

Treatment of Mid-Face Aging with Calcium Hydroxylapatite: Focus on Retaining Ligament Support

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Abstract: The mid-face has been rendered as the cornerstone of facial aesthetic improvement, since treating the mid-face has also beneficial effects on neighboring esthetic units and therefore should be one of the first areas to be assessed. Retaining ligaments (RL) bind soft tissue layers of the face to the underlying facial skeleton. It remains controversial whether RL suffers laxity with aging or if changes in bone and other structures where ligaments are inserted lead to altered mechanical function of the latter. Enhancement of the supportive effect of the ligaments could help restore the soft tissues to their original anatomical positions and achieve a lifting effect. While injectable hyaluronic acid implants have been used to improve ligament support, calcium hydroxylapatite has one of the highest viscoelasticities when compared with other dermal fillers and can induce collagen synthesis, which could provide long-term laxity correction. In this preliminary report of a case series, our goal was to describe the use of calcium hydroxylapatite in different dilutions and combinations for different aging profiles to treat the midface as an alternative for hyaluronic acid injections and to describe the ultrasonographic behavior in the long run.

Keywords: rejuvenation, retaining ligaments, calcium hydroxylapatite, hyaluronic acid, soft tissue repositioning, aging pattern

Introduction

It has been conceptualized that the soft tissues of the face are arranged into five basic layers bound by a system of facial retaining ligaments. Retaining ligaments are responsible for binding the soft-tissue layers of the face to the underlying facial skeleton, acting as anchor points, and retaining and stabilizing the skin and superficial fascia (SMAS) to the underlying deep fascia and facial skeleton in defined anatomical locations.¹ The ligamentous structures of the face play an important role in restricting facial mobility in different anatomical regions, dictating the way the tissues yield in response to gravity.

The face can be divided into 3 parts, namely upper face: from hairline to glabella; midface from glabella to subnasal and lower face from subnasal to submental.² Since the mid-face has been rendered as the cornerstone of facial aesthetic improvement and should be one of the first areas to be assessed, as treating the mid-face also has beneficial effects on neighboring aesthetic units.³ The most relevant ligaments in the mid-face are the orbital-retaining ligament, malar septum (zygomatic-cutaneous ligament; ZCL), and McGregor's patch (zygomatic ligament).⁴ ZCL is a true an osteocutaneous septum-like structure osteocutaneous ligament originating from the periosteum of the maxilla and zygoma, traversing the overlying fat compartment and muscle and inserting into the skin of the anteromedial mid-face.⁵ It starts at the origin of the levator labii superioris and then extends laterally following the curvature of the inferior bone margin of the zygoma in the form of a crescent⁶ and plays an important role in fixing the skin of the face. The latter differs from the masseteric and mandibular ligaments, which are false fascio-SMAS ligaments that fixate the superficial fascia and platysma muscle.⁷

It is controversial whether ligaments that tether the facial tissues into the anatomic position suffer laxity with aging^{8–10} or if changes to the bone and other structures where ligaments are inserted lead to an altered mechanical function such that

a ligament that supports the fat within a compartment (superficial or deep) may fatigue and bulge along its course, leading to the appearance of sagging of the respective fat compartment.^{1,11–15} With aging, bone resorption in the anterior and inferior aspects of the maxilla leads to retrusion of the mid-face, which, in addition to working as a true slide for the descent of the mid-face soft tissues, further decreases bone support for the zygomatic cutaneous ligament to maintain its tensile strength.^{16,17} Approaches to sagging appearance entail repositioning of descended soft tissues to the anatomical position of the youth.¹⁸ In this setting, enhancement of the supportive effect of the ligaments, in its bone or skin insertion, could help restore the soft tissues to their original anatomical positions and achieve a lifting effect. The herein proposed “string-of-pearls” technique takes into consideration for the mid-face the zygomatic cutaneous ligament (ZCL). While injectable hyaluronic acid (HA) implants have been used to improve ligament support in the mid-face,^{18,19} there is a concerning trend related to the overfilled syndrome. The latter occurs due to secondary to excessive filler use and suboptimal injection techniques, leading to excess midfacial volume and/or as unnatural smile.^{20–22}

In addition to having one of the highest viscoelasticities when compared with other dermal fillers,^{23,24} CaHA can induce collagen synthesis,^{25–27} and extracellular matrix remodeling, which could provide long-term laxity correction²⁸ without adding extra volume. In this setting, we describe in this preliminary study the use of CaHA in different dilutions and combinations for different aging profiles to treat the midface as an alternative for hyaluronic acid injections and to describe the ultrasonographic behavior in the long run. Moreover, we present variations in techniques considering 3 different laxity patterns: normovolumetric laxity, atrophic laxity (“sinkers”; laxity with lower skin density and atrophy of fat compartments) and heavy-face laxity (“Saggers”; laxity with fat bulges).²⁹

Methods

All procedures performed in this study involving human patients were in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Ethics Approval

This preliminary report of a case series was approved by a centralized institutional review board (IRB from Pontificia Universidade Católica Do Paraná; approval number: 67654322.5.0000.0020). Written informed consent was provided by all patients to have the case details and any accompanying images published.

We report three cases of facial rejuvenation with increased support of the retaining ligaments using undiluted calcium hydroxylapatite with 0.3% powdered lidocaine hydrochloride (CaHA (+); Radiesse Plus[®]; Merz Pharmaceuticals GmbH, Frankfurt, Germany) and diluted calcium hydroxylapatite (CaHA; Radiesse[®]; Merz Pharmaceuticals GmbH, Frankfurt, Germany). Eligible patients were men and women aged >18 years who sought facial rejuvenation and agreed to participate in the study.

Two-dimensional (2D) photographs were obtained using a stereovision digital camera (LifeVizTM; Quantificare S.A., Sophia Antipolis, France). The standardized indirect light, aperture, speed, and distance of the camera were controlled. Digital photographs were reconstructed in three dimensions (3D) with LifeVizTM App software (Quantificare S.A., Sophia Antipolis, France). Vector analyses to evaluate soft tissue repositioning and surface analysis were performed.

Procedure

All cases were treated with a session of CaHA(+) with the “String of Pearls technique”, and received a re-treatment after 1 year. Ultrasound evaluation (18 MHz and 22 MHz; LOGIQe (R7); GE, USA) was performed immediately after the injection, 2 months after 1st treatment, before re-treatment (1 year after 1st treatment), and 2 months after re-treatment.

Depending on the indication, further treatment with CaHA diluted with a solution containing 0.5 mL of lidocaine 2% without epinephrine (case#2- heavy-face laxity) or 1.5 mL of a lidocaine-saline solution was performed (case#3; atrophic skin laxity).

“String of Pearls” Technique

This technique is suitable for distinct patient's profiles who desire laxity improvement and mid-face soft tissue repositioning with a minimal volumetric gain, consisting of 2 steps.

Step 1: Support of Bony Maxilla (ZCL Origin)

Delineation of the anteroinferior border of the zygoma and palpebromalar groove should be performed (Figure 1A). With a single-entry point below the apex of the zygoma, suprapariosteal boluses of CaHA (+) should be performed with a 22G cannula, from the transition of the palpebral malar groove to the antero-inferior border of the zygoma (Figure 1B). Two different techniques are possible: to inject multiple small boluses totaling 0.7 mL of product or 3 boluses, being one 0.3mL bolus (more anterior) and two 0.2mL boluses. Nonetheless, to standardize the technique, all patients were treated with three boluses, as described previously.

Step 2: Zygoma (ZCL Insertion)

From the same entry point, retroinjection of subcutaneous microboluses of CaHA(+) along the whole zygoma area should be performed, with a total volume of 0.8 mL (Figure 1C).

Usually, one 1.5 mL syringe of CAHA(+) per side is suggested for moderate cases, whereas in mild cases, a total volume of ½ syringe per side (with half the suggested dose per area) may suffice. Moreover, in severe cases or in broader faces, more than one suprapariosteal bolus of 0.3 mL may be required (Case #2; Figures 2B and 3A).

After ZCL support was performed with steps one and two, extra steps can be necessary to improve mid face laxity. First and foremost, it is necessary to differentiate laxity that occurs in a normovolumetric face from that in a heavy face, and if laxity is accompanied by skin atrophy. This preliminary report includes a patient with severe loss of weight, but normo-volumetric face (case #1), a menopausal woman with “heavy face” (case #2) and an athlete with mid-facial laxity and atrophic skin (case #3).

For patients with heavy faces, an additional step of the technique involves approaching the lateral face, aiming to create a posterior-lateral vector for further tissue support. CaHA (1.5 mL) should be diluted with 0.5mL of lidocaine 2% without epinephrine, to a total volume of 2 mL. With an entry point in the infra-zygomatic area, microboluses with retrograde injection technique and 22G canunula (1 mL per side) should be injected in the subcutaneous plane, parallel and inferior to the zygomatic arch (Case #2; Figure 2D).

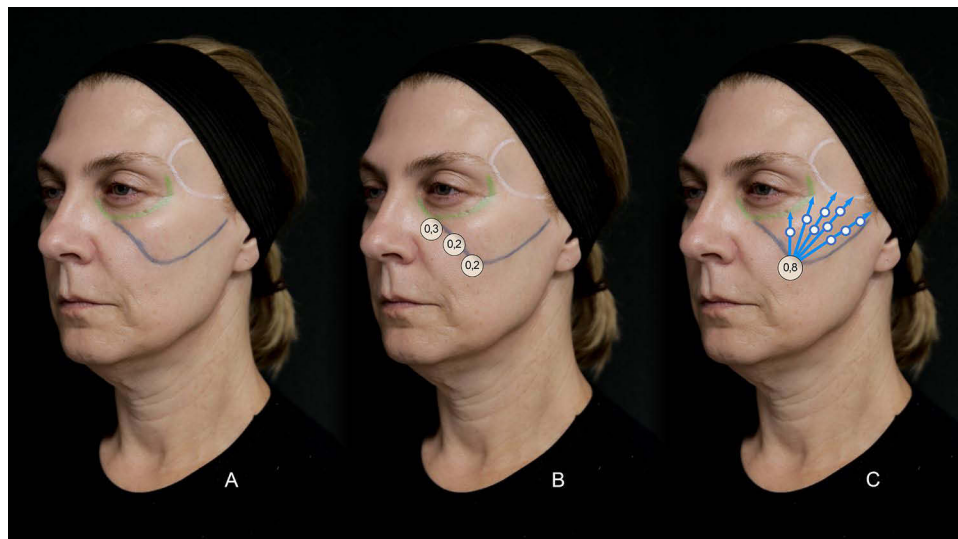


Figure 1 String of Pearls technique. (A) Delineation of the antero-inferior border of the zygoma and the palpebro-malar groove. (B) From an entry point below the apex of the zygoma, inject 1 suprapariosteal bolus of 0.3mL of CaHA(+) in the transition of the palpebral malar groove and the antero-inferior border of the zygoma, and while retracting the cannula, 1 bolus of 0.2mL in the deep subcutaneous plane and another 0.2mL bolus in the superficial subcutaneous plane. (C) Retroinjection of subcutaneous microboluses of CaHA(+) along the whole zygoma area.

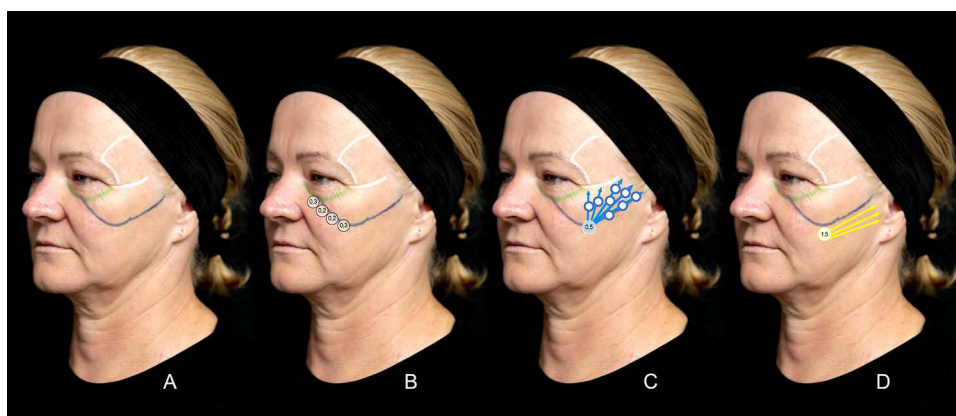


Figure 2 Variation of the technique for heavy faces. (A) Delineation of the antero-inferior border of the zygoma and the palpebro-malar groove. (B) For severe cases or in broader faces, more than one suprapariosteal bolus of 0.3mL may be needed, totaling 4 boluses (2 suprapariosteal, 1 deep subcutaneous, 1 superficial subcutaneous). (C) Retroinjection of subcutaneous microboluses of CaHA(+) along the whole zygoma area. (D) Injection of 1mL of CaHA (Dilution: 1.5mL + 0.5mL of lidocaine 2% without epinephrine) parallel to the zygomatic arch to create a posterior-lateral vector for further tissue support.

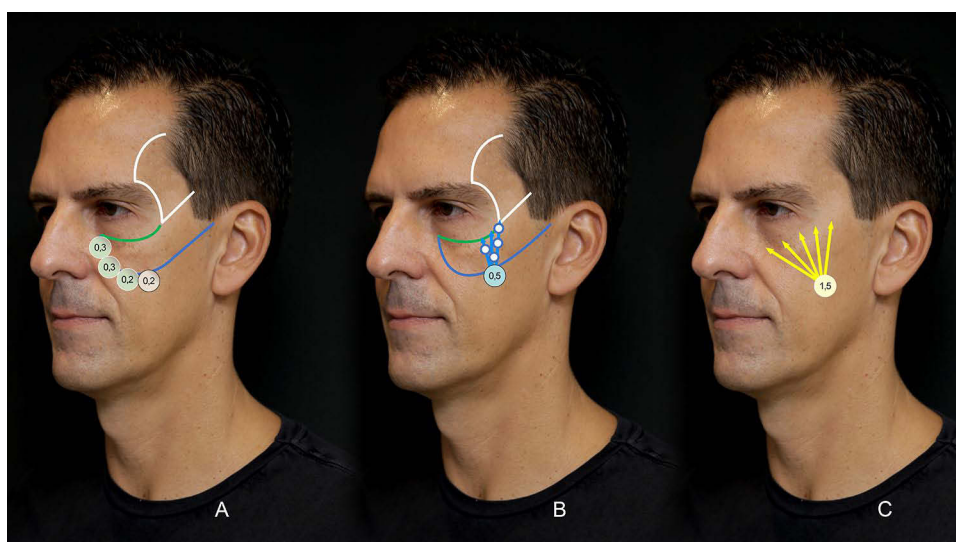


Figure 3 Variation of the technique for cases with associated skin laxity with atrophy. (A) From an entry point below the apex of the zygoma, injection of 4 boluses (2 suprapariosteal, 1 deep subcutaneous, 1 superficial subcutaneous). (B) Retroinjection of subcutaneous microboluses of CaHA(+) along the whole zygoma area. In males, to avoid broadening and feminization of the face, point the cannula to the insertion of the orbicular ligament. (C) non-volumetric bio stimulation with CaHa diluted 1:1 in the subcutaneous plane to improve skin collagen content, with minimal volumization.

For subjects that present laxity with skin atrophy, further non-volumetric bio stimulation with CaHa diluted 1:1 with a solution of 0.5 mL of lidocaine 2% without epinephrine and 1 mL of saline, for a final volume of 3 mL (Case #3; Figure 3C) should be injected with a 22G cannula (1.5 mL/side) in the subcutaneous plane to improve skin collagen content and provide a dermal scaffold, with minimal volumization.

In males, the vector along the zygoma of the “String of Pearls” technique should be shifted to point to the insertion of the orbicular ligament (Figure 3B) to avoid broadening and feminization of the face.

Results

Demography

The patients enrolled were 48–54 years of age (median age, 48 years). The relevant medical history included bariatric surgery with great weight loss (case #1), superior blepharoplasty, and menopause (case #2). No other relevant medical history was reported (eg, diabetes, neurologic diseases, connective tissue diseases, allergies, history of infections or

presence of active infections, and use of medications that cause bleeding). None of the patients had undergone any injectable procedure, surgery within the last 12 months, or referred use of permanent fillers.

Quantificare Vector Analysis

Quantificare vector analyses comparing pre- and 1-year post-treatment images demonstrated soft-tissue repositioning (Figure 4).

Ultrasound Evaluation

Immediately after the injection, the CaHa(+) boluses were observed as hyperechogenic images right next to the periosteum in the deep subcutaneous plane, and superficial subcutaneous plane, illustrating the dual-plane approach (Figures 5A, B and 6A). After two months, the deep CaHa(+) boluses have accommodated and coalesced as a hyperechogenic homogeneous strip, suggesting good product integration and localized effects (Figure 6B). One year after the 1st treatment the thick hyperechogenic band was still present, but the echogenicity was lower than that in the image from 1 year before (Figure 7A). After re-treatment, new boluses are observed below the band (Figure 7B). Two months after re-treatment, a new thick hyperechogenic band was observed below the previous band, adding extra support (“build-up” effect) (7C).

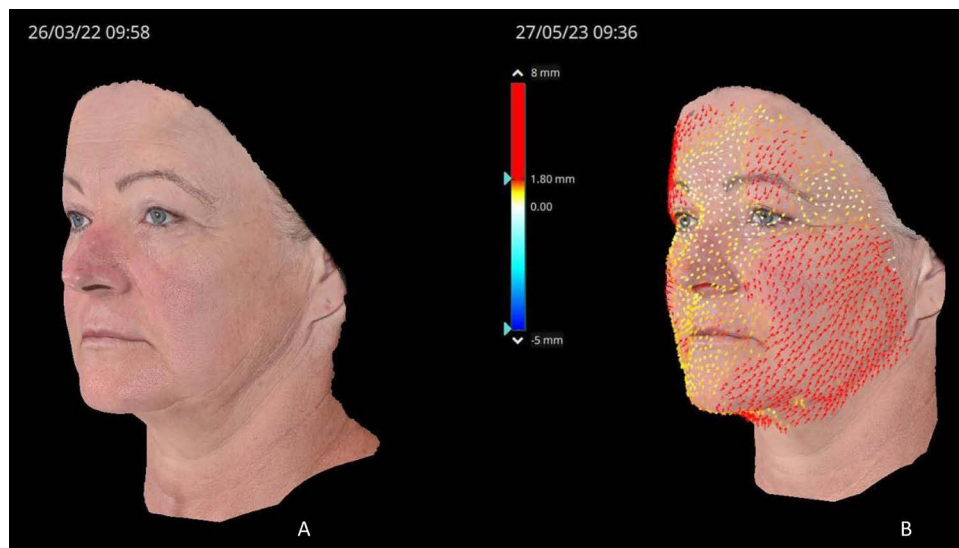


Figure 4 (A) Quantificare vector analyses to evaluate soft tissue repositioning. (B) Arrows demonstrate direction of tissue displacement and red color indicates degree of displacement. Red arrows in the malar area demonstrate the lifting effect post-treatment.

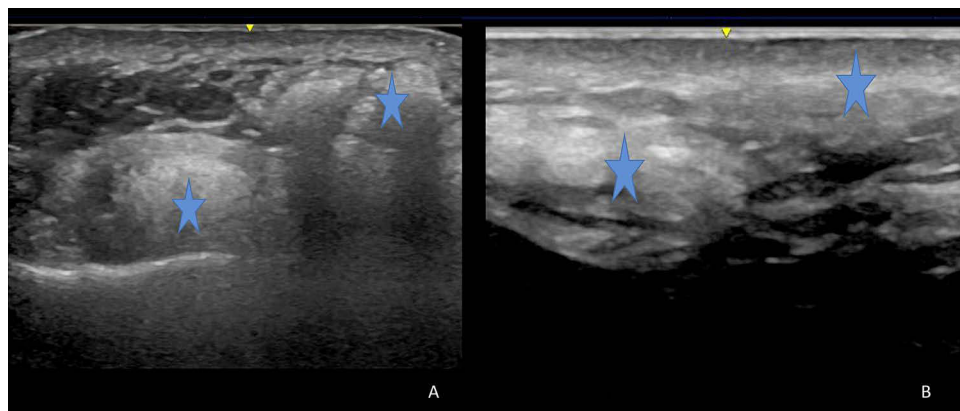


Figure 5 Ultrasound image highlighting the dual plane approach. CaHa(+) observed as hyperechogenic images right next to the periosteum (blue star; (A), in the deep subcutaneous plane and also in the superficial subcutaneous plane (blue stars; (B).

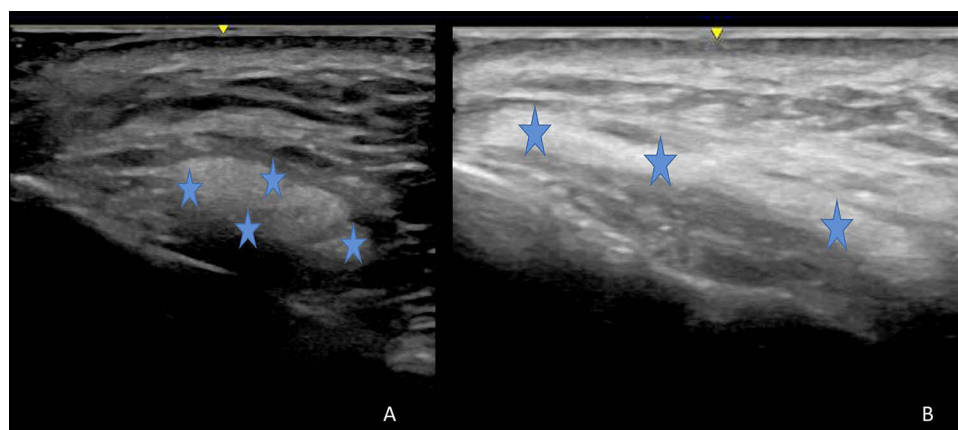


Figure 6 Coalescence of injected boluses. **(A)** CaHa (+) boluses right after injection (blue stars). **(B)** 2-month follow-up: Boluses have coalesced as a hyperechogenic homogeneous strip (blue stars).

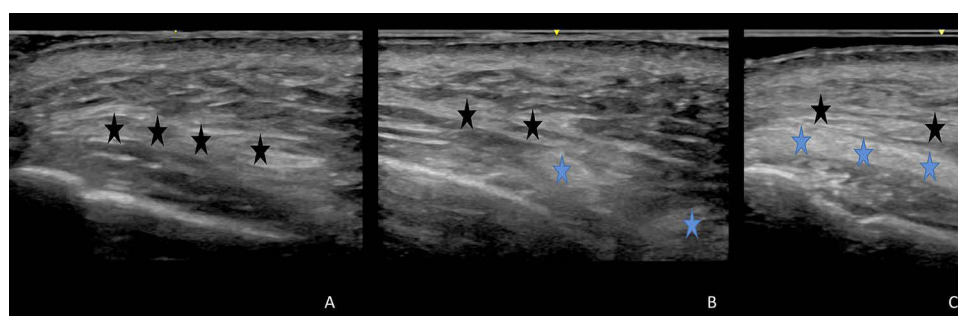


Figure 7 Build-up effect. **(A)** One year after the 1st treatment the hyperechogenic band is still present (black stars). **(B)** Right after re-treatment, new boluses (blue stars) are observed below the band (black stars). **(C)** Build-up effect: 2 months from re-treatment, a new thick hyperechogenic band (blue stars) is observed below the previous band (black stars).

Discussion

Aging is a multifactorial process involving alterations in different layers and structures of the face. The mid-face plays such a pivotal role during the aging process that it has become a target for facial rejuvenation.³

The retaining ligaments of the face are strong and deep fibrous attachments that originate from the periosteum or deep facial fascia and travel perpendicularly through facial layers to be inserted into the dermis and act as anchor points,¹ fixating soft tissue in anatomical positions, and resisting gravitational forces.⁸ Microscopically, periosteal or deep fascial thickening is rooted in a tree-like distribution that branches out as it approaches the SMAS (retinacula cutis), which in turn spreads through the subcutaneous to the fibrous stroma of the dermis.³⁰ In contrast to the use of stiff HA pillars positioned on the bone, which act as support pillars to the overlying subcutaneous layer,³¹ the idea behind the string-of-pearls~ technique is to create support with a string of boluses around the zygomatic-cutaneous ligament, from the periosteum to the skin, which with time will settle in a linear strip (Figure 6B) connecting the deep periosteum to the dermis. The boluses in the supraperiosteal plane with CaHa aimed to restore the support of the ZCL to maintain its tensile strength. They also have a high lifting capacity to provide bone-like structural support for overlying soft tissues and compensate for the natural volume decrease caused by age-related bone resorption.^{15–17,32} Fibroblasts observed by electron microscopy in the periosteum may account for the neocollagenesis observed after CaHA deposition at the supraperiosteal level.³³

Furthermore, the microboluses injected along the zygomatic arch aim to support the part of the zygomatic-cutaneous ligament that extends along the entire length and width of the zygomatic arch,¹⁹ and further induce soft tissue lifting (Figure 4) since lateral injections to the line of ligaments (Lateral orbital thickening, mandibular ligament, temporal ligamentous adhesion, zygomatic ligament aligned in one line) entail a lifting effect³⁴ and simulate the surgical correction of the retaining ligaments.¹⁸

CaHA was the product of choice because of its unique rheology and versatility.²³ For instance, it can be used without dilution for more focal support and soft tissue repositioning or with different dilutions to improve skin quality and/or provide a vector effect. Furthermore, CaHA has one of the highest viscoelasticities when compared with other dermal fillers, allowing it to remain in the place where it is injected and not migrate into the surrounding tissue,²³ as well as a high ability to resist deformation (high viscoelasticity),^{23,24} ideal for use in specific areas that need focal support. The ability of CaHA to induce bio-stimulation, elastin production, and angiogenesis not only provides physiological remodeling of the extracellular matrix and dermal cell proliferation,³⁵ but also induces neocollagenesis,^{24–28} with improvement in dermal thickness as assessed by ultrasound.³⁶ The latter CaHA's property to induce collagen formation at injection sites, both in the deep supraperiosteal boluses and along the CaHA (+) strip that superficializes to the skin, provides long-term laxity correction. At the 2-month follow-up, the injected boluses accommodated into a linear strip, which was still visible in the one-year post-treatment ultrasound assessment corroborating the long-term results in previous studies which followed patients up to 3 years.³⁷ The re-treatment after 1 year induced a “build-up” in the previous collagenic support induced by the first CaHA (+) injection (Figure 7C). In addition to ZCL support, it is paramount to customize treatment according to the laxity patterns. For instance, when also skin atrophy is present, the association of diluted CaHA leads to a non-volumetric regenerative bio-stimulation, improving skin quality by increasing the collagen content of the skin (Case#3, Figure 3).

Finally, CaHA also has the advantage to not have the hydrophilic properties of hyaluronic acid (HA), being ideal for repositioning of facial soft tissues since it does not add extra volume to the injected area. In particular, when focusing on mid-face soft tissue repositioning, volume should be used with caution to avoid an overfilled face, which occurs when the volume of the mid-facial fat compartments together with the injected product are projected anteriorly when the patient smiles (Overfilled facial Syndrome).²⁰ In a recent comparison of the clinical aesthetic outcomes of treating the mid-face aging with same volume of CaHA or HA (Vycross; Juvederm Voluma, Allergan), HA presented a more volumizing effect, whereas CaHA presented a stronger lifting capacity³⁸ and better support overlying tissue, without the need for excess product volume.³⁸ Moreover, CaHA(+) provided better support, as well as more durable outcomes than an equal volume of HA, providing a higher value to the patient.

Conclusion

The proposed technique may be an alternative treatment option to address the mid-face by providing enhanced support to the zygomatic-cutaneous ligament with a versatile biostimulatory filler: CaHA can be used without dilution for more focal support and soft tissue repositioning, without adding extra-volume, or with different dilutions to provide a field effect (for skin quality improvement) and/or vector effect. Further studies with a larger number of patients should be performed to validate these results.

Acknowledgment

This research received no specific grants from any funding agency in the public, commercial, or not-for-profit sector. Medical writing and editorial assistance were provided by Dr. Danielle Shitara (Private Practice) and were supported by the Medical Affairs of Merz Aesthetics LATAM, through its affiliate Merz Farmaceutica Comercial Ltda, in accordance with the Good Publication Practice guidelines.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

Merz Aesthetics LATAM funded medical writing assistance and provided products to this study through its affiliate in Brazil – Merz Farmaceutica Comercial Ltda. Despite this support, this study was conducted with autonomy and independence by the medical authors, and Merz Farmaceutica Comercial, Ltda. had no participation or influence in designing, conducting, collecting, assessing, or evaluating the presented data.

Disclosure

Dr Sato and Dr Muniz have been speakers for Merz Pharmaceuticals. The authors report no other conflicts of interest in this work.

References

1. Alghoul M, Codner MA. Retaining ligaments of the face: review of anatomy and clinical applications. *Aesthet Surg J*. 2013;33(6):769–782. doi:10.1177/1090820X13495405
2. Baker S, Neil A. *Local Flaps in Facial Reconstruction*. St. Louis, MO: Mosby; 2007:340.
3. Wollina U. Facial rejuvenation starts in the midface: three-dimensional volumetric facial rejuvenation has beneficial effects on nontreated neighboring esthetic units. *J Cosmet Dermatol*. 2016;15(1):82–88. doi:10.1111/jocd.12175
4. Fitzgerald R, Carqueville J, Yang PT. An approach to structural facial rejuvenation with fillers in women. *Int J Womens Dermatol*. 2019;5(1):52–67. doi:10.1016/j.ijwd.2018.08.011
5. Caruso F, Villa R, Rossi M, et al. Mitochondria are primary targets in apoptosis induced by the mixed phosphine gold species chlorotriphenylphosphine-1,3-bis(diphenylphosphino)propanegold(I) in melanoma cell lines. *Biochem Pharmacol*. 2007;73(6):773–781. doi:10.1016/j.bcp.2006.11.018
6. Duan J, Cong LY, Luo CE, Luo SK. Clarifying the anatomy of the zygomatic cutaneous ligament: its application in midface rejuvenation. *Plastic Reconstr Surg*. 2022;149(2):198e–208e. doi:10.1097/PRS.00000000000008716
7. Mirontsev A, Andruschenko O, Vasil'ev Y, et al. Clinical anatomy of the ligaments of the face and their fundamental distinguishing features. *Medicina*. 2024;60(5):681. doi:10.3390/medicina60050681
8. Stuzin JM, Baker TJ, Gordon HL, Baker TM. Extended SMAS dissection as an approach to midface rejuvenation. *Clin Plast Surg*. 1995;22(2):295–311.
9. Reece EM, Pessa JE, Rohrich RJ. The mandibular septum: anatomical observations of the jowls in aging-implications for facial rejuvenation. *Plastic Reconstr Surg*. 2008;121(4):1414–1420. doi:10.1097/01.prs.0000302462.61624.26
10. Rossell-Perry P, Paredes-Leandro P. Anatomic study of the retaining ligaments of the face and applications for facial rejuvenation. *Aesthetic Plast Surg*. 2013;37(3):504–512. doi:10.1007/s00266-012-9995-x
11. Cotofana S, Fratila AA, Schenck TL, Redka-Swoboda W, Zilinsky I, Pavicic T. The anatomy of the aging face: a review. *Facial Plast Surg*. 2016;32(3):253–260. doi:10.1055/s-0036-1582234
12. Suwanchinda A, Webb KL, Rudolph C, et al. The posterior temporal supraSMAS minimally invasive lifting technique using soft-tissue fillers. *J Cosmet Dermatol*. 2018;17(4):617–624. doi:10.1111/jocd.12722
13. Mendelson BC, Freeman ME, Wu W, Huggins RJ. Surgical anatomy of the lower face: the premaseter space, the jowl, and the labiomandibular fold. *Aesthetic Plast Surg*. 2008;32(2):185–195. doi:10.1007/s00266-007-9060-3
14. Minelli L, Yang HM, van der Lei B, Mendelson B. The surgical anatomy of the jowl and the mandibular ligament reassessed. *Aesthetic Plast Surg*. 2022. doi:10.1007/s00266-022-02996-3
15. Wong CH, Mendelson B. Newer understanding of specific anatomic targets in the aging face as applied to injectables: aging changes in the craniofacial skeleton and facial ligaments. *Plastic Reconstr Surg*. 2015;136(5 Suppl):44S–48S. doi:10.1097/PRS.0000000000001752
16. Mendelson B, Wong CH. Changes in the facial skeleton with aging: implications and clinical applications in facial rejuvenation. *Aesthetic Plast Surg*. 2012;36(4):753–760. doi:10.1007/s00266-012-9904-3
17. Toledo Avelar LE, Cardoso MA, Santos Bordonni L, de Miranda Avelar L, de Miranda Avelar JV. Aging and sexual differences of the human skull. *Plast Reconstr Surg Glob Open*. 2017;5(4):e1297. doi:10.1097/GOX.0000000000001297
18. Cohen S, Artzi O, Mehrabi JN, Heller L. Vectorial facial sculpting: a novel sub-SMAS filler injection technique to reverse the impact of the attenuated retaining ligaments. *J Cosmet Dermatol*. 2020;19(8):1948–1954. doi:10.1111/jocd.13546
19. Cong LY, Duan J, Luo CE, Luo SK. Injectable filler technique for face lifting based on dissection of true facial ligaments. *Aesthet Surg J*. 2021;41(11):NP1571–NP1583. doi:10.1093/asj/sjaa348
20. Cotofana S, Gotkin RH, Frank K, Lachman N, Schenck TL. Anatomy behind the facial overfilled syndrome: the transverse facial septum. *Dermatol Surg*. 2019. doi:10.1097/DSS.0000000000002236
21. Schelke L, Harris S, Cartier H, et al. Treating facial overfilled syndrome with impaired facial expression-presenting clinical experience with ultrasound imaging. *J Cosmet Dermatol*. 2023;22(12):3252–3260. doi:10.1111/jocd.16013
22. Lim TS, Wanitphakdeedecha R, Yi KH. Exploring facial overfilled syndrome from the perspective of anatomy and the mismatched delivery of fillers. *J Cosmet Dermatol*. 2024;23(6):1964–1968. doi:10.1111/jocd.16244
23. Sundaram H, Voigts B, Beer K, Meland M. Comparison of the rheological properties of viscosity and elasticity in two categories of soft tissue fillers: calcium hydroxylapatite and hyaluronic acid. *Dermatologic Surg*. 2010;36(Suppl 3):1859–1865. doi:10.1111/j.1524-4725.2010.01743.x
24. Loghem JV, Yutskovskaya YA, Philip Werschler W. Calcium hydroxylapatite: over a decade of clinical experience. *J Clin Aesthet Dermatol*. 2015;8(1):38–49.
25. Dallara JM, Baspeyras M, Bui P, Cartier H, Charavel MH, Dumas L. Calcium hydroxylapatite for jawline rejuvenation: consensus recommendations. *J Cosmet Dermatol*. 2014;13(1):3–14. doi:10.1111/jocd.12074
26. Gonzalez N, Goldberg DJ. Evaluating the effects of injected calcium hydroxylapatite on changes in human skin elastin and proteoglycan formation. *Dermatologic Surg*. 2019;45(4):547–551. doi:10.1097/DSS.0000000000001809
27. Yutskovskaya YA, Sergeeva AD, Kogan EA. Combination of calcium hydroxylapatite diluted with normal saline and microfocused ultrasound with visualization for skin tightening. *J Drugs Dermatol*. 2020;19(4):405–411. doi:10.36849/JDD.2020.4625
28. Yutskovskaya Y, Kogan E, Leshunov E. A randomized, split-face, histomorphologic study comparing a volumetric calcium hydroxylapatite and a hyaluronic acid-based dermal filler. *J Drugs Dermatol*. 2014;13(9):1047–1052.
29. Swift A, Liew S, Weinkle S, Garcia JK, Silberberg MB. The facial aging process from the “inside out”. *Aesthet Surg J*. 2021;41(10):1107–1119. doi:10.1093/asj/sjaa339
30. Mendelson BC. Extended sub-SMAS dissection and cheek elevation. *Clin Plast Surg*. 1995;22(2):325–339. doi:10.1016/S0094-1298(20)30971-8

31. McKee D, Remington K, Swift A, Lambros V, Comstock J, Lalonde D. Effective rejuvenation with hyaluronic acid fillers: current advanced concepts. *Plastic Reconstr Surg*. 2019;143(6):1277e–1289e. doi:10.1097/PRS.0000000000005607
32. Mendelson BC, Jacobson SR. Surgical anatomy of the midcheek: facial layers, spaces, and the midcheek segments. *Clin Plast Surg*. 2008;35(3):395–404. doi:10.1016/j.cps.2008.02.003
33. Hirashima S, Ohta K, Kanazawa T, et al. Anchoring structure of the calvarial periosteum revealed by focused ion beam/scanning electron microscope tomography. *Sci Rep*. 2015;5:17511. doi:10.1038/srep17511
34. Casabona G, Frank K, Koban KC, et al. Lifting vs volumizing—the difference in facial minimally invasive procedures when respecting the line of ligaments. *J Cosmet Dermatol*. 2019;18:1237–1243. doi:10.1111/jocd.13089
35. de Almeida AT, Figueredo V, da Cunha ALG, et al. Consensus recommendations for the use of hyperdiluted calcium hydroxyapatite (Radiesse) as a face and body biostimulatory agent. *Plast Reconstr Surg Glob Open*. 2019;7(3):e2160. doi:10.1097/GOX.0000000000002160
36. Yutskovskaya YA, Kogan EA. Improved neocollagenesis and skin mechanical properties after injection of diluted calcium hydroxylapatite in the neck and décolletage: a pilot study. *J Drugs Dermatol*. 2017;16(1):68–74.
37. Bass LS, Smith S, Busso M, McClaren M. Calcium hydroxylapatite (Radiesse) for treatment of nasolabial folds: long-term safety and efficacy results. *Aesthet Surg J*. 2010;30(2):235–238. doi:10.1177/1090820X10366549
38. Durkin A, Lackey A, Tranchilla A, Poling M, Glassman G, Woltjen N. Single-center, prospective comparison of calcium hydroxylapatite and Vycross-20L in midface rejuvenation: efficacy and patient-perceived value. *J Cosmet Dermatol*. 2021;20(2):442–450. doi:10.1111/jocd.13881

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