ADVANCED ULTRASOUND-GUIDED FACIAL FILLER TECHNIQUES WITH HYALURONIC ACID

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Abstract

Hyaluronic acid (HA) is widely used in aesthetic biomedicine due to its biocompatibility, water-retention capacity, and effectiveness in restoring facial volume and contour. However, facial filler procedures involve potential risks, particularly those associated with the facial vascular anatomy. In this context, ultrasonography has emerged as an important complementary tool, enabling real-time visualization of anatomical structures and contributing to greater safety and precision during procedures. The present study is an integrative literature review aimed at analyzing scientific evidence regarding the use of ultrasonography in facial filler procedures with hyaluronic acid. Articles published within the last ten years were included from the PubMed, SciELO, Embase, and Google Scholar databases. The findings indicate that the association between HA and ultrasound improves the planning, execution, and monitoring of procedures, reducing the risk of complications such as vascular occlusions and nodule formation. Furthermore, ultrasonography assists in personalizing techniques according to the individual characteristics of each patient. It can be concluded that the integration of these approaches represents a significant advancement in facial harmonization, promoting greater safety, efficacy, and clinical predictability.

Keywords: **hyaluronic acid; ultrasonography; facial fillers; facial harmonization; safety.**

I. INTRODUCTION

Hyaluronic acid (HA) is a natural polysaccharide present in the extracellular matrix, widely recognized for its ability to retain water, maintain skin hydration, and provide tissue support [1,2]. Due to its biocompatibility, biodegradability, and low immunogenic potential, it has become one of the most commonly used fillers in aesthetic biomedicine. Its clinical applications include the correction of wrinkles, folds, dark circles, volume restoration, and facial contour redefinition, enabling predictable and aesthetically satisfactory results [3,4]. However, complications such as edema, nodule formation, hypersensitivity, and, in more severe cases, vascular events—including tissue necrosis and even vision loss—highlight the importance of anatomical knowledge and proper injection techniques [5,6].

Ultrasonography, in turn, is a non-invasive diagnostic tool that uses high-frequency sound waves to produce real-time images of anatomical structures [7,8]. Its use in healthcare is well established due to the absence of radiation, accessibility, and versatility, allowing detailed evaluation of soft tissues, muscles, blood vessels, and adjacent structures [7]. In aesthetics, the application of ultrasound has increased significantly in recent years, enabling the monitoring of complications, detection of nodules and granulomas, as well as the analysis of the persistence of biomaterials such as dermal fillers [9,10]. Doppler ultrasound, in particular, adds value by enabling vascular mapping, assisting in the prevention of serious complications associated with inadvertent intravascular injections [11,12]. These advances highlight ultrasound not only as a diagnostic tool but also as a resource for safety and precision in minimally invasive aesthetic procedures [9,11].

The integration of hyaluronic acid and ultrasonography represents a significant advancement in aesthetic biomedical practice [9,10]. Recent studies demonstrate that the use of ultrasound guidance during facial filler procedures allows vascular mapping, identification of appropriate anatomical planes, assessment of tissue depth, monitoring of product distribution, and early detection of complications [13,14]. Research indicates that this association enhances result predictability, increases patient safety, and reduces potentially severe adverse events [15,16]. Nevertheless, there are still no widely standardized clinical protocols for the use of ultrasound in facial filler procedures, representing a scientific gap that deserves further investigation [17].

Given this context, the proposed intervention in this project consists of developing an integrative literature review aimed at gathering, analyzing, and synthesizing updated evidence regarding the use of ultrasonography in facial filler procedures with hyaluronic acid. The objective is to support the development of safer guidelines for aesthetic biomedical practice, highlighting the importance of anatomical expertise, the use of technological resources, and professional training.

II. METHODOLOGY

This study consists of an integrative literature review aimed at gathering, analyzing, and synthesizing the available scientific evidence regarding the use of ultrasound in aesthetic procedures involving hyaluronic acid. The search for articles was conducted in indexed databases such as PubMed, SciELO and Google Scholar, using the descriptors “hyaluronic acid,” “ultrasound,” “facial filler,” and their corresponding terms in Portuguese. Articles published within the last ten years, in both Portuguese and English, that directly addressed the application of ultrasound in facial filler procedures with hyaluronic acid, as well as its efficacy and safety, were included. Duplicate studies, articles without full-text access, and studies unrelated to the proposed topic were excluded. After the selection process, the articles were organized and analyzed according to authorship, publication year, objectives, methods, results, and conclusions. Subsequently, the data were compared and critically discussed, with emphasis on scientific advances, existing gaps, and future perspectives for aesthetic biomedical practice.

III. THEORETICAL FRAMEWORK

Anatomy of the Upper Face

Detailed anatomical knowledge of the upper face is essential for performing aesthetic procedures with fillers safely and effectively [18]. This region is composed of muscular, vascular, neural, and lymphatic structures, whose proper understanding enables greater precision in product application and reduction of complications [19]. Among the main muscles in this area are the frontal muscle, responsible for eyebrow elevation and the formation of horizontal forehead lines; the corrugator supercilii muscle, which promotes the approximation and depression of the eyebrows, generating the vertical wrinkles of the glabella; and the procerus muscle, which contributes to the formation of transverse lines located at the nasal root [20]. Understanding the function and location of these structures is essential not only to avoid asymmetries but also to correctly interpret the dynamics of facial expression [20].

The vascularization of the frontal region constitutes one of the main challenges in clinical practice with fillers [21]. The supratrochlear and supraorbital arteries, both derived from the ophthalmic artery, travel through the frontal subcutaneous tissue and present anastomoses with the ocular circulation, a condition that explains potentially severe complications such as skin necrosis and amaurosis in cases of accidental intravascular injection [20]. Given these risks, safer strategies such as the use of ultrasonography for vascular mapping and identification of infiltration planes have been recommended, as they contribute to reducing the likelihood of adverse events [19]. Another clinically relevant aspect is the innervation of the upper face [18]. The supratrochlear and supraorbital nerves are responsible for the sensitivity of the frontal region and anterior scalp, while branches of the facial nerve control muscular activity related to facial expressions [20]. Additionally, the periorbital lymphatic drainage is fragile, explaining the predisposition to edema following local aesthetic procedures [21]. Thus, the integration between muscles, vessels, nerves, and lymphatics must be considered during therapeutic planning to ensure safe and effective interventions [19].

The characteristics of the anatomical layers also deserve emphasis. The skin in this region is thin, with a compact dermis and minimal subcutaneous tissue, factors that increase its vulnerability to injury [22]. Beneath this superficial layer are the superficial musculoaponeurotic system (SMAS), fat compartments, and the periosteum, which are closely related to bony structures such as the frontal bone and glabella [23]. This complex overlap of anatomical planes makes injection depth a critical factor, determining both the success of the procedure and the occurrence of possible complications [24].

The natural aging process directly influences the anatomy of the upper face [25]. Changes such as bone resorption, reduction of subcutaneous fat, weakening of the SMAS, and decreased skin elasticity contribute to sagging, eyebrow descent, and deepening of facial folds [24]. In this context, the use of fillers aims not only to restore volume but also to provide structural support and functional balance to the region [18]. Understanding age-related anatomical modifications is essential for selecting individualized techniques, thereby promoting harmonious and safe results [25].

Hyaluronic Acid

HA is a natural polysaccharide belonging to the class of non-sulfated glycosaminoglycans, composed of repetitive units of glucuronic acid and N-acetylglucosamine [26]. It is widely distributed throughout different human tissues, with higher concentrations in the extracellular matrix of the skin, and is also present in the eyes, joints, and umbilical cord [27]. Its main physiological function is related to maintaining tissue hydration, elasticity, and structural integrity, attributed to its high capacity to attract and retain water molecules, thereby providing the skin with viscoelastic properties essential for cutaneous turgor [28]. These biological characteristics justify its extensive use in different areas of healthcare and aesthetics, being considered a biocompatible, biodegradable biomaterial with low immunogenic risk [29].

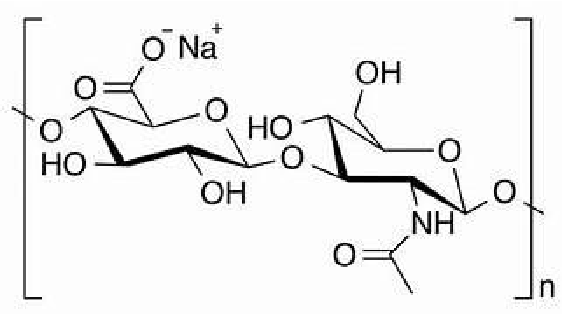

Figure 1: Chemical structure of hyaluronic acid.

In aesthetic dermatology, hyaluronic acid (HA) has become one of the main facial fillers, widely used for volume restoration, correction of folds, contour definition, and non-surgical facial rejuvenation [30]. Commercially, it is available in different formulations, mainly as cross-linked and non-cross-linked hyaluronic acid [31]. Non-cross-linked HA is indicated for treatments focused on hydration and improvement of skin quality, such as the skinbooster technique [31]. In contrast, cross-linked HA, due to its greater density and durability, is preferably used in areas requiring structural support, such as the malar region, jawline, and nasolabial folds [31]. This versatility allows the type of HA to be tailored to the specific needs of each patient, ensuring greater personalization of aesthetic outcomes [32].

In addition to its applications in aesthetics, HA is relevant in several medical specialties [32]. In ophthalmology, it is used in eye drops and as a vitreous substitute; in orthopedics, it acts as a viscosupplement in joints affected by osteoarthritis; in dentistry, it assists in tissue regeneration processes; and in regenerative medicine, it plays an important role in wound healing [32]. This broad applicability reinforces its clinical safety, since its biocompatibility significantly reduces the risk of severe adverse reactions [32]. Another important feature is the possibility of reversing its effects through the use of the enzyme hyaluronidase, an essential resource for managing complications in aesthetic procedures [28].

The efficacy and safety of HA in aesthetic procedures depend on multiple factors, including product density, anatomical plane of application, and injection technique [31]. The durability of the results varies according to the degree of product cross-linking and the treated region, ranging from 6 to 18 months [31]. Although HA is considered a safe material, complications may occur, such as edema, nodules, the Tyndall effect, tissue necrosis, and, in more severe cases, amaurosis resulting from intravascular injection [32]. In this context, mastery of facial anatomy, combined with an understanding of HA properties and the use of adjunctive tools such as ultrasonography, is essential to improve clinical predictability and reduce procedure-related risks.

Evaluation of the Rheological Properties of HA Fillers

The rheological properties of hyaluronic acid (HA) represent one of the main determinants of its clinical behavior in aesthetic procedures [33–35]. Rheology, the science that studies how materials respond to the application of external forces, is essential for understanding the behavior of hyaluronic acid-based fillers during and after their application into tissues [33,35]. In the context of aesthetic biomedicine, rheological analysis makes it possible to evaluate how the material deforms, flows, and adapts to anatomical structures, directly influencing its interaction with tissues and the clinical outcomes achieved.

Therefore, understanding rheological properties becomes essential for the appropriate selection of the product, since these characteristics determine its performance, durability, and safety in aesthetic procedures [36]. Viscosity refers to the gel's resistance to flow and is associated with both ease of injection and its integration into adjacent tissues [35]. Elasticity, often expressed by the storage modulus (G'), evaluates the gel's ability to recover its original shape after deformation [35]. This parameter is particularly relevant in areas requiring greater support and subjected to higher mobility, such as the malar region and jawline [37]. Products with higher G' values provide greater firmness and lifting effect, favoring projection and definition in areas requiring structural support [37].

Another rheological factor of clinical importance is cohesivity, which describes the gel's tendency to remain integrated as a single mass, without fragmentation or tissue migration [35]. This characteristic impacts both the natural appearance of the result and the risk of local complications, such as nodule formation [35]. The careful selection of the filler should therefore consider the interaction between cohesivity, viscosity, elasticity, depth of application, and individual anatomical variability [35].

From a technological perspective, manufacturers develop different HA formulations by varying parameters such as degree of cross-linking, particle size, and gel density in order to meet different clinical demands [35]. Fillers with high viscosity and greater elastic modulus are indicated for areas requiring projection and volumetric support, whereas lighter formulations, with lower density and greater malleability, are preferred for delicate regions such as the tear troughs and lips, where the objective is to achieve subtler and more natural results [38].

Thus, understanding the rheological parameters of HA-based fillers is fundamental to ensuring clinical practice grounded in safety and efficacy [35]. Such knowledge allows professionals to select products in a personalized manner, respecting both the anatomical particularities and the aesthetic or therapeutic goals of each patient, thereby reducing risks and maximizing outcomes [35].

Fundamentals of Ultrasound

Ultrasound is a medical imaging modality widely used in different specialties due to its safety profile, since it does not employ ionizing radiation, and its ability to provide real-time images [39]. Its physical principle is based on the emission of high-frequency sound waves, generally between 1 and 20 MHz, which travel through biological tissues and undergo phenomena of reflection, refraction, and absorption according to the density and composition of the encountered structures [40]. These waves return to the transducer and are converted into electrical signals that, after processing, generate two-dimensional or three-dimensional images, depending on the technological resources of the equipment [7,8].

The quality of ultrasonographic imaging is influenced by factors such as the frequency used, tissue acoustic impedance, depth of the examined region, and the technical experience of the operator [41]. In superficial structures, such as the face, high-frequency transducers (10 to 18 MHz) are used, allowing detailed visualization of layers such as the skin, subcutaneous tissue, musculature, and vascular network [42].

This diagnostic precision expands the applicability of ultrasound in different areas, ranging from traditional specialties—such as cardiology, obstetrics, and dermatology—to emerging fields, such as orofacial harmonization and minimally invasive aesthetic procedures [11,9].

In facial filler procedures, ultrasonography offers significant advantages [43]. Among them are the possibility of identifying critical structures, such as facial arteries and vascular branches, thereby reducing the risk of complications, as well as assisting in defining the ideal depth for hyaluronic acid application [44]. The method can also be used in real time during the procedure, promoting greater precision in product deposition [43,44]. Additionally, it plays an important role in the diagnosis of complications, such as nodules, granulomas, and vascular obstructions, providing support for safer and more effective therapeutic management [45,46]. Thus, ultrasound has become established as an essential support technology in contemporary clinical practice, with remarkable expansion in the aesthetic field [47]. The integration of ultrasonography with detailed anatomical knowledge of the face enhances the predictability of outcomes and increases the safety margin in facial filler procedures, reinforcing its importance for professionals working with minimally invasive techniques [39].

Principles of Ultrasound Technique

Ultrasonography is based on the physical principles of high-frequency acoustic waves and their interaction with biological tissues [39]. When these waves encounter interfaces between tissues with different acoustic impedances, part of the energy is reflected back toward the transducer, while the remaining fraction is transmitted to the subsequent layers [40]. The magnitude of the reflection is directly related to the contrast in acoustic impedance between tissues, enabling the generation of images that represent these structural differences [7,8].

In addition to reflection, other physical phenomena influence the quality of ultrasonographic imaging [41]. Attenuation corresponds to the progressive loss of sound wave intensity during its propagation through tissues, resulting from processes of absorption, scattering, and energy deviation [42]. Scattering occurs when waves strike irregular surfaces or structures smaller than the wavelength, producing echoes distributed in multiple directions [43]. Refraction results from changes in wave propagation speed as it passes through media with different densities, potentially causing displacement in the apparent position of the obtained images [44]. The operator's understanding of these physical phenomena is essential for accurate interpretation of ultrasonographic findings [48].

In clinical practice, the selection of transducer frequency is a determining factor for the quality of the examination [47]. High-frequency transducers (10–18 MHz) provide greater spatial resolution and are indicated for the analysis of superficial structures, such as the skin, subcutaneous tissue, and facial musculature [42]. In contrast, low-frequency transducers (1–5 MHz) offer greater penetration, although with less anatomical detail, and are therefore more commonly used for the evaluation of deeper regions [41].

In orofacial harmonization, mastery of these physical principles allows professionals to correctly interpret ultrasonographic anatomy, identify critical vascular structures, and assess the depth of tissue planes [39,43]. This approach enables greater precision in the planning and execution of facial filler procedures, enhancing the safety and efficacy of the employed techniques [44,47]. Thus, the practical application of ultrasonography fundamentals constitutes an indispensable resource in contemporary clinical aesthetic practice [11,9].

Ultrasound-Guided Nasal Filler Techniques

The use of ultrasonography in nasal filler procedures has emerged as a highly relevant tool for increasing the precision and safety of aesthetic interventions [48]. Nonsurgical rhinoplasty, a minimally invasive technique that uses hyaluronic acid to reshape the nose, demonstrates significant benefits when performed under ultrasound guidance [49]. This resource enables real-time visualization of anatomical structures, facilitating the identification of blood vessels and other critical structures, while also allowing the injection technique to be adapted according to the individual anatomical characteristics of each patient [50,51].

Two main approaches are described for ultrasound-guided nasal filling: needle injection and cannula injection [52]. The needle technique, traditionally used, allows precise deposition of the filler material into the desired plane [53]. However, the use of cannulas has become increasingly valued due to the lower incidence of vascular complications, including hematomas and embolisms, since the blunt tip enables a safer and more controlled trajectory, especially in regions with complex vascular anatomy [50,51]. The choice of instrument should take into account factors such as the patient's anatomy, the treatment area, and the professional's clinical experience.

The integration of ultrasonography into nonsurgical rhinoplasty procedures not only enhances safety but also contributes to the optimization of aesthetic outcomes [54]. Dynamic visualization of anatomical structures allows immediate adjustments during the injection, ensuring proper filler placement within the appropriate tissue layers and reducing the risk of inadvertent injections into blood vessels or other sensitive structures [52]. Furthermore, ultrasound enables longitudinal follow-up of the filler, facilitating the early detection of possible complications and timely corrective interventions, thereby increasing the predictability and clinical effectiveness of the procedure [50,51].

Technique: Deep Needle Injections

Deep needle injections are considered one of the most traditional approaches in nasal filling with hyaluronic acid, allowing high precision in the deposition of the filler material [55]. In this method, the professional uses fine-gauge needles to apply the product directly into the desired anatomical planes, such as the nasal dorsum or tip, aiming to achieve more natural, proportional, and symmetrical aesthetic outcomes [56]. The use of ultrasonography as a supportive tool enhances the safety of the technique by enabling prior and real-time identification of critical structures, such as blood vessels, thereby preventing significant complications, including hematomas, tissue necrosis, or embolization [57]. Additionally, dynamic monitoring of the material distribution promotes a more uniform dispersion of the gel, minimizing superficial irregularities and ensuring proper nasal contouring [58]. It is important to emphasize that this technique requires extensive anatomical knowledge and clinical experience, since small variations in the angle or depth of insertion may significantly affect the achieved aesthetic results [56].

The effectiveness of this approach lies in the association between the mechanical precision of the needle and the diagnostic support provided by ultrasound [59]. Evidence indicates that the use of ultrasonography during needle injections contributes to reducing the risk of inadvertent intravascular injection, while also increasing the predictability and reproducibility of the results [57]. Another relevant aspect is the possibility of post-procedure imaging follow-up, which allows the early detection of complications, such as gel displacement or nodule formation, enabling immediate corrective interventions [60]. Thus, ultrasound-guided nasal filler injection with needles represents a significant advancement in orofacial harmonization by combining clinical safety with aesthetic precision.

Ultrasound-Guided Superficial Injection Techniques

Superficial injection techniques guided by ultrasound have gained increasing relevance in facial aesthetic procedures due to their ability to provide subtle refinements and improved contour definition with enhanced procedural safety [67]. In nasal filling procedures, superficial applications of hyaluronic acid are generally indicated for the correction of minor irregularities, asymmetries, and contour imperfections located in the dermal or immediate subdermal planes [68]. Because these anatomical layers are closely associated with the cutaneous vascular network, the use of ultrasonography becomes especially important for accurate visualization of tissue planes and vascular structures, reducing the likelihood of inadvertent intravascular injection [69].

During the procedure, high-frequency ultrasound transducers enable real-time identification of the skin, subcutaneous tissue, cartilage, and superficial vessels, allowing the practitioner to precisely control needle or cannula positioning and the depth of product deposition [70]. This imaging guidance contributes to a more homogeneous distribution of hyaluronic acid and minimizes complications such as the Tyndall effect, irregularities, edema, or superficial nodules [71]. Furthermore, ultrasound-assisted superficial injections improve procedural predictability by enabling dynamic assessment of filler placement and tissue response throughout the intervention [72].

Another important advantage of ultrasound-guided superficial techniques is the possibility of individualized treatment planning according to each patient's anatomy [73]. Variations in skin thickness, vascularization, and tissue characteristics can be identified before injection, allowing safer and more precise adjustments in product selection, injection depth, and filler volume [74]. In addition, ultrasound monitoring may assist in post-procedural follow-up by facilitating the early detection of filler displacement, inflammatory reactions, or localized complications, thereby improving therapeutic management and patient safety [75].

Therefore, ultrasound-guided superficial injection techniques represent a significant advancement in minimally invasive rhinofilling procedures, combining anatomical precision, real-time visualization, and enhanced safety. The integration of ultrasonography into superficial facial filler applications contributes to more natural aesthetic outcomes, reduced complication rates, and greater clinical predictability in facial harmonization procedures [76].

Ultrasonographic Anatomy of the Nasolabial Fold

The nasolabial fold, classically referred to as the nasolabial crease and popularly known as the "smile line," corresponds to an anatomical fold extending from the nasal ala to the labial commissure, delimiting the transition between the malar region and the upper lip [67]. The aging process, associated with structural skin changes, redistribution of subcutaneous fat, and bone remodeling, accentuates the depth of this fold, making it a frequent aesthetic complaint among patients undergoing facial rejuvenation procedures [68]. In this context, ultrasonography (US) has emerged as an important diagnostic and planning tool because it enables real-time evaluation of anatomical structures and assists in the execution of minimally invasive techniques, such as dermal fillers, with greater safety and predictability [69,70].

The nasolabial fold region presents complex anatomy involving the skin, subcutaneous tissue, fibers of the orbicularis oris muscle, the zygomaticus major muscle, and critical vascular structures such as the facial and lateral nasal arteries [71]. The use of ultrasonography allows accurate identification of these elements, guiding the selection of the injection plane, the most appropriate technique, and the ideal depth for hyaluronic acid application [72]. In addition, it enables the detection of individual anatomical variations, particularly regarding the positioning and depth of blood vessels, thereby reducing the risk of complications such as hematomas, tissue necrosis, or embolization [69,70].

The integration of ultrasonography into the planning of nasolabial fold filling procedures also promotes greater personalization of aesthetic interventions [73]. Real-time ultrasonographic visualization allows the practitioner to adapt the technique according to each patient's specific anatomical characteristics, including skin thickness, vascular distribution, and the degree of tissue laxity or volume loss in the region [74]. Thus, beyond improving the clinical safety margin, ultrasonography contributes to more natural and harmonious aesthetic outcomes, consolidating its role as an indispensable tool in contemporary facial rejuvenation practice [69,70].

Ultrasound-Guided Nasolabial Fold Filling Techniques

The nasolabial fold, commonly referred to as the "smile line," is one of the facial regions most susceptible to the appearance of aging signs due to subcutaneous volume loss, atrophy of fat compartments, and muscular laxity [75]. Aesthetic harmonization of this area predominantly involves the application of dermal fillers, with hyaluronic acid (HA) being the most commonly used agent because of its biocompatibility, tissue hydration capacity, and structural properties [76]. The use of ultrasonography (US) enables detailed visualization of underlying anatomical structures, including blood vessels, muscles, and subcutaneous tissue, thereby increasing procedural safety and minimizing complications such as hematomas, necrosis, or embolization [77,78].

Ultrasound-guided techniques involve the assessment of the ideal depth for filler placement as well as the selection of the most appropriate instrument — needle or cannula — according to the patient's individual anatomy [79]. Ultrasonography allows the identification of specific anatomical variations, such as the location of the facial and labial arteries, enabling the technique to be adapted to each patient's needs [80]. Furthermore, real-time monitoring of HA distribution ensures uniform filler placement, preventing superficial irregularities and promoting natural and harmonious contours in the nasolabial region [77,78].

The integration of ultrasonography into the planning and execution of nasolabial fold filling procedures enables a personalized approach that considers factors such as skin thickness, degree of tissue laxity, and individual vascular anatomy [81]. This personalization contributes to the optimization of aesthetic outcomes while improving procedural safety and effectiveness. Therefore, the incorporation of ultrasonography into nasolabial filling techniques represents a significant advancement in minimally invasive facial harmonization practice, combining technical precision with predictable and safe aesthetic results [77,78].

Supraperiosteal Filler Insertion with Needle

The supraperiosteal filler insertion technique using a needle is widely employed in facial harmonization for volume repositioning and enhancement of facial contours [82]. This approach consists of depositing hyaluronic acid directly onto the periosteum, providing firm structural support and promoting an immediate and long-lasting lifting effect [83,84]. Precise needle placement is essential for procedural safety, as inadvertent injection into blood vessels or nerves may result in complications such as hematomas, tissue necrosis, or other adverse reactions [83,84]. Ultrasonography (US) has become an essential tool in this context, enabling real-time visualization of anatomical structures and guiding filler placement into the desired tissue layers [85].

Ultrasonography allows the identification of individual anatomical variations, including the location and depth of arteries and other critical structures, ensuring that the procedure is performed accurately, safely, and effectively [83,84]. Evidence indicates that the combination of the supraperiosteal technique with ultrasound guidance significantly improves aesthetic outcomes, providing more natural, symmetrical, and harmonious facial contours [86]. Continuous visualization of anatomical structures also enables immediate adjustments during filler application, increasing procedural accuracy and patient satisfaction [83,84].

Ultrasonographic Anatomy of the Zygomatic and Preauricular Regions

The zygomatic and preauricular regions are highly relevant in facial harmonization practice, particularly in minimally invasive procedures such as hyaluronic acid filler injections [87,88]. Ultrasonography (US) has become an indispensable tool for the assessment of these areas, enabling detailed visualization of anatomical structures and supporting a safer and more precise approach [89,88]. The zygomatic region is composed of osseous, muscular, and vascular elements that can be identified through US, facilitating filler application and minimizing the risk of complications [90,91].

The use of ultrasonography allows real-time visualization of the different tissue layers, including the skin, subcutaneous tissue, muscles, and blood vessels, providing essential information for the performance of aesthetic procedures [92,89]. Precise identification of the location and depth of facial arteries, such as the transverse facial artery, is crucial to prevent intravascular injections, thereby reducing the occurrence of hematomas, necrosis, and other adverse events [90,91]. Furthermore, US enables the assessment of skin thickness and the detection of individual anatomical variations, allowing personalization of the filling technique according to each patient's characteristics [93,88].

The preauricular region, located anterior to the ear, is also of great interest in facial harmonization [87,89]. Through ultrasonography, it is possible to identify critical structures such as the masseter muscle, the facial nerve, and the transverse facial artery, all of which are essential for the safety and effectiveness of aesthetic procedures in this area [93,91]. Visualization of these structures contributes not only to the prevention of complications but also to the achievement of more natural and harmonious aesthetic outcomes [90,91].

Filling Techniques for the Zygomatic and Preauricular Regions

The zygomatic region, commonly referred to as the "cheekbone area," represents one of the most valued facial areas in aesthetic harmonization, providing youthfulness and definition to the facial contour [94,95]. Hyaluronic acid (HA) filler injection in this region has gained increasing popularity, offering natural and long-lasting results [94,96]. The use of ultrasonography (US) as an auxiliary tool in this procedure has proven effective in guiding precise filler application, increasing both safety and predictability of clinical outcomes [91]. Ultrasound-guided filling techniques enable real-time visualization of facial anatomical layers, facilitating the identification of critical structures such as blood vessels and nerves and allowing selection of the most appropriate injection plane [93,92]. Ultrasonography also provides information regarding the ideal depth for HA deposition, contributing to the prevention of complications such as hematomas, tissue necrosis, or embolization [91]. Several technical approaches may be employed in zygomatic region filling procedures, including the linear technique, the fanning technique, and the layering technique [95,94]. The choice of the most appropriate method should consider the patient's individual characteristics as well as the desired aesthetic goals [96]. The use of ultrasonography allows customization of the procedure, enabling real-time adjustments during filler application and optimizing the final outcome [91]. The integration of ultrasonography into zygomatic filling techniques provides a safer and more effective approach, promoting more natural, symmetrical, and satisfactory aesthetic results for patients [93,96]. Furthermore, US enables post-procedure monitoring, facilitating the early detection of possible complications and reinforcing clinical safety in facial harmonization practice [91].

Limitations

Despite the advances in the use of ultrasonography (US) to guide facial filler procedures, several important limitations must be considered [96][93]. Dependence on specialized equipment and the need for adequate technical training may restrict its application in smaller clinics or among professionals without prior experience [94,95]. Correct interpretation of ultrasonographic images requires continuous practice, since precise visualization of critical facial structures — such as blood vessels, muscles, and bones — is essential for preventing complications during the procedure [91,97].

Another limitation arises from individual anatomical variations among patients [95,92]. Differences in skin thickness, adipose tissue volume, and vascularization may hinder the standardization of techniques, making individualized planning indispensable for each region, whether nasal, zygomatic, or nasolabial [96,94]. Although ultrasonography provides real-time guidance, it does not replace detailed clinical evaluation, which remains fundamental for ensuring safety and satisfactory aesthetic outcomes [98][99].

Additionally, the choice of filler type and its rheological properties directly influences the effectiveness and durability of the results [100,94]. Hyaluronic acids with higher viscosity provide greater support in deeper regions but may limit precise contouring in more delicate areas [95,92]. Similarly, injection techniques using needles or cannulas present limitations regarding depth of deposition and the risk of tissue trauma, even when ultrasound-guided [100,91]. Finally, although the use of ultrasonography significantly reduces risks, it does not completely eliminate the possibility of complications such as hematomas, edema, or vascular embolism [93,96]. The effectiveness of the procedure depends on the practitioner's skill, the quality of the equipment, and patient cooperation [94,92]. Therefore, comprehensive knowledge of ultrasonographic anatomy and the properties of hyaluronic acid, combined with clinical experience, remains indispensable for performing safe and effective facial filler procedures [98,99].

IV. CONCLUSION

This integrative review demonstrated that the use of hyaluronic acid associated with ultrasonography represents a significant advancement in the practice of aesthetic biomedicine, especially in the context of facial fillers. The findings showed that hyaluronic acid presents a high safety profile, clinical efficacy, and versatility, being widely used for volumetric restoration and facial rejuvenation. However, the occurrence of complications, although rare, reinforces the need for anatomical and technical expertise on the part of the professional. In this context, ultrasonography stands out as an essential complementary tool, enabling real-time visualization of facial structures, vascular mapping, and precise guidance during product injection. Furthermore, it contributes to the early diagnosis of complications, increasing the predictability of clinical outcomes. Despite limitations related to the need for specialized training and equipment, its incorporation into clinical practice significantly enhances procedural safety. Therefore, it can be concluded that the integration of anatomical knowledge, filler properties, and technologies such as ultrasound is fundamental for performing safer, more effective, and personalized aesthetic interventions.

CONFLICT OF INTEREST

The authors affirm that they have no conflicts of interest.

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