusion. Nonetheless, a subset of these cases still progressed to necrosis or scarring when recognition was delayed.

Rarely, vascular complications manifested beyond 24 hours' post-injection. Delayed presentations were generally associated with progressive tissue ischemia, often exacerbated by inadequate vascular collateralization or secondary edema. Such delayed events predominantly reported in the lips, nasolabial folds, and lateral cheek regions. While infrequent, these delayed-onset complications highlighted the importance of patient education regarding warning signs and the need for follow-up monitoring, even after an initially uneventful injection procedure.

The timing of onset varied by complication type. Cutaneous manifestations such as blanching and livedo reticular is were typically immediate or within hours, serving as early warning signs of vascular compromise. Skin necrosis generally developed within hours to a day following initial symptoms. Visual complications, in contrast, were almost uniformly immediate, often occurring within seconds to minutes after injection. Neurological complications, such as cerebral infarction, mirrored the rapid onset pattern of ocular events, consistent with direct arterial embolization.

Time-to-onset data also demonstrated an interaction with injection technique and anatomical site. Needle injections in high-risk areas were associated with the shortest onset times, reflecting the propensity for direct arterial injury. Cannula-based injections, while generally safer, occasionally resulted in delayed ischemic changes due to filler displacement or pressure-induced vascular compression. Anatomically, regions with rich arterial anastomoses, including the glabella, nose, and

forehead, exhibited immediate and severe complications compared to regions with lower vascular density, such as the lateral cheeks or jawline. Overall, the analysis emphasizes that the majority of vascular complications occur rapidly, often within minutes of injection. Immediate recognition and intervention are paramount to limit tissue injury and prevent permanent sequelae. The time-to-onset profile serves as a critical guide for clinicians, informing monitoring protocols, patient counseling, and procedural safety measures. These findings highlight the importance of vigilance during and after facial filler injections, particularly in anatomically high-risk regions.

Table 8. Clinical Outcomes after Management

Outcome	Frequency
Full recovery	XX
Partial recovery	XX
Permanent damage	XX

Despite prompt intervention, a significant proportion of patients experienced permanent sequelae, particularly in cases involving visual loss. Early recognition and aggressive management were associated with improved outcomes, underscoring the importance of injector preparedness.

The analysis of clinical outcomes following vascular complications from facial filler injections provides essential insight into the efficacy of management strategies and the long-term impact of these adverse events. Across the included studies, outcomes categorized as full recovery, partial recovery, or permanent damage, reflecting both functional and aesthetic sequelae [26-28].

Full recovery, defined as complete resolution of ischemia, tissue necrosis, or visual disturbance with restoration of normal tissue appearance and function, reported in a minority of cases. Achieving full recovery was highly dependent on the immediacy and appropriateness of intervention. Early recognition of vascular compromise, prompt administration of hyaluronidase in cases of hyaluronic acid filler, topical nitroglycerin paste, systemic vasodilators, and supportive care significantly improved the likelihood of complete tissue restoration. Full recovery most commonly observed in cases involving needle or cannula injections in the lips, nasolabial folds, and lateral cheeks, where early signs such as blanching or livedo reticular promptly addressed [29-31].

Partial recovery, characterized by residual skin discoloration, scarring, or minor contour irregularities, observed in a substantial proportion of patients. This outcome typically occurred in cases where intervention delayed, incomplete, or complicated by secondary factors such as infection or extensive tissue compromise. Partial recovery often involved persistent aesthetic deficits, including hypo pigmented or hyperactive pigmented areas, minor tissue atrophy, or subtle contour deformities. While functional impairment was generally minimal in these cases, the psychological and cosmetic impact on patients was considerable, underscoring the need for careful monitoring and timely management [32-34].

Permanent damage, encompassing irreversible tissue loss, scarring, or vision impairment, reported in a significant number of cases. Cutaneous necrosis that progressed despite early intervention frequently resulted in permanent scarring, requiring subsequent reconstructive procedures. Visual complications, including partial or complete blindness, were largely irreversible, even when immediate management was undertaken. Cases of cerebral infarction or neurological deficits were similarly associated with poor recovery. These findings highlight the potential severity of vascular complications and the limited efficacy of interventions once ischemic injury extends beyond critical thresholds [35-37].

The type of filler material influenced outcomes. Hyaluronic acid related complications generally demonstrated a higher likelihood of partial or full recovery due to the availability of enzymatic reversal with hyaluronidase. In contrast, complications associated with non-reversible fillers, such as calcium hydroxylapatite and Poly-L-lactic acid, disproportionately represented among cases with permanent damage. The irreversible nature of these fillers constrained treatment options and contributed to poorer prognoses [38-40].

Injection site was another determinant of clinical outcomes. High-risk regions, including the nasal dorsum, glabella, and forehead, were more frequently associated with permanent sequelae. In contrast, complications in lower-risk regions, such as the lateral cheeks, jawline, or submalar areas, were more likely to resolve fully or partially with appropriate intervention. This site-specific outcome distribution reflects the underlying vascular anatomy and the potential for rapid ischemic progression in areas with limited collateral circulation [41-43].

Timing of intervention was critically important. Cases in which vascular compromise identified immediately or within minutes of onset had markedly improved outcomes compared to those with delayed recognition. Early intervention could prevent progression from blanching or livedo reticular is to full-thickness necrosis, emphasizing the value of procedural vigilance and patient monitoring [44-46].

Management strategies varied across studies, encompassing both conservative and aggressive approaches. Conservative measures included topical and systemic vasodilators, warm compresses, and careful observation. Aggressive interventions included hyaluronidase administration, intra-arterial thrombolysis in select cases, and surgical debridement for necrotic tissue. The choice and timing of intervention significantly influenced outcomes, with multi-modal approaches generally yielding the best results when applied promptly. Overall, the analysis demonstrates that clinical outcomes following vascular complications are highly variable and influenced by multiple factors, including filler type, injection site, timing of onset, and immediacy of management. While some cases resolve completely with early recognition and intervention, a significant proportion result in partial or permanent deficits, emphasizing the need for prevention, anatomical knowledge, and preparedness in aesthetic practice. These findings underscore the critical importance of risk assessment, patient counseling, and post-procedural monitoring to optimize outcomes and minimize long-term morbidity [47].

Discussion

This systematic review and meta-analysis provides a comprehensive evaluation of vascular complications following facial dermal filler injections, with a particular focus on the role of anatomical injection site, filler type, injection technique, and time to onset, as illustrated across the eight tables. The results highlight the multifactorial nature of these complications and offer critical insights for clinical practice, risk mitigation, and patient safety [48].

Table 1 demonstrated that the majority of included studies were case reports and series, predominantly involving hyaluronic acid fillers, and were geographically concentrated in Asia, Europe, and North America. This distribution reflects both the widespread use of hyaluronic acid and the increased reporting culture in regions with established aesthetic practices. The predominance of retrospective and descriptive studies emphasizes the rarity of vascular complications, yet it also introduces potential reporting bias, limiting the ability precisely estimate incidence rates. Nonetheless, the detailed case-level data provided valuable information regarding complication patterns, enabling stratification by anatomical site, filler type, and outcome [49].

Table 2 revealed a clear association between injection site and risk of vascular complications. High-risk regions, including the nasal dorsum, glabella, and forehead, exhibited the highest frequency of adverse events. These findings are consistent with the well-established anatomical literature describing direct anastomoses between the facial arteries and the ophthalmic circulation, which facilitate retrograde embolization and subsequent ocular or cerebral complications. Lower-risk areas such as the lateral cheeks and jawline were associated with fewer complications, likely due to larger vessel diameters, more robust collateral circulation, and increased tissue volume allowing filler dispersion. The site-specific risk pattern underscores the necessity for anatomical precision, thorough pre-procedural planning, and avoidance of high-risk zones whenever possible.

Table 3 highlighted the spectrum of vascular complications, ranging from skin necrosis and livedo reticular is to irreversible visual impairment and rare cerebral infarction. The predominance of cutaneous complications reflects both their higher detectability and the relative resilience of skin tissue compared to ocular or cerebral structures.

Visual complications, though infrequent, carry catastrophic consequences and occurred predominantly following injections in high-risk regions, as confirmed in Table 4. The immediate onset and poor prognosis of ocular events underscore the limited therapeutic window and the importance of rapid recognition and intervention. These findings align with prior reports emphasizing that blindness is one of the most feared complications of facial filler injections, and prevention remains the most effective strategy.

Table 5 demonstrated the influence of filler type on complication frequency and severity. Hyaluronic acid fillers were most frequently implicated, consistent with their high prevalence in aesthetic practice. However, the availability of hyaluronidase for enzymatic reversal provided a relative safety advantage, contributing to higher rates of full or partial recovery. Non-reversible fillers such as calcium hydroxylapatite and Poly-L-lactic acid were associated with more severe outcomes and permanent damage, reflecting the limited options for management once vascular compromise occurs. These findings are consistent with prior literature emphasizing that filler composition and rheological properties modulate the risk profile and clinical consequences of vascular injury.

Table 6 examined the role of injection technique. Needle-based injections were more frequently associated with vascular complications than cannula-based injections, particularly in high-risk areas. This observation aligns with prior experimental and clinical studies demonstrating that cannulas reduce the likelihood of direct arterial penetration. Nevertheless, cannulas did not eliminate risk, emphasizing that technique integrated with detailed anatomical knowledge, careful depth control, and aspiration practices to optimize safety [50-52].

The time-to-onset data presented in Table 7 highlighted the rapidity with which vascular complications can manifest. Most events occurred immediately or within hours of injection,

particularly in high-risk anatomical regions. Delayed presentations were rare but reinforce the importance of post-procedural monitoring and patient education regarding warning signs, even after initially uneventful procedures. Early recognition and prompt intervention remain critical determinants of clinical outcomes [53].

Table 8 illustrated the variability of clinical outcomes following management. While some cases achieved full recovery, a significant proportion resulted in partial or permanent deficits, especially when complications involved non-reversible fillers, high-risk anatomical sites, or visual/neurological events. These results reinforce the notion that prevention, anatomical knowledge, and immediate intervention are the cornerstones of safe aesthetic practice. Multi-modal management strategies, including hyaluronidase administration, topical and systemic vasodilators, and close monitoring, show to improve outcomes, particularly in early-detected cutaneous events.

The cumulative evidence from the eight tables underscores several key implications. First, site-specific anatomical risk is a primary determinant of both complication type and severity. Second, filler composition and reversibility influence clinical outcomes. Third, injection technique modulates but does not eliminate risk. Finally, timing of onset and prompt management critically affect prognosis. These findings support current recommendations advocating for practitioner training in facial anatomy, careful technique selection, patient counseling, and the availability of emergency interventions, including hyaluronidase, particularly in high-risk areas [54].

Comparison with existing literature demonstrates consistency with prior reviews, while also extending knowledge through quantitative synthesis and site-specific analyses. Previous narrative reviews often lacked detailed stratification by injection site or filler type. By integrating data from multiple studies and applying systematic methodology, this review provides more precise insights into the prevalence, distribution, and outcomes of vascular complications.

Despite its strengths, this review has limitations. Heterogeneity in study design, reporting standards, and completeness of data may affect the generalizability of findings. The predominance of case reports introduces publication bias; as severe or unusual events are more likely to be reported. Additionally, accurate incidence rates cannot be determined from the available data. Nevertheless, the aggregation of detailed case-level information provides clinically relevant guidance for risk assessment, procedural planning, and patient safety.

In conclusion, vascular complications following facial filler injections are site-specific, filler-dependent, and technique-influenced, with rapid onset and potentially severe outcomes. Prevention through anatomical knowledge, careful technique, and appropriate filler selection remains paramount. Early recognition and prompt management can mitigate adverse outcomes, particularly for cutaneous events, but irreversible complications, especially ocular events, underscore the need for vigilance and preparedness. This systematic review synthesizes current evidence, providing a comprehensive framework for understanding and minimizing vascular complications in aesthetic facial procedures [55].

Conclusion

This systematic review and meta-analysis comprehensively evaluated vascular complications associated with facial dermal filler injections, integrating data from XX studies encompassing XXXX patients. The findings highlight the multifactorial nature of these adverse events and provide critical insights for clinical practice, risk stratification, and patient safety.

The distribution of complications was highly site-dependent. High-risk anatomical regions including the nasal dorsum, glabella, and forehead consistently demonstrated the highest frequency of vascular adverse events. These findings reflect the complex vascular anatomy of the face, particularly the direct anastomoses between facial arteries and the ophthalmic circulation, which facilitate retrograde embolization and contribute to severe complications, including visual impairment and cerebral infarction. Conversely, lower-risk areas such as the lateral cheeks, jawline, and submalar regions exhibited fewer complications, suggesting that tissue volume, vessel diameter, and collateral circulation modulate risk. Clinicians should therefore exercise heightened caution in high-risk zones, and careful anatomical planning should guide filler placement.

Filler type emerged as another critical determinant of complication frequency and severity. Hyaluronic acid fillers were the most frequently implicated, primarily due to their widespread use in aesthetic practice. Importantly, their reversibility with hyaluronidase allowed for prompt management in many cases, contributing to partial or full recovery. Non-reversible fillers, including calcium hydroxylapatite and Poly-L-lactic acid, were associated with more severe and often permanent outcomes, highlighting the importance of filler selection in mitigating adverse events. These observations underscore that safety profiles influenced not only by anatomical factors but also by material properties and reversibility.

Injection technique further modulated complication risk. Needle-based injections were more commonly associated with vascular events than cannula-based techniques, particularly in anatomically sensitive regions. Cannula use appeared to reduce, but not eliminate, the risk of severe outcomes. Technique-

related safety is therefore contingent upon proper training, depth control, aspiration practices, and adherence to site-specific anatomical considerations. Even experienced injectors encountered complications, emphasizing that anatomical knowledge and vigilance are paramount. Time to onset of vascular complications was typically immediate or within hours of injection, particularly for ocular and severe cutaneous events. Rapid recognition and early intervention were strongly associated with improved outcomes. Delayed-onset complications, though rare, highlight the need for post-procedural patient education and monitoring. Management strategies varied from conservative measures, such as topical vasodilators and observation, to aggressive interventions, including hyaluronidase administration and surgical debridement. Outcomes ranged from full recovery to partial recovery with residual aesthetic deficits, and in some cases, irreversible tissue or visual loss.

The integration of these findings provides actionable insights. Prevention through meticulous anatomical knowledge, careful technique, appropriate filler selection, and awareness of high-risk zones remains the cornerstone of patient safety. Early recognition of vascular compromise, supported by rapid intervention protocols, can significantly mitigate morbidity, particularly for cutaneous complications. Despite advancements in management, irreversible outcomes such as blindness or cerebral infarction underscore that certain complications cannot fully reversed, reinforcing the primacy of prevention.

In conclusion, this review demonstrates that vascular complications following facial filler injections influenced by a combination of injection site, filler type, technique, and timing. High-risk regions require meticulous planning, reversible fillers should be preferred in vulnerable areas, and prompt recognition with immediate intervention is essential to optimize outcomes. These findings provide a comprehensive framework for clinicians to minimize vascular complications, guide patient counseling, and inform future research on safety measures in facial aesthetic procedures. Ultimately, the study underscores that while dermal fillers are widely regarded as safe, vigilance, training, and preparedness are critical to preventing rare but potentially devastating vascular adverse events.

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