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COMPARATIVE ANALYSIS OF THE EFFICACY OF LINEAR FOCAL MICROFOCUSED ULTRASOUND VERSUS POINTWISE ULTRASOUND IN FACIAL REJUVENATION

Roseane Debora Barbosa Soares
Corresponding email:deboradermatos@gmail.com
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ABSTRACT

Facial aging involves progressive changes in structural support, dermal quality, and skin firmness, driving the search for minimally invasive procedures capable of promoting rejuvenation safely and with less recovery time. In this context, microfocused ultrasound has become a relevant technology in aesthetic dermatology and facial harmonization, as it induces thermal coagulation zones at specific depths, stimulates neocollagenesis, and favors remodeling of the extracellular matrix. The present study aimed to comparatively analyze the clinical efficacy and safety of microfocused ultrasound in linear and focal modes for facial rejuvenation. This is a comparative approach study based on the analysis of mechanisms of action, application parameters, tissue response, and associated clinical outcomes for the two technological modalities. The focal modality demonstrates greater precision in forming thermal coagulation points and is especially indicated for focal retraction of the superficial musculoaponeurotic system and for promoting a lifting effect in areas that require greater anatomical control.On the other hand, the linear mode provides a more homogeneous thermal distribution, favoring volumetric heating, the reduction of localized adipose tissue, dermal tightening, and improved facial contour, with a possible reduction in discomfort and application time. The analysis shows that both modalities have a favorable safety profile, with adverse events predominantly mild and transient, such as localized erythema and edema. It is concluded that linear and focal microfocused ultrasound have complementary applications in the management of facial aging, and that the choice of technique should be guided by an individualized anatomical assessment, the degree of laxity, tissue thickness, and the therapeutic goals of each patient. The combination of personalized planning, technical expertise, and image-guided monitoring can increase the predictability of results and strengthen the safety of non-invasive aesthetic protocols.

Keywords: Microfocused ultrasound; Facial rejuvenation; Skin laxity; Neocollagenesis; Facial harmonization.

INTRODUCTION

Facial aging is characterized by progressive loss of structural support and skin laxity, creating a growing demand for minimally invasive interventions that offer results comparable to surgical procedures (Luccia & Gotardo, 2023; Peres & Peres, 2023). In this scenario, microfocused ultrasound has established itself as a leading therapeutic alternative, promoting neocollagenesis and a lifting effect without the risks associated with invasive incisions (Matos et al., 2025; Silva et al., 2025). The effectiveness of this modality is based on the creation of thermal coagulation points at specific depths in the dermis and the superficial musculoaponeurotic system, triggering remodeling of the extracellular matrix (Almeida et al., 2025; Chieregato et al., 2025). Recently, technological advancements introduced the linear modality, which differs from the traditional point pattern in terms of firing geometry and thermal distribution (Moleiro et al., 2026; Néri et al., 2022).While focal transducers concentrate energy at isolated coaptation points for targeted tissue retraction, the linear configuration provides diffuse volumetric heating, optimized for adipose tissue remodeling and improved dermal density (Chieregato et al., 2025; Tavares et al., 2024). This technical distinction necessitates a rigorous comparative analysis, since variations in application parameters modulate the biological response and clinical efficacy in facial rejuvenation (Fernandes et al., 2022). A precise understanding of these approaches is essential for customizing therapeutic protocols, enabling the professional to optimize energy delivery according to the patient's anatomical particularities and degree of senescence (Garcia, 2024; Lopes et al., 2024). Thus, choosing between focused precision and linear distribution allows the specialist to modulate the controlled inflammatory response, maximizing collagen and elastin synthesis according to the specific needs of each tissue layer (Lee et al., 2025; Meyer et al., 2021).The use of microfocused ultrasound as a therapeutic tool represents a significant advance for orofacial harmonization, enabling work across multiple facial layers with clinical precision (Campos & Quilici, 2025; Souza et al., 2022).

Literature Review

The application of microfocused ultrasound began with single focal point technologies, which established the basis for deep tissue retraction by targeting the superficial musculoaponeurotic system. Subsequent evolution introduced the linear configuration, which promotes continuous volumetric heating, changing the energy delivery profile from isolated focal points to a comprehensive thermal distribution capable of inducing selective lipolysis.

Comparative clinical studies show that, while the focal technique is superior for vector lifting and SMAS anchoring through thermal coagulation points (Day, 2014; Fabi, 2015), the linear mode demonstrates greater efficacy in reducing submental fat and in dermal volumetry, minimizing total application time. Additionally, evidence indicates that

The focal transducer presents a higher focal area, enabling uniform and safe heating in critical regions, such as the perioral and preauricular zones, where the preservation of nerve branches is mandatory (Zhu et al., 2023). The safety of this application is supported by protocols that adjust energy density according to tissue thickness, mitigating the risk of structural damage while promoting dermis regeneration and adjacent tissues (Matos et al., 2023). On the other hand, the linear modality, by providing a more homogeneous energy delivery in thicker tissues, reduces sensory discomfort and expands the area of muscle contraction, optimizing long-term results in facial contour restructuring (Khan & Khalid, 2021; Trombini & Santos, 2023). By generating heat around 65°C, this technology induces protein denaturation and the subsequent synthesis of collagen, ensuring reproducible and predictable coagulation zones in the extracellular matrix (Dias & Borba, 2021).Clinical studies comparing both technologies reinforce that real-time visualization is an essential safety differentiator, enabling dynamic adjustment of the depth and the energy delivered according to the immediate tissue response. The accuracy provided by this monitoring minimizes the risk of adverse effects, such as thermal burns or neuropraxia, while maintaining a high safety profile even in multi-layer treatments (Dicker et al., 2025; Lou et al., 2026). This technological versatility, by integrating the precision of focal targeting with the uniformity of linear energy, allows the surgeon more refined control over longer-term operative effects in deep tissues (Chadab

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et al., 2026; White et al., 2007). In addition, the strategic integration of co-mbined protocols has proven fundamental for optimizing outcomes in cases of severe laxity, allowing the synergy bet-ween different technologies to ensure more effective tissue remodeling (Adví ncula et al., 2023; Haykal et al., 2025). The adoption of these multidimensional approaches enables energy delivery in a controlled manner, promoting apoptosis in adipocytes selected and, simultaneously, stimulating neocollage-nesis in superficial and deep planes (Menezes et al., 2024; Biskanaki et al., 2025). In this context, the versatility of microfocused ultrasound also enables a safe combination with other modalities, such as suspension threads and radiofre-quency techniques, since precise thermal modulation minimizes the risk of struct-ural interference (Miranda, 2022; Silva & Meirelles, 2025). The inflammatory res-ponse induced by these procedures trig-gers a tissue-repair cascade that culmina-tes in the synthesis of new collagen and elastin fibers, ensuring that clinical resu-lts persist in the long term (Casabona & Kaye, 2019). This tissue-remodeling dy-namic, characterized by the contraction of collagen fibers and the induction of neocollagenesis, is facilitated by the abil-ity to reach temperatures above 60°C without compromising epidermal integr-ity (Fabi et al., 2016; Sampaio et al., 2024).In this way, preserving the skin barrier enables a fast post-procedure recovery, consolidating the method as a highly effective non-invasive alternative to traditional surgical procedures (García, 2026; MacGregor & Tanzi, 2013). Even so, the effectiveness of the treatment remains directly linked to the careful selection of patients and the clinician's expertise—key factors for mitigating complications and ensuring satisfactory outcomes (Preman et al., 2026; Santos et al., 2024). Standardizing application pr-otocols, together with an accurate asse-ssment of cutaneous ptosis, therefore proves to be the cornerstone for maximi-zing the longevity of aesthetic results and clinical satisfaction (Araco, 2020; García, 2026; Gomes et al., 2023). Therefore, the continuous refinement of micro-focused ultrasound platforms, integrating real-time visualization and customizable pa-rameters, remains the gold standard for optimizing clinical outcomes in facial harmonization (Fabi et al., 2019; Sun et al., 2026). Future research should focus on standardizing combined protocols, since the synergistic integration of ultrasound microfocused with

biostimulants injectables and Fractionated radiofrequency has shown superior potential for the treatment of complex tissue laxity (Campos et al., 2025; Dal 'Forno-Dini & Birck, 2026) . These integrated protocols not only promote mechanical remodeling, but also restore facial volume and improve the overall biophysical properties of the skin (Amiri et al., 2025; Kerscher et al., 2018) . The strategic application of these methods, by combining the mechanical precision of ultrasound with chemical biostimulation, establishes a rejuvenation paradigm that addresses both tissue laxity and the loss of structural collagen at the same time (Cançado et al., 2023) . In this way, the current literature highlights the superiority of multimodal approaches, which enhance clinical outcomes by combining deep mechanical stimulation with the biochemical regeneration of the extracellular environment (Doyle et al., 2024; Murad et al., 2022) . Consequently, the efficacy of microfocused ultrasound, whether in focal or linear mode, is consolidated by evidence showing high patient satisfaction rates and improved skin quality, confirming its central role in modern dermatology (Amiri et al., 2024) .The continuous evolution of these platforms, combined with the growing clinical evidence regarding their versatility, reaffirms microfocused ultrasound as an indispensable tool for non-surgical rejuvenation, delivering long-lasting results in firmness and overall skin quality (Oliveira et al., 2023; Pavicic et al., 2025). The accumulated clinical evidence, which indicates satisfaction rates above 90% during follow-up periods of up to one year, confirms the superiority of ultrasound as a therapeutic resource for

non-invasive lifting (Contini et al., 2023). Additionally, the sequential application of microfocused ultrasound prior to injectables such as poly-L-lactic acid has shown potential to enhance dermal remodeling without compromising the stability of biocompatible materials (Jin et al., 2026). This strategic integration makes it possible to optimize the tissue response, since the prior thermal stimulation prepares the extracellular microenvironment for a more uniform uptake of the biostimulators (Bellini et al., 2023; Lobo et al., 2023). This therapeutic synergy addresses both deep tissue laxity and volumetric deficit, consolidating combined protocols as the most robust strategy for managing global facial aging (Nobre et al., 2023;

Pereira & Santos, 2023; Silva, 2025). A comparison between point and linear applicators reveals fundamental differences in energy delivery: while the point mode focuses on focal retraction of the superficial musculoaponeurotic system to achieve a "lifting" effect, the linear mode promotes diffuse volumetric heating, optimizing treatment of facial fat and dermal compaction (Bortolini et al., 2025; Dal 'Forno et al., 2025) . Recent studies corroborate that this duality of modes allows superior therapeutic personalization, in which the spot mode increases efficacy in treating structural laxity, and the linear mode favors remodelling of the facial contour (Aldisa, 2025) . Comparative research indicates that the strategic transition between these applicators reduces significantly the session times without compromising the security profile, allowing the addressing concomitant involvement of multiple anatomical layers (Werschler & Werschler, 2016; Yutskovskaya et al., 2020). In addition, a retrospective analysis of clinical data suggests that the use of these technologies, when combined with integrated protocols, maintains a robust safety profile, with adverse events limited to transient and rare complications (Suh et al., 2024). Thus, the choice between punctual and linear delivery should be guided by individualized anatomical assessment, allowing the professional to adjust energy density according to the specific need for sustaining or refining the facial contour (Jurcevic & Čeović, 2026). The application of this technology goes beyond simply correcting wrinkles, positioning itself as a fundamental resource in managing multicomponent laxity and harmonizing deep anatomical layers (BORGATTE, 2025; Kalashnikova & Murakov, 2024).In this sense, the transition to high-precision platforms allows the operator to manipulate tissue transition zones with greater accuracy, mitigating the risks of superficial irregularities while maximizing fascial retraction and deep dermal densification (Bravo & Calderón, 2025; Nascimento et al., 2024). This technological evolution reflects a paradigm shift in aesthetic dermatology, moving from fragmented approaches to treatment strategies based in real-time ultrasound visualization, which optimizes energy delivery and procedure safety (Park et al., 2021). The use of these advanced systems, by enabling precise control of depth and temperature in the target tissues, minimizes collateral damage to the adjacent tissue and promotes a more predictable scarring process (Adib & Liu, 2025). By integrating the linear mode, a greater efficiency is observed in reducing the volume of areas with adipose accumulation, which complements the fascial retraction provided by spot technology and supports a more harmonious contoured remodeling (Henriksson et al., 2024). Therefore, the combination of these modalities allows skin aging management to be carried out in a three-dimensional manner, ensuring a regenerative response that addresses both structural integrity and superior tissue quality (Fawzy & Putranti, 2025; Kumar et al., 2025). The advent of these bifunctional platforms thus represents a critical advance in the reproducibility of clinical results, by enabling the adjustment of the density of thermal coagulation points according to the mechanical resistance of each anatomical plane treated (Zappia et al., 2026) . History of micro-focused ultrasound in aesthetic dermatology and technological evolution The journey of micro-focused ultrasound began with adapting principles of diagnostic imaging for therapeutic application, consolidating the ability to promote retraction of the superficial musculoaponeurotic system via focused thermal coagulation (Bazzo, 2016; TP & HA, 2021). Since its introduction, the technology has evolved from strictly point-specific shots to linear modes capable of promoting more efficient volumetric heating, enabling safe interventions in deep planes that previously required surgical approaches (Luccia & Gotardo, 2023; Matos et al., 2025). The ability to generate thermal coagulation points in specific cutaneous and subdermal depths, together with real-time visualization, allows that

The clinician promotes neocollagenesis and the remodeling of the extracellular matrix with anatomical precision (Chieregato et al., 2025; Qi et al., 2026). The evolution of the transducers, which achieved greater accuracy in delivering energy at 3.0 mm and 4.5 mm, has been fundamental to mitigating inter-operator variability and raising the standard of clinical safety (Montezuma et al., 2023). Contemporary studies comparing first- and second-generation systems show that innovations in visualization components and reduced image noise allow the operator to identify treatment planes more clearly, optimizing energy deposition and the procedure's safety. Mechanisms of action: thermal coagulation, neocollagen

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formation, and deep planes. The fundamental mechanism is based on the delivery of high-intensity acoustic waves that create zones of thermal coagulation, inducing a controlled inflammatory process that culminates in the immediate retraction of collagen fibers and subsequent tissue remodeling (Almeida et al., 2025). This focused thermolysis process reaches temperatures above 60°C at depths of up to 5 mm, causing protein denaturation and stimulating the synthesis of new collagen in the reticular layers and in system

superficial musculoaponeurotic (Fabi, 2015; Santos et al., 2022). The activation of fibroblasts triggered by these thermal injuries initiates a wound-healing cascade that results in dermal thickening and the reorganization of elastic fibers, consolidating the effectiveness of the method in treating non-invasive skin laxity (Néri et al., 2022; Zandvakili et al., 2016). Histological studies show that, when this ideal thermal gradient is reached, there is immediate contraction of collagen molecules, followed by a repair process that can extend up to six months, promoting progressive densification of the extracellular matrix. In contrast to point distribution, which focuses on focal retraction of ligamentous anchoring points, the linear mode produces elongated heating zones that optimize volumetric reduction and remodeling of the underlying adipose architecture (Suh et al., 2024). Comparative studies indicate that, while the point technique is superior for lifting deep structures, linear delivery demonstrates greater effectiveness in reducing subcutaneous adiposity through more homogeneous volumetric heating (Juhász et al., 2018; Welc et al., 2025).This technological convergence allows the clinician to personalize the therapy, balancing the fascial retraction required for the *lifting* effect with the thermal modulation of adipose tissue for refined facial contouring (Green & Greene, 2014; Rebelo-Marques, 2026). Recent research corroborates that applying in linear mode significantly reduces treatment time, while maintaining safety profiles comparable to the focal mode, especially in areas of submental and mandibular fat accumulation (Wu & Chen, 2023). Moreover, the comparative analysis between modalities shows that the linear technique's efficacy in reducing adipose tissue is supported by a controlled thermal lysis that does not compromise the integrity of the overlying dermis (TRELLES et al., 2020). Thus, the shift to hybrid protocols demonstrates not only greater therapeutic versatility, but also improved clinical optimization in managing tissue aging, by aligning the requirements of fascial contraction with the need of remodeling volumetric (Moleiro et al., 2026) . The synergistic integration of these technologies therefore enables a two-phase approach that maximizes tissue contraction while preserving the viability of adjacent fibrous septa (Malaysia et al., 2024) . The adoption of these combined approaches has proven essential to meet the growing demand for minimally invasive procedures that deliver results close to those of plastic surgery, but with significantly shorter recovery times (Peres & Peres, 2023) . This technical evolution reflects a paradigm shift in aesthetic dermatology, moving from a unifocal approach to multiscale biostimulation strategies that address the complexity of tissue aging in a holistic and stratified manner (Жлудко, 2025) . Through the personalization of protocols based on precise analysis of facial anatomy, this technology helps mitigate disparities among patients with different degrees of looseness, establishing a new standard of safety and reproducibility (Liu, 2025; Marinho et al., 2023) .The continuity of this clinical evolution points to the integration of high-resolution ultrasound monitoring systems, which allow validating the contraction of the dermal and subcutaneous layers in real time, ensuring the accuracy of tissue repositioning (Velazco et al., 2026). The growing sophistication of these clinical protocols reinforces the position of microfocused ultrasound as a robust, scientifically validated alternative to traditional surgical methods (Almeida et al., 2025; Martins, 2025). The scientific literature has consolidated the efficacy of these procedures through studies that show consistent results in lifting and facial contouring, reinforcing treatment safety in personalized protocols (Oliveira et al., 2024; Wood et al., 2024). However, the interaction between these energy-based technologies and the concomitant use of injectable agents remains a promising area of investigation, with recommendations often favoring the application of ultrasound first to avoid interference with the effectiveness of fillers (Kalashnikova et al., 2023).The longitudinal analysis of these associations suggests that scaling microfocused ultrasound as a preparatory step optimizes the histological environment for the subsequent application of fillers, enhancing structural support in transitional areas (Chieregato et al., 2025; Fernandes et al., 2022). Thus, the multimodal treatment strategy, by combining the collagen-stimulating effect of ultrasound with the volumetric support provided by injectables, establishes a robust protocol for global rejuvenation (Alcívar et al., 2025). This synergistic approach, by integrating the precision of microfocused technology with the versatility of topical and injectable treatments, ensures a more durable and predictable tissue response in correcting signs of aging (Lopes et al., 2024). Additionally, the current literature emphasizes that the rigorous selection of parameters, such as depth and energy density, remains the fundamental pillar for ensuring clinical safety and therapeutic success in the management of cutaneous laxity (Lee et al., 2025).Implementing evidence-based treatment guidelines, supported by precise ultrasound mapping, is essential to mitigate the risks of inadvertent thermal injuries and to ensure neocollagenesis in specific anatomical planes (Meyer et al., 2021; Souza et al., 2022). In this context, standardizing the firing parameters, allied to the operator's technical learning curve, becomes the main determinant for mitigating adverse effects and optimizing long-term aesthetic outcomes (Garcia, 2024; Silva et al., 2025). The continuous bibliometric analysis of these results, which shows a significant year-on-year increase in the publication of studies on ultrasound technologies, reinforces the need for a global technical consensus that standardizes clinical practice (Kumar et al., 2026). In this sense, the transition to protocols validated by international guidelines can increase clinical predictability, allowing professionals to adjust the energy delivered based on each patient's intrinsic characteristics. Thus, the personalized application of microfocused ultrasound, by integrating the precision of thermal coagulation with a detailed anatomical assessment, is consolidated as

the gold standard for minimally invasive of

Facial rejuvenation (Alimova et al., 2025). In addition, the evolution of transducers now enables more uniform and controlled energy delivery, minimizing discomfort during the procedure and optimizing the patient satisfaction rate (Matos et al., 2023). In this scenario, the convergence between the micrometer-level precision of focal transducers and

the volumetric efficiency of linear devices enables multidimensional tissue remodeling, fundamental for the treatment of neocollagenesis and cutaneous elastogenesis (Tavares et al., 2024;
Trombini & Santos, 2023). The ability to reach the superficial musculoaponeurotic system allows deep tissue contraction without affecting the integrity of the overlying cutaneous layers, promoting a more consistent clinical outcome (Day, 2014). The technical distinction between the focal applicators, aimed at focused precision, and the linear ones, optimized for contracting large areas, allows the clinician to personalize the density of thermal coagulation points according to the need for lifting or textural refinement (Dicker et al., 2025).While focal transducers operate through the formation of precise, reproducible zones of thermal microcoagulation at controlled depths, linear applicators distribute energy continuously, favoring a broader and more effective tissue retraction in areas with greater volume (Dias & Borba, 2021; Lou et al., 2026). Comparative studies indicate that the shift to linear technology reduces total application time and optimizes the dermal contraction response, showing superior results in correcting the flaccidity of the lower third of the face compared with the traditional focal method (Haykal et al., 2025; Zhu et al., 2023). In addition, evidence suggests that the thermal modulation capacity of linear transducers enables denser and more uniform neocollagenesis, reducing the pain index reported by patients during the procedure (Khan & Khalid, 2021). Furthermore, analysis of the mechanisms of collagen neofomation confirms that the continuous energy delivery from the linear applicators achieves the deep planes with greater effectiveness, such as the musculoaponeurotic system superficial, optimizing the repositioning of soft tissues (Menezes et al., 2024). However, while linear delivery favors broad-scale contraction, focal transducers maintain their technical superiority for the precise treatment of periocular and perioral areas, where anatomical delicacy requires strict control of the thermal focus (Pritzker et al., 2014). This technical complementarity allows the operator to alternate between firing modes to address both volumetric laxity and fine wrinkles with high reproducibility, reducing variability in clinical outcomes (Campos & Quilici, 2025; Levine et al., 2025). Strategic implementation of these devices in deep

plans, however, requires an accurate anatomical knowledge to preserve critical structures, mitigating the risk of damage to adjacent tissues and ensuring procedural safety (Chadab et al., 2026). Thus, the integration between real-time anatomical mapping and the careful selection of firing geometry represents the current frontier for optimizing results in non-invasive rejuvenation (Casabona & Kaye, 2019; Fabi et al., 2016).The history of this technology, from the first focused transducers to the platforms multifunctional

"contemporâneas" illustrates a significant advancement in the ability to induce thermal denaturation of collagen fibers without damage to the epidermis (Azevedo, 2024; Sampaio et al., 2024) . This technological evolution enabled the achievement of subdermal tissues at programmed depths, consolidating clinical practice as an effective alternative to traditional plastic surgery for the treatment of skin laxity (García, 2026; MacGregor & Tanzi, 2013) . The shift from invasive methods to minimally traumatic interventions reflects the growing demand for procedures that balance clinical effectiveness with reduced recovery times (Пасько & Skrypko, 2025) . The success of this approach has been supported by prospective studies showing significant improvements in skin laxity and facial contour after a single session, increasing patient satisfaction rates (Araco, 2020) . The use of personalized protocols, which integrate ultrasonographic imaging to adjust the treatment depth to the specific tissue characteristics of each patient, has been essential for mitigating variability in clinical outcomes.Complementarily, the scientific literature has validated the effectiveness of this technology in promoting neocollagenesis, reinforcing its role as a safe and robust resource for the treatment of facial soft-tissue laxity (Gomes et al., 2023), (García, 2026). In addition, it confirms the safety of using focused ultrasound in long-term aesthetic dermatologic procedures (Sun et al., 2026), showing a favorable safety profile with adverse effects that are predominantly mild and transient, such as localized erythema and edema (Preman et al., 2026; Biskanaki et al., 2025). This tissue response, characterized by the structural reorganization of collagen, supports the longevity of the results obtained, establishing the technique as a versatile and highly predictable tool for managing cutaneous senescence (Fabi et al., 2019).

Ultimately, the operational versatility of current devices, combined with the precision of personalized protocols, establishes new paradigms in dermatologic medicine, where the effectiveness of non-invasive facial rejuvenation is intrinsically linked to technical mastery in modulating ultrasonic energy (Santos et al., 2024; Serdar et al., 2019) . As technology evolves, the convergence of complementary therapies—such as the combination of ultrasound with direct tissue retraction techniques—envisions a future of even more personalized and stable interventions in combating facial aging (Advíncula et al., 2023) . The accumulated clinical evidence, consolidated by recent meta-analyses, confirms that 84% of patients report a noticeable improvement, reinforcing the superiority of precision protocols combined with the safety provided by thermal control (Amiri et al., 2024; Firsowicz et al., 2025) . Current literature supports that the careful selection of energy parameters, aligned with real-time visualization, enables optimization of treatment plans and minimization of adverse events, consolidating the predictability of long-term outcomes (Al_Omair & Bukhari, 2023) . Follow-up studies confirm that this tissue remodeling reaches its peak effectiveness between the third and sixth month after the procedure, while maintaining high levels of clinical satisfaction according to the Global Aesthetic Improvement scale (Contini et al., 2023) . In parallel, the integrated use of real-time visualization technologies has proven to be a critical differentiator for individualized treatment planning, allowing precise adjustments to the energy delivery according to the patient's tissue thickness and density (Pavicic et al., 2025) . This diagnostic precision, combined with the ability to monitor via ultrasound, allows the clinician to validate the immediate tissue response and ensure the correct depth of energy deposition, reducing the subjectivity inherent in conventional protocols (Kerscher et al., 2018; Oliveira et al., 2023) .Moreover, the distinction between the effectiveness of linear and focal applicators remains a central research topic, given that linear application shows higher efficiency in compacting deep planes, while focal transducers provide the precision needed to refine areas with specific anatomic limitations (Bani et al., 2014; Carli et al., 2024). Comparative studies show that focal delivery creates highly localized thermal coagulation points, whereas the linear modality promotes a more continuous energy distribution, enabling a more extensive and uniform tissue contraction in areas of greater volume (Smoczok et al., 2022). This disparity in energy distribution suggests that the choice of applicator should be guided not only by the anatomic zone, but also by the depth of the looseness and the predominant clinical objective, whether it is structural lifting or refinement of the skin surface. Additionally, the literature indicates that linear technology enables the application of the *Thermal Thread Technique* ™, which demonstrated superior safety and efficacy in vector-based skin retraction when using parallel high-intensity beams (Oku, 2024). On the other hand, point transducers maintain their clinical value by their ability to modulate focal depth with high resolution in areas that are difficult to access, such as the periorbital region, where circumscribed thermal control is essential to avoid collateral damage to delicate structures (Dal 'Forno et al., 2025). In this sense, the careful selection between these energy-delivery modalities allows the practitioner to optimize tissue remodeling according to the need to volumetric traction or focused restructuring (Aldisa, 2025). The integration of these approaches ensures that treatment is not limited to superficial retraction, but instead promotes a deep reorganization of the musculoaponeurotic system superficial,

enhancing the structural support of the face (Coelho et al., 2025; Ferreira et al., 2025). The ability to selectively and reproducibly create zones of thermal damage in this specific plane is a milestone for non-invasive rejuvenation, as validated by histological studies in cadaver facial tissue (White et al., 2007). These histopathological experiments confirmed that the system can generate precise, discrete thermal coagulation lesions at the planned depths, fully preserving the epidermis and deep structures such as the parotid glands and branches of the facial nerve (White et al., 2006). Such histological evidence reinforces that circumscribed thermal control enables the safe application of higher energies, optimizing the neocollagenesis stimulus in deep planes while minimizing the risk of collateral tissue damage (Miranda, 2022). This precision in energy delivery is essential to ensure clinical safety, allowing the procedure to be carried out effectively even in areas of greater anatomical complexity (Heitzmann et al., 2025).In this way, the transition to protocols that combine the precision of ultrasound with injectables, such as hyaluronic acid fillers or biostimulators, has shown superior synergistic results, while maintaining a robust safety profile supported by extensive clinical reviews (Silva, 2025; Suh et al., 2024). Thus, the multimodal combination of ultrasound energy and biological modulation with collagen biostimulators represents the state of the art in facial harmonization, enhancing the longevity of results by addressing simultaneously structural laxity and volumetric loss (Campos et al., 2025; Jurcevic & Čeović, 2026). The synergistic application of these approaches allows that

the clinician treats aging in multiple layers, since ultrasound promotes deep structural lifting while injectables provide volumetric support and continuous stimulation of the extracellular matrix (Bellini et al., 2023). The literature confirms that this integrated strategy leads to significant improvements

in global aesthetic assessment scales, surpassing the isolated results of each technology (Amiri et al., 2025; Dal ' Forno-Dini & Birck, 2026). In addition, the strategic combination enables a significant increase in collagen synthesis, enhancing the effects of tissue remodeling through complementary and synergistic mechanisms of action (Casabona et al., 2023),(Lobo et al., 2023). optimizing dermal architecture and providing a more durable and balanced lifting effect (Doyle et al., 2024; Murad et al., 2022). As materials science evolves, the combination of ultrasound with biostimulators

injectables — such as calcium hydroxyapatite — have consolidated as a robust strategy for full-face biostimulation, promoting coordinated neocollagenesis and neoelastogenesis at different dermal and subdermal depths (Cançado et al., 2023). Recent studies highlight that this combined approach substantially improves global aesthetic assessment scores, with measurable dermal thickening evidenced by high-frequency ultrasonography (Bravo et al., 2024; Diaz et al., 2022). Thus, ultrasound monitoring not only validates treatment efficacy, but also supports safety by enabling real-time visualization of the treated layers, minimizing the risk of complications (Bravo et al., 2021). Additionally, the current literature confirms that integrating these protocols enables an optimized tissue response with a high patient satisfaction rate, maintaining a favorable safety profile with self-limited adverse events (Meçani et al., 2025).Therefore, the continuous refinement of combined techniques, aligned with layered, evidence-based planning, establishes a new paradigm of effectiveness in non-surgical rejuvenation (BORGATTE, 2025; Yutskovskaya et al., 2020). This technical evolution reflects a paradigm shift in which treatment personalization, guided by histological and clinical evidence, becomes the main determinant of sustained and natural results (Doyle et al., 2025; Lopes et al., 2026). In this context, the transition to protocols that balance controlled ultrasound thermolysis with the bioactive action of hybrid fillers, such as hyaluronic acid associated with calcium hydroxyapatite, increases the longevity of results by promoting a three-dimensional tissue restructuring (Bravo & Calderón, 2025; Queiroz et al., 2025). Understanding the underlying biochemical mechanisms of these bioactive materials is essential to maximize the fibroblast differentiation response and the subsequent reorganization of the extracellular matrix (Almeida, 2025; Maldonado et al., 2025). Specifically, calcium hydroxyapatite of

Calcium acts as a powerful modulator of tissue regeneration, promoting angiogenesis and an increase in dermal thickness, as verified in ultrasound follow-ups (Morales et al., 2024; Oliveira et al., 2021). Additionally, comparative studies between microfocused ultrasound technologies show that, while the spot mode is superior for anchoring septa and providing focused retraction, the linear mode enables a more homogeneous thermal distribution over large areas, optimizing stimulation of overall skin firmness. This technical difference reflects the platform's evolution, in which the spot applicator concentrates energy into discrete focal points for mechanical retraction. of system

musculoaponeurotic, while the linear one promotes diffuse volumetric heating, enhancing elastogenesis in areas with greater extent (Chieregato et al., 2025; Luccia & Gotardo, 2023). Consequently, choosing between these modalities allows the clinician to tailor treatment according to each patient's specific needs, balancing the precision of tissue retraction with the need for volumetric biostimulation in regions with greater laxity. Recent research indicates that the transition to using linear transducers has significantly reduced operational time, while maintaining the

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efficacy in neocollagenesis observed with the conventional focal technique (Luiz et al., 2023). At the same time, the linear mode enables more precise control of thermal depth, minimizing undesired energy dispersion in tissues adjacent to the target planes. Thus, a judicious choice between these technologies optimizes the management of the extracellular matrix, adapting thermal delivery according to tissue density and the specific goals of the rejuvenation plan (Cavallini et al., 2026). The safety of these procedures is supported by the high precision in inducing thermal microcoagulations, which trigger reparative processes without compromising the integrity of the superficial layers (Matos et al., 2025). The clinical effectiveness of this approach lies precisely in its ability to induce neoformation of collagen through controlled thermal coagulation zones, minimizing collateral damage to the surrounding tissue (Cançado et al., 2023). In this scenario, the application of focused energy at temperatures above 60° C ensures the denaturation of collagen fibers in system

superficial musculoaponeurotic and in the deep reticular dermis (Fabi, 2015). This thermal rise triggers a proliferative inflammatory response that culminates in the synthesis of new collagen, promoting the structural tightening that characterizes non-surgical lifting (Néri et al., 2022; Peres & Peres, 2023). Technological advances in these devices have enabled increasingly refined control of depth and energy density—key aspects for achieving predictable and safe aesthetic results (Almeida et al., 2025). Historically, the transition from macro and microfocused ultrasound technology has allowed refinement in thermolysis modulation, evolving from fixed parameters to energy delivery that respects the complex histological architecture of the subcutaneous layers. The development of this instrumentation has enabled physicians to precisely reach therapeutic temperatures between 45°C and 65°C, optimizing the immediate shortening of collagen molecules without causing unnecessary thermal damage to adjacent tissues (Green & Greene, 2014).This accuracy in energy modulation is fundamental, since the literature shows that achieving appropriate internal temperatures is the main determinant for effective collagen denaturation and the subsequent tissue retraction, ensuring superior clinical outcomes (Dias & Bogado, 2024).

METHODOLOGY

This study outlines a comparative prospective design to assess the clinical efficacy and safety of microfocused ultrasound applicators in linear and point mode. The sample, comprising 30 patients, will be stratified to compare tissue response under standardized energy-delivery protocols, aiming to quantify variation in dermal retraction and collagen production (Qi et al., 2026). Inclusion criteria select individuals aged 30 to 65 years with mild to moderate skin laxity, who undergo protocols using 3.0 mm and 4.5 mm transducers to ensure thermal delivery in the deep planes and in the SMAS (Montezuma et al., 2023). Treatment parameters will be adjusted individually for power (J/cm 2) and line spacing, ensuring a consistent and reproducible biological response across the experimental groups (Chieregato et al., 2025; Oliveira et al., 2024).Assessment of the results will be carried out through serial photographic documentation and high-frequency ultrasound analysis, which will allow measurement of dermal thickness and the level of tissue density at intervals of 3 and 6 months after the procedure (Zappia et al., 2026). In addition to image analysis, patient satisfaction will be monitored using validated self-report scales, while the safety profile will be rigorously documented by the incidence and severity of any adverse events (Lee et al., 2025). Statistical analysis of the data, including paired t-tests and assessment of effect size using Cohen's d, will be conducted to determine the clinical significance of the differences observed between the modalities (Adib & Liu, 2025). Additionally, the use of computational analysis software, as described in prior experimental studies, will enable metric correlation between the contraction vectors and changes in facial symmetry measurements (Meyer et al., 2021). Finally, the direct comparison between collagen densities in the intervention groups will provide robust quantitative evidence on the superiority of linear thermal induction over the point-by-point pattern across different dermal thicknesses (Lopes et al., 2024),(Wu & Chen, 2023). and also to assess the influence of facial architecture on long-term tissue response (Werschler & Werschler, 2016). This comparative analysis aims to establish evidence-based clinical guidelines, consolidating microfocused ultrasound as a high-precision tool for non-invasive facial harmonization (Souza et al., 2022). Thus, it is expected that standardization of energy parameters and a rigorous comparative analysis will contribute to the development of optimized protocols that maximize the efficacy of facial rejuvenation (Fernandes et al., 2022; Silva et al., 2025). In addition, analysis of the results will allow validation of the technological transition to the micropulsed mode, consolidating its efficacy in facial slimming and in defining the mandibular contour, as evidenced in recent clinical studies (Henriksson et al., 2024). The implementation of protocols customized allows adjusting energy delivery according to anatomical variations in the lower third of the face, maximizing safety and lifting outcomes (Wood et al., 2024). Thus, investigating differences between linear and focal thermal delivery patterns enables an unprecedented refinement of the therapeutic approach, aligning coagulation density with the cutaneous tension vectors needed for rejuvenation (Suh et al., 2024).

RESULTS

The comparative analysis between the modalities shows that linear delivery produces a more pronounced volumetric reduction in the submental adipose tissue compared to the focal mode, which is superior in SMAS retraction and focal cutaneous lifting (Marinho et al., 2023; Tavares et al., 2024). While the linear mode is more effective at reducing the thickness of the fat pad, the focal mode enables a more precise coagulation density in the fibrous septa, favoring optimized tissue remodeling as observed in high-frequency imaging studies (Day, 2014; Lou et al., 2026). Regarding the pain profile, the patients reported a level of discomfort significantly lower with the linear mode, possibly due to a more homogeneous distribution of thermal energy, which minimizes peaks of acute pain often observed in the traditional spot technique (Zhu et al., 2023). Additionally, reports of edema and erythema were classified as acute and transient responses, with no evidence of late complications in either

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group (Matos et al., 2023). The durability of the clinical results showed a marked maintenance of the facial contour at 6 months, with patient satisfaction rates consistent with the efficacy observed in reducing laxity, corroborating the current literature indicating the technology as a safe and effective alternative to surgical intervention (Haykal et al., 2025; Menezes et al., 2024). However, the persistence of aesthetic effects in the long term requires a more extensive longitudinal assessment, since collagen remodeling and the stabilization of the extracellular matrix continue to evolve after the initial six-month period (Alhaddad et al., 2018; Kumar et al., 2025). Future studies should focus on optimizing parameters combined for

to enhance the stabilization of the skin, ensuring that the benefits of cutaneous remodeling are maintained over extended time windows (Campos & Quilici, 2025). In addition, integrating adjuvant therapies, such as radiofrequency, can synergize with the effects of ultrasound to prolong tissue firmness and improve the remodeling of the extracellular matrix (Fawzy & Putranti, 2025). This combined approach, which associates the thermal precision of ultrasound with the

modulation volumetric of radiofrequency demonstrated higher rates of clinical approval in long-term evaluations (Lee et al., 2023). Such multimodal protocols not only enhance deep neocollagenesis, but also refine the safety profile by mitigating individual variability in the inflammatory tissue response (Khan & Khalid, 2021; Trombini & Santos, 2023). Based on the literature, the observed safety is reflected in the absence of serious adverse effects, with transient erythema being the most common reaction reported after treatment (Malaysia et al., 2024), (Panithaporn, 2025). Tolerability to the procedure is reinforced by the technology's ability to promote tissue lifting with manageable pain levels, even in areas with higher densities of sensory receptors (Gold & Biron, 2023). The incidence of complications, such as thermal burns or nerve damage, remains statistically insignificant, validating the safety of microfocused ultrasound as a non-invasive procedure with high reproducibility (Araco, 2020; Gomes et al., 2023).Additionally, the consistency of the technology's security profile, when used alone or in combined protocols, supports its clinical feasibility in patients seeking consistent results with less invasive interventions (Fabi, Goldman, et al., 2016; Fabi, Green, et al., 2016). In this context, reducing recovery time allows patients to return quickly to their everyday activities, consolidating the technique as an attractive option when pursuing aesthetic procedures with minimal impact on lifestyle (Biskanaki et al., 2025). Therefore, the accuracy of micro-focused ultrasound with real-time visualization acts as a determining factor in mitigating risks, enabling personalized adjustment according to the patient's specific tissue layers (Preman et al., 2026). The integration of prior ultrasound mapping makes it possible to identify variations in the thickness of the subcutaneous plane, ensuring that energy is deposited precisely in the target plane to optimize both the lifting effect and tissue safety (Casabona & Kaye, 2019).In this way, image-based customization allows the clinician to adjust the depth and intensity of the firing according to the thickness of the fascia and adipose tissue, drastically reducing variability in results among different patients (Fabi et al., 2019). This precision in energy delivery promotes more robust neocollagenesis across multiple tissue levels, resulting in a deep-healing response that optimizes long-term collagen remodeling (MacGregor & Tanzi, 2013). The scientific literature reinforces this effectiveness, indicating that high patient satisfaction—reaching levels above 80% in various protocols—is directly related to the accuracy of thermal delivery in the deep layers of the dermis and the SMAS. Consequently, the correlation between subjective satisfaction and objective improvement in skin quality underscores the role of ultrasound as an indispensable tool in the non-surgical approach to facial aging (Amiri et al., 2024). Careful selection of candidates and the technical qualification of the professional are therefore fundamental pillars to ensure predictable clinical outcomes and the maintenance of satisfaction in the long term (Bukhari et al., 2024). The implementation of rigorous clinical follow-up protocols, structured with periodic assessments up to 20 months, has proven essential to validate the persistence of the tissue response and the stability of the anatomical changes achieved (García, 2026a, 2026b).Additionally, the use of anonymous questionnaires and validated facial assessment scales has proven fundamental to reduce gratitude bias, providing more accurate data on the actual perception of aesthetic improvement (Chang et al., 2019). The use of advanced imaging methods, such as the *Vectra H2*, makes it possible to objectively quantify these volumetric and surface changes, consolidating the scientific rigor needed to support the long-term clinical effectiveness of the technology (Oliveira et al., 2023). The technical distinction between the point mode and the linear mode allows the clinician to personalize the biological response, where the first focuses on the immediate contraction of collagen and the second on volumetric modulation of the subdermal adipose tissue (Dicker et al., 2025; Park et al., 2021). While point application is preferably indicated for vertical lifting in deep layers through focused coagulation, the linear mode enables homogeneous thermal distribution and is superior in the treatment of mild laxity and in remodeling adipose tissue (Advíncula et al., 2023).

DISCUSSION

The clinical effectiveness of this technology lies in its ability to transition between focused precision—required for retraction of the superficial musculoaponeurotic system—and linear application, optimized for tissue volumetry (Garcia, 2024). While point transducers induce zones of thermal coagulation that favor structural lifting (Smoczok et al., 2022), the linear modality promotes diffuse heating that modulates the density of adipose tissue, enabling a more refined facial contour. This differentiation of applicators is crucial because it allows the practitioner to select the energy delivery strategy according to skin thickness and the patient's degree of ptosis, optimizing structural repositioning without compromising the vitality of the subcutaneous tissue (Chadab et al., 2026). Personalizing the protocol based on prior ultrasound analysis of tissue layers enables an individualized approach, adjusting the density and

the energy plan according to the patient's morphological variations (Velazco et al., 2026). Thus, a careful choice between the focal transducer for areas with greater structural support and the linear one for regions with localized fat accumulation helps achieve more natural and reproducible results (TP & HA, 2021). However, the economic viability of this practice requires a rigorous cost-effectiveness analysis, considering that intensive use of linear transducers, although promising for contouring, may increase the per-session

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investment without invariably ensuring superior clinical outcomes in cases of severe laxity (Santos et al., 2024; Sun et al., 2026). Therefore, future studies should prioritize comparative analyses that correlate

the cost-benefit of these technologies with the durability of results in specific populations, mitigating commercial bias and establishing robust clinical guidelines (Contini et al., 2023; Pritzker et al., 2014). In addition, standardizing these protocols must consider variability in skin phenotypes, given that inflammatory responses and collagen synthesis show different behavior according to the Fitzpatrick scale (RebeloMarques, 2026). Thus, implementing adjustable parameters is essential to ensure safety in higher phototypes, minimizing the risk of thermal adverse effects and optimizing the efficacy of neocollagenesis (Dias & Borba, 2021; Juhász et al., 2018). The limitations inherent to studies focused on small samples underscore the need of investigations

wider multicentric models capable of determining whether the efficiency of tissue remodeling justifies the high investment in inputs and state-of-the-art equipment (Bazzo, 2016; Kumar et al., 2026) . Moreover, the cost-benefit analysis must integrate the operator's learning curve and the required frequency of maintenance sessions, which are essential to sustain clinical effectiveness in the long term (Pritzker & Robinson, 2014) . Ultimately, the sustainability of this therapeutic model depends on the convergence between technical precision, rigor in the selection of parameters, and the ongoing validation of results through follow-up protocols based on evidence (Forato et al., 2022; Martinez et al., 2023) . Moreover, integration of technologies

Complementary procedures, such as fillers and collagen stimulators, emerge as a promising strategy to enhance the results of ultrasound, addressing any volumetric deficits that isolated treatment cannot mitigate (Dal 'Forno-Dini & Birck, 2026). The exploration of complementary diagnostic methods, such as high-frequency ultrasound and elastography, therefore becomes a necessary step to quantitatively monitor changes in dermal density and the structure of the subcutaneous tissue after the intervention (Pequeno & Bagatin, 2024). Consequently, the correlation between the therapy's biophysical parameters and the synthesis of the extracellular matrix may consolidate the transition of these niche treatment technologies into evidence-based regenerative medicine protocols (Bernardy et al., 2025). Standardizing these protocols, however, requires overcoming regulatory barriers that still hinder global harmonization of practices, as observed in integrative dermatological approaches (Haykal et al., 2026).In this way, improving the operator's technical competence remains the main determinant of safety and therapeutic success, requiring ongoing training to correctly correlate ultrasound images with the underlying histopathological changes (Levy et al., 2021).

CONCLUSION

Microfocused Ultrasound Represents a significant advance in aesthetic dermatology, offering therapeutic versatility through selective modulation between the point and linear modes for managing facial aging. The systematic integration of complementary technologies and continuous ultrasound monitoring are imperative for transitioning these interventions toward a regenerative medicine model, maximizing the neocollagenesis and the long-term structural efficacy (Campos et al., 2025; Kerscher et al., 2018; Pavicic et al., 2025) .

In addition, future research should prioritize refining energy delivery algorithms aimed at automated personalization, as well as quantitative assessment of elastography-mediated tissue remodeling (Czajkowska et al., 2023) .

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