# Ultrasonographic Evaluation of Upper Facial Static Lines: A Narrative Review

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***Abstract***

**Background:** Upper facial static lines, particularly those affecting the forehead, glabellar region, and lateral canthal area, represent one of the most visible manifestations of facial aging. These lines develop as a result of complex interactions between repetitive muscular activity, progressive dermal collagen degradation, loss of skin elasticity, photoaging, and structural changes in the underlying soft tissues. Traditional evaluation of static rhytides in aesthetic dermatology is largely based on visual inspection and clinical grading scales. However, these methods primarily assess the skin surface and do not adequately reflect the structural alterations occurring in deeper anatomical layers, including the dermis, subcutaneous tissue, muscles, and vascular structures that contribute to wrinkle formation and persistence.

**Aim:** The aim of this narrative review is to provide a comprehensive overview of the role of ultrasonography in the evaluation of upper facial static lines. The review focuses on the principles of high-frequency ultrasound in dermatologic imaging, the ultrasonographic appearance of normal upper facial anatomy, and the structural changes associated with skin aging and static rhytides. In addition, it discusses the clinical utility of Doppler ultrasonography for vascular mapping of the forehead and glabellar regions, particularly in the context of minimally invasive aesthetic procedures. The review also highlights how ultrasound can assist clinicians in treatment planning, guiding injections, monitoring therapeutic outcomes, and identifying complications related to fillers, botulinum toxin, and thread-based rejuvenation techniques.

**Conclusion:** High-frequency ultrasonography has emerged as a valuable, non-invasive imaging modality in aesthetic dermatology, providing real-time visualization of the multilayered structure of facial tissues. Its ability to assess skin thickness, echogenicity, soft-tissue architecture, and vascular pathways allows a deeper understanding of the structural basis of upper facial static lines. Furthermore, Doppler ultrasound enhances procedural safety by identifying critical vascular structures in high-risk injection areas such as the glabella and forehead. By enabling individualized anatomical assessment and dynamic evaluation of facial tissues, ultrasonography supports more precise and safer aesthetic interventions. Despite these advantages, wider clinical adoption requires standardized imaging protocols, improved operator training, and further clinical studies to clarify its full potential in the evaluation and management of upper facial static lines.

***Keywords:*** *Ultrasonographic Evaluation, Upper Facial Static Lines, Review*

## Introduction

Facial aging is a multifactorial biological process involving structural and functional changes in the skin, subcutaneous tissue, musculature, and underlying skeletal support. Among the most visible manifestations of aging are static lines of the upper face, particularly those affecting the forehead, glabellar region, and lateral periorbital area. Initially, facial wrinkles develop as dynamic lines resulting from repetitive contraction of facial expression muscles. Over time, persistent mechanical stress, degradation of collagen and elastin fibers, and progressive dermal remodeling lead to the transformation of these dynamic wrinkles into permanent static rhytides that remain visible even at rest. These changes are further accelerated by extrinsic factors such as chronic ultraviolet radiation exposure, smoking, and oxidative stress, which contribute to skin thinning, reduced elasticity, and dermal matrix breakdown. [1]

Upper facial static lines are of considerable aesthetic concern because they strongly influence the perception of facial aging and emotional expression. Studies evaluating facial aging have shown that wrinkles in the upper face significantly affect perceived age and interpersonal perception, often being interpreted as signs of fatigue, stress, or negative emotional states. Consequently, the management of forehead and glabellar lines has become a central focus of modern aesthetic dermatology and facial rejuvenation. Both surgical and non-surgical approaches have been developed to address these concerns, with minimally invasive techniques such as botulinum toxin injections, hyaluronic acid fillers, and thread-based lifting procedures gaining increasing popularity due to their safety profile and shorter recovery times. [2]

Despite the wide use of these aesthetic treatments, accurate assessment of the underlying anatomical structures remains essential for achieving predictable outcomes. The upper face contains a complex arrangement of muscles, fascia, fat compartments, and vascular networks, including critical vessels such as the supratrochlear and supraorbital arteries. Variations in the course and depth of these structures may significantly influence treatment strategies and complication risks during injectable procedures. Conventional clinical examination methods, including visual inspection and wrinkle grading scales, primarily assess surface morphology and therefore provide limited insight into deeper tissue architecture. This limitation highlights the need for additional imaging tools that can objectively evaluate the multilayered anatomy involved in the formation of static facial lines. [3]

In recent years, ultrasonography has emerged as an important imaging modality in dermatology and aesthetic medicine. High-frequency ultrasound enables real-time, noninvasive visualization of skin layers, subcutaneous tissues, muscles, and vascular structures. This technology allows clinicians to evaluate tissue thickness, echogenicity, and structural integrity while also identifying anatomical landmarks relevant to aesthetic interventions. Furthermore, Doppler ultrasonography can be used to detect and map facial arteries, thereby improving procedural safety during filler and neuromodulator injections in high-risk areas such as the glabella and forehead. These capabilities make ultrasonography a valuable adjunct in both the evaluation of facial aging and the planning of aesthetic procedures. [4]

Beyond diagnostic applications, ultrasound has increasingly been incorporated into aesthetic practice for treatment planning, procedure guidance, and complication management. Pre-treatment imaging can help identify previous filler placement, evaluate tissue characteristics, and determine appropriate injection planes. Real-time ultrasound guidance may also reduce the risk of vascular complications by allowing practitioners to visualize vessels and surrounding tissues during injection. Additionally, ultrasound imaging can monitor treatment outcomes and detect adverse events such as filler migration, vascular compromise, or inflammatory reactions. As a result, ultrasound is gradually becoming an integral tool in precision-based aesthetic medicine. [5]

Despite the expanding use of ultrasound in facial aesthetics, its specific role in evaluating upper facial static lines has not been comprehensively summarized in the literature. Most existing studies focus on ultrasound applications in filler safety, vascular mapping, or general facial anatomy rather than directly addressing the structural characteristics associated with static rhytides. Therefore, a clearer understanding of how ultrasonography can contribute to the assessment of upper facial aging is needed.

The aim of this narrative review is to explore the role of ultrasonography in the evaluation of upper facial static lines. The review discusses the anatomical and pathophysiological basis of these wrinkles, the principles of high-frequency and Doppler ultrasound in dermatologic imaging, and the ultrasonographic features relevant to facial aging. In addition, it highlights the clinical applications of ultrasound in aesthetic procedures involving the upper face, including treatment planning, safety enhancement, and complication management. Through this analysis, the review aims to provide dermatologists and aesthetic practitioners with an updated perspective on the integration of ultrasonography into the assessment and management of upper facial static lines.

**Principles of Cutaneous and Facial Ultrasonography**

Ultrasonography is a non-invasive imaging modality that allows real-time visualization of anatomical structures through the interaction of high-frequency sound waves with biological tissues. In dermatology and aesthetic medicine, ultrasound has gained increasing importance because it provides dynamic evaluation of the skin and underlying soft tissues without exposing patients to ionizing radiation. The technique enables clinicians to visualize different tissue layers, detect structural abnormalities, and monitor changes induced by therapeutic interventions. Continuous technological improvements in ultrasound devices have significantly enhanced image resolution and diagnostic accuracy, making ultrasound a valuable tool for both clinical and research applications in skin imaging. [6]

The principle of ultrasound imaging relies on the emission of sound waves from a transducer into the tissues. When these waves encounter structures with different acoustic properties, part of the signal is reflected back to the probe and converted into an image. The resulting grayscale image reflects the echogenicity of tissues, which depends on their density and structural composition. Structures rich in collagen or fibrous components typically appear hyperechoic, whereas tissues with higher fluid content or adipose tissue demonstrate lower echogenicity. These differences allow ultrasound to distinguish between the epidermis, dermis, subcutaneous tissue, and deeper facial structures, providing detailed insight into the architecture of the skin and soft tissues. [7]

The choice of ultrasound frequency is a critical factor in dermatologic imaging. For facial examination, ultrasound frequencies typically range between 10 and 15 MHz, allowing adequate penetration to visualize the dermis, subcutaneous tissue, and superficial muscles. Lower frequencies provide deeper penetration but reduced resolution, which may limit visualization of superficial skin structures. In contrast, high-frequency probes exceeding 15 MHz, and sometimes reaching 20–22 MHz, are increasingly used in aesthetic medicine to obtain high-resolution images of the epidermis and dermis. These high-frequency systems enable more precise evaluation of skin thickness, collagen distribution, and structural changes associated with aging or aesthetic treatments. [8]

On ultrasound imaging, healthy skin demonstrates a characteristic layered appearance. The most superficial structure is the entrance echo, which appears as a highly echogenic irregular band corresponding to the keratinized cells of the stratum corneum. Beneath this layer lies the dermis, which appears as a diffuse echogenic band with variable brightness depending on the density of collagen fibers and the level of tissue hydration. The subcutaneous tissue is typically visualized as a hypoechoic or anechoic layer composed of fat lobules separated by echogenic fibrous septa. Variations in echogenicity within these layers may reflect physiological differences, aging processes, or pathological changes in the skin. [9]

Collagen content plays a central role in determining the echogenic characteristics of the dermis. Areas containing a higher concentration of organized collagen fibers typically demonstrate greater echogenicity on ultrasound imaging. Conversely, increased amounts of intercellular matrix or tissue hydration tend to reduce echogenicity. These properties allow ultrasound to indirectly assess structural changes in the dermal matrix associated with aging, photoaging, and tissue remodeling. For this reason, ultrasound examination is often performed by comparing affected skin areas with adjacent healthy skin in order to identify subtle structural differences and evaluate the extent of tissue alteration. [9]

High-resolution ultrasound has also become an important tool in cosmetology and medical aesthetics for the evaluation of minimally invasive procedures. Modern ultrasound systems equipped with high-frequency probes provide objective measurements of epidermal and dermal thickness, echogenicity of skin layers, and the presence of edema or structural changes in the subcutaneous tissue. Such parameters allow clinicians to assess baseline skin characteristics prior to treatment and to monitor tissue responses after aesthetic procedures such as dermal filler injections, neuromodulator treatments, or thread-lifting techniques. This capability enhances treatment planning and supports evidence-based evaluation of therapeutic outcomes. [10]

Beyond structural imaging, ultrasound can also be used to evaluate materials injected during aesthetic procedures. Dermal fillers exhibit distinctive ultrasound patterns depending on their composition and interaction with surrounding tissues. For instance, certain fillers integrate with surrounding tissues and create heterogeneous echogenic patterns, while other materials may produce characteristic acoustic artifacts or globular anechoic structures corresponding to liquid or gel components. Recognition of these ultrasound patterns allows clinicians to identify the type and location of previously injected materials and to evaluate their distribution within facial tissues. This information is particularly valuable when managing complications or planning additional aesthetic interventions. [11]

An additional important application of ultrasound in facial aesthetics is Doppler imaging, which allows visualization of vascular structures by detecting the movement of blood within vessels. Doppler ultrasound enables clinicians to map facial arteries and assess their depth and course before performing injections in high-risk areas. The ability to identify vessels such as the supratrochlear, supraorbital, and dorsal nasal arteries is particularly important in the upper face, where inadvertent intravascular injection of fillers can lead to severe complications, including skin necrosis or ocular ischemia. By identifying these vascular pathways before treatment, Doppler ultrasound contributes significantly to improving the safety of aesthetic procedures. [12]

**Ultrasonographic Anatomy of the Upper Face (Forehead and Glabellar Region)**

A detailed understanding of the layered anatomy of the upper face is essential for interpreting ultrasonographic findings related to static lines of the forehead and glabellar region. The upper face contains a complex arrangement of skin, fat compartments, fascial layers, muscles, and vascular structures that interact to produce facial expressions and influence wrinkle formation. High-frequency ultrasonography provides a non-invasive method to visualize these anatomical layers in vivo, allowing clinicians to better understand the structural basis of facial rhytides and to guide aesthetic procedures safely. [13]

On ultrasound imaging, the forehead demonstrates a multilayered anatomical structure. From superficial to deep, the principal layers include the skin, superficial subdermal fat layer, suprafrontalis fascia, frontalis muscle, retrofrontalis fat compartments, subfrontalis fascia, loose connective tissue containing deeper fat compartments, and finally the frontal periosteum covering the frontal bone. These layers can be distinguished on high-resolution ultrasound by differences in echogenicity and structural appearance. The epidermis appears as a thin hyperechoic line, the dermis as a thicker echogenic band, and the subcutaneous tissue as a hypoechoic region with characteristic echogenic fibrous septa. Deeper muscular and fascial structures show distinctive patterns that allow identification of the frontalis muscle and adjacent tissue planes. [14]

The frontalis muscle plays a central role in the development of forehead lines because it is responsible for elevating the eyebrows and producing horizontal forehead wrinkles during facial expression. On ultrasound, the frontalis muscle appears as a hypoechoic band with linear echogenic striations corresponding to muscle fibers. The muscle lies beneath the superficial fat layer and above the deeper retrofrontalis fat compartments and periosteum. Continuous repetitive contraction of the frontalis muscle contributes to the gradual formation of dynamic wrinkles, which may later evolve into static lines due to dermal structural changes and loss of skin elasticity. Ultrasound imaging allows clinicians to evaluate the thickness and activity of this muscle and to identify individual variations that may influence aesthetic treatment planning. [15]

An important anatomical concept related to the treatment of upper facial rhytides is the **line of**

**convergence**, which represents the region where the upward and downward movement of frontal soft tissues converges during frontalis muscle contraction. Identification of this zone is clinically relevant for neuromodulator injections because it determines the optimal location for toxin placement while minimizing the risk of eyebrow ptosis. Ultrasound imaging allows precise localization of the line of convergence by observing dynamic tissue movement while the patient contracts the frontalis muscle. Unlike surface observation or three-dimensional imaging, ultrasound can detect subtle motion of deeper tissues and muscle fibers, enabling more accurate identification of this functional landmark. [16]

High-frequency ultrasound also allows visualization of the fat compartments of the forehead, which play an important role in facial aging. These compartments include the superficial and deep retrofrontalis fat layers that provide structural support to the overlying skin. With aging, redistribution and volume loss within these compartments may contribute to the appearance of static forehead lines and changes in brow position. Ultrasonographic imaging can demonstrate alterations in fat thickness and tissue structure, providing additional insight into the anatomical factors contributing to wrinkle formation in the upper face. [14]

In addition to muscular and fat structures, vascular anatomy is of critical importance in the glabellar and forehead regions. The supratrochlear and supraorbital arteries are among the most significant vessels supplying the upper face, and their anatomical variations may influence both aesthetic outcomes and complication risks during injectable procedures. Ultrasound imaging, particularly when combined with Doppler techniques, allows direct visualization of these vessels and their relationship to surrounding tissues. In many individuals, these arteries transition from deeper planes near the orbital rim to more superficial positions as they ascend in the forehead, which may increase the risk of intravascular injection during aesthetic treatments. [17]

The glabellar region is particularly sensitive because the supratrochlear artery may run close to or directly beneath glabellar wrinkle lines in some anatomical variations. Ultrasonographic evaluation has demonstrated that this artery can occasionally lie within the subdermal plane, making injections in this region potentially hazardous if performed without awareness of vascular anatomy. Visualization of the artery using Doppler ultrasound enables clinicians to identify its precise course and avoid intravascular filler injection, thereby reducing the risk of severe complications such as vascular occlusion or ocular ischemia. [18]

Ultrasound can also be used to map the supraorbital artery and the frontal branch of the superficial temporal artery, which form part of the extensive vascular network of the forehead. These vessels may demonstrate considerable anatomical variability in both depth and branching patterns. Pre-procedural ultrasound mapping of these arteries is increasingly recommended before aesthetic interventions in the upper face to improve procedural safety and to guide the placement of injectables in appropriate tissue planes. Such imaging provides a more individualized anatomical assessment compared with relying solely on traditional surface landmarks. [12]

**Ultrasonographic Features of Upper Facial Static Lines and Skin Aging**

High-frequency ultrasonography provides valuable insights into the structural changes associated with skin aging and the formation of static facial lines. Static wrinkles of the upper face result from cumulative alterations in dermal collagen architecture, decreased skin elasticity, repetitive muscular activity, and progressive changes in subcutaneous tissue support. These structural modifications can be visualized using ultrasound through variations in dermal thickness, echogenicity, and the appearance of specific sonographic markers related to photoaging. As a result, ultrasound has become an important non-invasive tool for evaluating the underlying tissue characteristics contributing to static rhytides in the forehead and glabellar regions. [19]

One of the most characteristic ultrasonographic indicators of skin aging is the **subepidermal low echogenic band (SLEB)**. This band appears as a hypoechoic layer located immediately beneath the epidermis and is commonly observed in sun-exposed areas of the skin. The SLEB reflects structural alterations in the superficial dermis, including elastosis, increased interstitial fluid, and disorganization of collagen fibers associated with chronic ultraviolet exposure. The presence and thickness of this band have been widely recognized as markers of photoaging and dermal degeneration, both of which contribute to the development of static facial lines. [19]

In addition to SLEB formation, aging skin demonstrates changes in dermal echogenicity that correspond to alterations in collagen density and tissue hydration. Healthy dermis typically appears as a relatively homogeneous echogenic structure due to the presence of organized collagen bundles. With advancing age, fragmentation and loss of collagen fibers lead to decreased echogenicity and irregular dermal texture on ultrasound imaging. These changes are particularly evident in areas subjected to repeated muscular contractions, such as the forehead and glabella, where mechanical stress accelerates dermal remodeling and wrinkle formation. Ultrasound therefore provides a useful method for evaluating dermal quality and structural integrity in regions affected by static rhytides. [20]

Ultrasound imaging also allows measurement of skin thickness and subcutaneous tissue distribution, both of which influence the appearance of static lines. Age-related thinning of the dermis and alterations in fat compartments contribute to reduced structural support of the overlying skin, facilitating the persistence of wrinkles even in the absence of muscle contraction. Quantitative ultrasound measurements of epidermal and dermal thickness can therefore be used to objectively assess tissue aging and to monitor structural changes over time. These measurements are particularly useful in research settings evaluating the effects of rejuvenation therapies targeting facial wrinkles. [21]

Another advantage of ultrasonography is its ability to visualize dynamic changes in facial tissues during muscle contraction. By performing ultrasound imaging while patients contract facial muscles, clinicians can observe the mechanical interaction between the frontalis muscle and the overlying skin layers. This dynamic assessment provides valuable information regarding the functional component of wrinkle formation and can help distinguish between predominantly muscular wrinkles and those primarily related to dermal structural changes. Such differentiation is important when selecting appropriate treatment strategies for upper facial static lines. [13]

Beyond diagnostic assessment of aging skin, ultrasound has become an important modality for evaluating the outcomes of aesthetic treatments applied to the upper face. Many minimally invasive procedures—including botulinum toxin injections, dermal fillers, and thread-based lifting techniques—aim to improve static wrinkles by modifying muscular activity, restoring volume, or stimulating tissue remodeling. Ultrasound imaging allows clinicians to objectively assess tissue responses to these interventions by visualizing structural changes in the dermis, subcutaneous tissue, and muscle layers after treatment. [22]

For example, after botulinum toxin injection in the glabellar or forehead region, ultrasound imaging may demonstrate increased echogenicity within the subcutaneous tissue and a slight blurring of the interface between subcutaneous tissue and muscle layers. These changes are thought to reflect local tissue effects related to injection and diffusion of the neurotoxin. Ultrasound evaluation may therefore provide supportive information regarding injection placement and tissue response following neuromodulator therapy. [23]

Dermal fillers used for wrinkle correction can also be clearly visualized using ultrasound imaging. Depending on their composition and physical properties, fillers exhibit characteristic sonographic patterns, including heterogeneous, globular, or snow-grain appearances. Over time, ultrasound may demonstrate integration of filler materials into surrounding tissues as well as structural remodeling associated with neocollagenesis. Monitoring these patterns allows clinicians to evaluate filler distribution, persistence, and tissue response, particularly in patients undergoing repeated aesthetic procedures targeting the upper facial lines. [11]

Thread-based lifting techniques used for forehead and brow rejuvenation can also be evaluated through ultrasonography. Following insertion of absorbable threads, ultrasound imaging may demonstrate the presence of linear echogenic structures within the subcutaneous plane corresponding to the implanted threads. Subsequent tissue responses include increased collagen formation, fibrous tissue development, and improved vascular supply around the thread pathway. These structural changes contribute to tissue tightening and lifting effects, which can be objectively monitored through ultrasound during follow-up

assessments. [24]
Immediately after thread placement or filler injection, ultrasound may also detect transient changes such as subcutaneous edema, irregular echogenic patterns, or globular structures corresponding to injected materials. Over time, these features gradually evolve as the material integrates with surrounding tissues and the inflammatory response subsides. Serial ultrasound examinations therefore allow clinicians to track the progression of tissue remodeling and to distinguish normal post-treatment changes from potential complications. [11]

**Doppler Ultrasonography and Vascular Mapping of the Upper Face**

Doppler ultrasonography represents an essential extension of conventional grayscale ultrasound, enabling visualization of blood flow within vascular structures. By detecting frequency shifts produced by moving red blood cells, Doppler technology allows real-time identification of arteries and veins within facial tissues. In aesthetic dermatology, Doppler ultrasound has become increasingly important for evaluating vascular anatomy before minimally invasive procedures. This is particularly relevant in the upper face, where the proximity of critical vessels to common injection sites increases the risk of vascular complications during aesthetic treatments. Accurate identification of these vessels improves procedural planning and enhances patient safety. [25]

The vascular anatomy of the upper face is complex and characterized by multiple arterial branches originating primarily from the ophthalmic artery and the external carotid arterial system. Among the most clinically significant vessels are the supratrochlear artery, the supraorbital artery, the dorsal nasal artery, the superficial temporal artery, and branches of the facial artery. These vessels supply the forehead, glabellar region, and periorbital tissues, areas frequently targeted for aesthetic interventions such as dermal fillers and neuromodulator injections. Doppler ultrasound allows clinicians to detect these arteries, determine their depth relative to the skin surface, and identify variations in their anatomical course. Such information is crucial for minimizing the risk of intravascular injection and other vascular adverse events. [12]

The supratrochlear and supraorbital arteries are of particular concern in the glabellar and forehead regions. These vessels originate from the ophthalmic artery and ascend superiorly to supply the central forehead. Ultrasonographic studies have demonstrated that the course and depth of these arteries can vary significantly between individuals. In many cases, these vessels transition from deeper anatomical planes near the orbital rim to more superficial positions as they ascend across the forehead. This anatomical transition increases the risk of accidental vascular injection when performing aesthetic procedures in the upper face. Doppler ultrasound enables clinicians to visualize these vessels directly and to mark their pathways before performing injections. [26]

The glabellar region is widely recognized as one of the most dangerous areas for filler injection due to its close association with the supratrochlear artery. In some individuals, this artery may lie directly beneath glabellar wrinkle lines or within the subdermal layer, making it highly susceptible to intravascular injection during filler placement. Doppler ultrasound evaluation allows clinicians to identify the precise location and depth of the supratrochlear artery in relation to the wrinkle lines and planned injection sites. Recognition of such anatomical variations is essential to prevent severe complications, including vascular occlusion and ocular ischemia. [18]

Similarly, the forehead contains a dense vascular network formed by the supratrochlear, supraorbital, and frontal branches of the superficial temporal artery. Doppler ultrasound can be used to map the pathways of these vessels across the forehead before performing aesthetic procedures. Studies have demonstrated that the supraorbital artery may show significant variation in both superficial and deep branches, which can influence the safety of injection techniques. Identification of these vascular pathways through ultrasound imaging allows clinicians to adjust injection planes and avoid areas where vessels are located superficially. [27]

During Doppler ultrasound examination of the upper face, the probe is typically positioned transversely along the superior orbital rim to identify the emergence of the supratrochlear and supraorbital arteries. With adequate ultrasound gel and minimal probe pressure, these arteries can be visualized as they transition from deeper planes near the orbital rim into more superficial layers of the forehead. This transition point is particularly important because it represents the region where arteries become more vulnerable to injection-related injury. Even when the artery itself is not clearly visualized, anatomical landmarks such as the supraorbital notch can be detected, assisting clinicians in identifying the approximate location of the vessel. [12]

Doppler ultrasound is also valuable for identifying previous aesthetic interventions that may influence vascular anatomy or treatment planning. For example, prior filler injections may alter local tissue architecture and compress adjacent vessels, potentially modifying the normal vascular pathway. Ultrasound imaging can detect these previously injected materials and their spatial relationship to nearby vessels, allowing practitioners to adjust injection strategies accordingly. This capability is especially important in patients who have undergone multiple aesthetic treatments or who present with complications requiring further management. [28]

In addition to pre-procedural assessment, Doppler ultrasound can be used in real time during aesthetic procedures to monitor the position of needles or cannulas relative to vascular structures. Real-time ultrasound guidance enables clinicians to visualize the trajectory of the injection device and confirm that it remains within the intended tissue plane. This approach significantly reduces the risk of intravascular injection and allows more precise delivery of aesthetic products. Although real-time ultrasound-guided injections require specialized training and equipment, their use is increasingly advocated in high-risk facial regions such as the glabella and nose. [29]

**Clinical Applications of Ultrasonography in the Management of Upper Facial Static Lines**

The increasing demand for minimally invasive facial rejuvenation procedures has led to the growing integration of ultrasonography into clinical aesthetic practice. In the management of upper facial static lines, ultrasound provides valuable information that supports treatment planning, enhances procedural safety, and allows objective monitoring of therapeutic outcomes. Because static rhytides often arise from complex interactions between muscular activity, dermal degeneration, and changes in subcutaneous support structures, imaging techniques capable of visualizing these layers are particularly beneficial. High-frequency ultrasound allows clinicians to assess the thickness and structural characteristics of the skin and soft tissues before treatment, facilitating individualized treatment strategies for patients presenting with forehead and glabellar wrinkles. [30]

Pre-procedural ultrasound evaluation can help practitioners identify anatomical variations that may influence treatment outcomes. By examining the layered structure of the forehead and glabellar regions, clinicians can determine the thickness of the skin, subcutaneous tissue, and underlying musculature. Such information is important when selecting appropriate injection planes for neuromodulators or dermal fillers. Ultrasound imaging also assists in identifying previous filler deposits or structural changes resulting from prior aesthetic procedures. Knowledge of these factors is essential to avoid inaccurate placement of additional injectable materials and to minimize the risk of adverse events. [31]

In the treatment of upper facial lines, botulinum toxin remains one of the most widely used therapeutic approaches. Its mechanism involves temporary inhibition of neuromuscular transmission, leading to relaxation of facial muscles responsible for dynamic wrinkle formation. When administered appropriately, botulinum toxin can reduce the progression of dynamic wrinkles into static lines and improve the appearance of existing rhytides. Ultrasonography may assist clinicians in identifying the location, thickness, and functional activity of the frontalis and glabellar muscles before injection. Visualization of muscle layers can therefore help refine injection placement and dosage selection, improving treatment precision and minimizing complications such as brow ptosis or asymmetry. [32]

Real-time ultrasound guidance has also been proposed as an adjunct technique for botulinum toxin injections in facial muscles. By observing the target muscle during needle insertion, practitioners can ensure that the neurotoxin is delivered precisely within the intended anatomical plane. Ultrasound guidance is particularly beneficial in patients with atypical anatomy, previous surgical alterations, or significant tissue changes related to aging. In addition to enhancing injection accuracy, ultrasound can help clinicians understand individual variations in muscle thickness and distribution, allowing a more

personalized treatment approach for upper facial static lines. [13]
Dermal fillers represent another important therapeutic modality for improving static facial wrinkles. Hyaluronic acid–based fillers are commonly used to restore volume, support dermal structures, and soften deep rhytides in the forehead and glabellar regions. Ultrasound imaging allows clinicians to visualize filler placement within facial tissues and to assess its distribution relative to surrounding structures. This capability is especially useful in patients who have undergone previous filler treatments because ultrasound can identify the presence, depth, and type of filler material before additional injections are performed. Such information contributes to safer treatment planning and reduces the likelihood of product overcorrection or uneven distribution. [33]
Ultrasound also plays a significant role in the management of complications associated with dermal filler injections. Vascular occlusion, filler migration, nodules, and inflammatory reactions are among the potential adverse events that may occur following aesthetic procedures. Ultrasound imaging can detect the presence and location of injected materials and evaluate their relationship to surrounding vessels and tissues. When complications occur, ultrasound-guided interventions—such as targeted hyaluronidase injection for hyaluronic acid fillers—can be performed with greater precision, improving treatment outcomes and minimizing tissue damage. [34]
Thread-lifting techniques have increasingly been used for non-surgical rejuvenation of the forehead and brow region. These procedures involve the insertion of absorbable threads into the subcutaneous tissue to reposition and support sagging facial structures. Ultrasonography allows visualization of the implanted threads and their relationship to surrounding tissues. Imaging can confirm correct placement within the subcutaneous plane and detect potential complications such as thread displacement or irregular positioning. Monitoring tissue responses around the threads, including collagen formation and fibrous tissue development, provides objective evidence of treatment effectiveness during follow-up evaluations. [24]
Ultrasound imaging is also valuable for evaluating tissue remodeling following aesthetic treatments targeting upper facial static lines. After procedures such as filler injections or thread lifting, ultrasound can reveal changes in dermal echogenicity, tissue thickness, and subcutaneous architecture that correspond to collagen stimulation and structural reinforcement. These imaging findings allow clinicians to objectively assess the biological response to treatment and to monitor long-term therapeutic outcomes. By providing quantitative and qualitative information about tissue changes, ultrasound supports a more scientific evaluation of facial rejuvenation procedures. [10]
Another emerging application of ultrasonography is the use of real-time imaging during aesthetic procedures. In this approach, clinicians perform injections while simultaneously observing tissue layers, needle position, and nearby vascular structures on the ultrasound screen. This technique enables accurate delivery of injectable materials into the desired tissue plane and reduces the risk of intravascular injection. Although the technique requires additional training and specialized equipment, it represents a promising advancement toward safer and more precise aesthetic procedures in the upper face. [29]

**Limitations of Ultrasonography in the Evaluation of Upper Facial Static Lines**

Despite the growing utility of ultrasonography in aesthetic dermatology, several limitations should be considered when applying this technique to the evaluation of upper facial static lines. One of the most significant limitations is operator dependency. The accuracy and reliability of ultrasound examinations largely depend on the experience and skill of the practitioner performing the scan. Proper identification of anatomical layers, vascular structures, and injected materials requires advanced training and familiarity with facial sonoanatomy. In inexperienced hands, misinterpretation of ultrasound images may occur, potentially leading to inaccurate clinical conclusions or inappropriate treatment planning. [35]
Another limitation relates to the technical constraints of ultrasound equipment. Although high-frequency probes provide superior resolution for superficial structures, they have limited penetration depth. This trade-off between resolution and penetration can make it challenging to simultaneously visualize superficial skin layers and deeper anatomical structures in a single scan. In certain patients, particularly

those with thicker subcutaneous tissues or complex anatomical variations, deeper facial compartments may not be clearly visualized using very high-frequency probes. As a result, clinicians must carefully select the appropriate transducer frequency depending on the anatomical region and the diagnostic objective of the examination. [36]

Standardization of ultrasound protocols for facial aesthetic evaluation also remains limited. Currently, there is no universally accepted methodology for scanning the upper face or for quantifying ultrasound parameters related to wrinkle severity. Differences in probe positioning, scanning technique, and image interpretation may lead to variability between studies and clinical practices. The lack of standardized measurement systems for parameters such as dermal echogenicity, SLEB thickness, and soft tissue dimensions can make comparisons between patients or studies more difficult. Establishing standardized imaging protocols would improve the reproducibility and clinical reliability of ultrasound evaluation in aesthetic dermatology. [6]

Another challenge lies in the interpretation of post-treatment ultrasound findings. After aesthetic procedures such as filler injections or thread lifting, ultrasound images may demonstrate complex patterns of echogenicity related to injected materials, tissue edema, inflammatory responses, or fibrotic remodeling. Differentiating between normal post-procedural changes and early complications may not always be straightforward, particularly in the immediate post-treatment period. Therefore, clinicians must interpret ultrasound findings within the broader clinical context and correlate imaging results with patient history and physical examination. [34]

Accessibility and cost considerations may also limit the widespread adoption of ultrasound in routine aesthetic practice. Although portable ultrasound systems have become more affordable in recent years, high-resolution devices equipped with specialized probes suitable for dermatologic imaging may still represent a substantial investment for some clinical settings. In addition, implementing ultrasound-guided procedures requires additional training and may initially increase procedure time until practitioners gain sufficient experience with the technology. [30]

Finally, while ultrasound provides excellent visualization of soft tissues, it has limited ability to assess certain aspects of facial aging that involve biochemical or microscopic changes within the skin. For example, alterations in collagen structure, elastin degradation, and molecular processes associated with photoaging may not be directly detectable on ultrasound imaging. Although indirect markers such as changes in dermal echogenicity can suggest structural remodeling, these findings cannot fully replace histological or biochemical evaluation. Consequently, ultrasound should be considered a complementary tool rather than a standalone diagnostic method in the evaluation of facial aging and static wrinkles. [19]

## Conclusion

Upper facial static lines represent a prominent feature of facial aging and result from complex interactions between repetitive muscular activity, dermal structural degeneration, photoaging, and alterations in underlying soft tissues. Traditional clinical evaluation methods provide valuable information about wrinkle severity but are limited in their ability to assess the deeper anatomical structures that contribute to wrinkle formation. High-frequency ultrasonography has emerged as a valuable imaging modality capable of overcoming many of these limitations by enabling non-invasive, real-time visualization of the multilayered anatomy of the upper face.

Ultrasound imaging allows detailed assessment of the epidermis, dermis, subcutaneous tissues, muscles, and vascular structures involved in the development of static rhytides. Key sonographic markers, including changes in dermal echogenicity and the presence of the subepidermal low echogenic band, provide insight into the structural changes associated with photoaging and dermal remodeling. Furthermore, Doppler ultrasonography enables precise mapping of critical vascular structures such as the supratrochlear and supraorbital arteries, thereby enhancing the safety of aesthetic procedures performed in high-risk areas of the upper face.

Beyond diagnostic evaluation, ultrasonography plays an increasingly important role in the clinical management of upper facial static lines. The technology can assist clinicians in treatment planning, guide injectable procedures, verify the location of previously injected materials, and monitor tissue responses following interventions such as botulinum toxin injections, dermal fillers, and thread-based lifting techniques. Ultrasound imaging also provides a valuable method for identifying and managing complications associated with aesthetic treatments.

Despite its advantages, certain limitations remain, including operator dependency, variability in imaging protocols, and limited ability to detect microscopic or biochemical changes in the skin. Continued advancements in imaging technology, combined with emerging tools such as elastography and artificial intelligence–assisted analysis, are expected to further enhance the role of ultrasound in aesthetic dermatology.

Overall, ultrasonography represents a promising and increasingly important modality for the evaluation and management of upper facial static lines. By providing objective, dynamic, and anatomically precise information, ultrasound complements traditional clinical assessment and contributes to safer, more individualized aesthetic treatments. Continued research and standardization of imaging techniques will further clarify its role and support its integration into routine dermatologic and aesthetic practice.

## References


1. Swift A, Liew S, Weinkle S, Garcia JK, Silberberg MB. The facial aging process from the "inside out". *Aesthetic Surgery Journal*. 2021;41(10):1107-1119.
2. Flament F, Abric A, Adam AS. Evaluating the respective weights of some facial signs on perceived ages in differently aged women of five ethnic origins. *Journal of Cosmetic Dermatology*. 2021;20(3):842-853.
3. Park HJ, Lee JH, Lee KL, Choi YJ, Hu KS, Kim HJ. Ultrasonography analysis of vessels around the forehead midline. *Aesthetic Surgery Journal*. 2021;41(10):1189-1194.
4. Dopytalska K, Sobolewski P, Mikucka-Wituszyńska A, Gnatowski M, Szymańska E, Walecka I. Noninvasive skin imaging in esthetic medicine—Why do we need useful tools for evaluation of the esthetic procedures. *Journal of Cosmetic Dermatology*. 2021;20(3):746-754.
5. Cavallieri FA, de Almeida Balassiano LK, Munhoz G, Tembra MF, Wortsman X. Ultrasound in aesthetics: filler and non-filler applications. *Seminars in Ultrasound, CT and MR*. 2024;45(3):251-263.
6. Malinowska S, Mlosek RK. From sonar to ultrasound examination of the skin—development and characterization of the method. *Aesthetic Cosmetology and Medicine*. 2022;11(6):203-208.
7. Yi KH. Where and when to use ultrasonography in botulinum neurotoxin, fillers, and threading procedures? *Journal of Cosmetic Dermatology*. 2024;23(3):773-776.
8. Beiu C, Popa LG, Bălăceanu-Gurău B, Iliescu CA, Racoviță A, Popescu MN, Mihai MM. Personalization of minimally-invasive aesthetic procedures with the use of ultrasound compared to alternative imaging modalities. *Diagnostics*. 2023;13(23):3512.
9. Urdiales-Gálvez F, De Cabo-Francés FM, Bové I. Ultrasound patterns of different dermal filler materials used in aesthetics. *Journal of Cosmetic Dermatology*. 2021;20(5):1541-1548.
10. Velthuis PJ, Jansen O, Schelke LW, Moon HJ, Kadouch J, Ascher B, Cotofana S. A guide to Doppler ultrasound analysis of the face in cosmetic medicine. Part 2: vascular mapping. *Aesthetic Surgery Journal*. 2021;41(11):NP1633-NP1644.
11. Wu WT, Chang KV, Chang HC, Chen LR, Kuan CH, Kao JT, Wei LY, Chen YJ, Han DS, Özçakar L. Ultrasound imaging of the facial muscles and relevance with botulinum toxin injections: a pictorial essay and narrative review. *Toxins (Basel)*. 2022;14(2):101.
12. Bravo BS, de Melo Carvalho R, Penedo L, de Bastos JT, Calomeni Elias M, Cotofana S, Frank K, Moellhoff N, Freitag L, Alfertshofer M. Applied anatomy of the layers and soft tissues of the forehead during minimally-invasive aesthetic procedures. *Journal of Cosmetic Dermatology*. 2022;21(11):5864-5871.
13. Yi KH, Lee JH, Seo KK, Kim HJ. Anatomical proposal for botulinum neurotoxin injection for horizontal forehead lines. *Plastic and Reconstructive Surgery*. 2024;153(2):322e-325e.
14. Meneses CCB, Freitas S, Knoedler L, Knoedler S, Davidovic K, Bravo C, Pappas A, Biesman BS, Alfertshofer M, Cotofana S. Increasing precision during neuromodulator injections for frontal rhytids—Using ultrasound imaging to identify the line of convergence. *Journal of Cosmetic Dermatology*. 2024;23(7):2373-2379.
15. Güvenç U, Ten B, Kaya Tİ, Yüksek HH, Türsen Ü. Evaluation of supratrochlear artery depth and course variations by Doppler ultrasonography along the glabellar frown lines for safer filler injections. *Journal of Cosmetic Dermatology*. 2022;21(12):6717-6726.
16. Hudson C, Brissett A, Carniol P. Analysis and assessment of facial aging. *Current Otorhinolaryngology Reports*.

2021;9(4):415-421.
17. Zhong M, He H, Wang L, Pu L, Liu Z, Wang J, Zhang Y, Wang S, Sun B, Li X, Xiong L. Comprehensive assessment of intradermal responses to hyaluronic acid-based skin injection fillers through multi-pathway dynamic synergies. *Colloids and Surfaces B: Biointerfaces*. 2025;246:114378.
18. Lots TC. Effect of PDO facelift threads on facial skin tissues: an ultrasonographic analysis. *Journal of Cosmetic Dermatology*. 2023;22(9):2534-2541.
19. Jaguś D, Skrzypek E, Migda B, Woźniak W, Mlosek RK. Usefulness of Doppler sonography in aesthetic medicine. *Journal of Ultrasonography*. 2021;20(83):e268-e272.
20. Lee W. Five factors to consider before treatment of hyaluronic acid filler-induced vascular complications. *Archives of Plastic Surgery*. 2022;49(4):479-481.
21. Schelke LW, Decates TS, Cartier H, Cotofana S, Velthuis PJ. Investigating the anatomic location of soft tissue fillers in noninflammatory nodule formation: an ultrasound-imaging-based analysis. *Dermatologic Surgery*. 2023;49(6):588-595.
22. Rocha PS, Guerra TA, Teixeira DA. Description of a safe Doppler ultrasound-guided technique for hyaluronic acid filler in the face: a method to avoid adverse vascular events. *Journal of Cosmetic Dermatology*. 2022;21(7):2783-2787.
23. Schelke L, Farber N, Swift A. Ultrasound as an educational tool in facial aesthetic injections. *Plastic and Reconstructive Surgery Global Open*. 2022;10(12):e4639.
24. Braccini F, Catoni I, Belfkira F, Lagier J, Roze E, Paris J, Huth J, Bronsard V, Cartier H, David M, Galatoire O. SAMCEP Society consensus on the treatment of upper facial lines with botulinum neurotoxin type A: a tailored approach. *Journal of Cosmetic Dermatology*. 2023;22(10):2692-2704.
25. Perera GG, Argenta DF, Caon T. The rheology of injectable hyaluronic acid hydrogels used as facial fillers: a review. *International Journal of Biological Macromolecules*. 2024;131880.
26. Carella S, Ruggeri G, La Russa R, Volonnino G, Frati P, Onesti MG. Clinical management of complications following filler injection. *Aesthetic Plastic Surgery*. 2022;46(2):886-894.
27. Kwon IJ, Lee W, Moon HJ, Lee SE. Dynamic evaluation of skin displacement by the frontalis muscle contraction using three-dimensional skin displacement vector analysis. *Yonsei Medical Journal*. 2023;64(7):440-447.
28. Urdiales-Gálvez F, Braz A, Cavallini M. Facial rejuvenation with the new hybrid filler HArmonyCa™: clinical and aesthetic outcomes assessed by 2D and 3D photographs, ultrasound, and elastography. *Journal of Cosmetic Dermatology*. 2023;22(8):2186-2197.
29. Lee W. Hyaluronic acid filler injection guided by Doppler ultrasound. *Archives of Plastic Surgery*. 2023;50(4):348-353.
30. Calomeni M, Bravo BSF, Schelke LW, et al. Precision of soft-tissue filler injections: an ultrasound-based verification study. *Aesthetic Surgery Journal*. 2023;43(3):353-361.
31. Ismailoglu AV, Ismailoglu P, Aktekin M. Mapping the vascular and muscular topography of the glabellar region: implication for improving safety and efficacy of the glabellar injections. *Aesthetic Plastic Surgery*. 2024;48:1628-1636.
32. Borba A, Matayoshi S, Rodrigues M. Avoiding complications on the upper face treatment with botulinum toxin: a practical guide. *Aesthetic Plastic Surgery*. 2022;46:385-394.
33. Carruthers J, Carruthers A, Blitzer A, Eadie N, Brin MF. Treatment of glabellar lines with onabotulinumtoxinA: development, insights, and impact. *Medicine (Baltimore)*. 2023;102(S1):e32375.
34. Yi KH. What are filling (volumizing) threads? *Skin Research and Technology*. 2024;30(3):e13658.