Newer Understanding of Specific Anatomic Targets in the Aging Face as Applied to Injectables: Aging Changes in the Craniofacial Skeleton and Facial Ligaments

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Summary: Logical correction of aging contour changes of the face is based on understanding its structure and the processes involved in the aging appearance. Aging changes are seen at all tissue levels between the skin and bone although the relative contribution of each component to the overall change of facial appearance has yet to be satisfactorily determined. Significantly, the facial skeleton changes profoundly with aging as a consequence of significant resorption of the bones of dental origin in particular. The resultant loss of skeletal projection gives the visual impression of descent while the reduced ligamentous support leads to laxity of the overlying soft tissues. Understanding the specific changes of the face with aging is fundamental to achieving optimum correction and safe use of injectables for facial rejuvenation. (*Plast. Reconstr. Surg.* 136: 44S, 2015.)

An evolution is occurring with the use of fillers similar to that in the formative years of surgical rejuvenation of the face, when the empiric approach leads to the "pulled look" from direct tightening of the skin. In both, real progress awaited the change to an anatomical approach.[1–3] This enables improved results while avoiding an artificial look. Performing an anatomically logical correction is based on replicating the youthful structure of the face and reversing, as best possible, the processes leading to the appearance of aging.

Aging of the face results from changes of both the soft-tissue envelope and the underlying facial skeleton.[4,5] Although clearly interrelated, there is not yet sufficient information to know the relative contribution of each, including the variations in different regions of the face and among individuals. Although aging of the skin surface is largely from environmental factors, the skin tone and texture is affected by internal soft-tissue laxity and tissue ptosis.[6] This article is not on the various techniques of filler injecting, about which much has been written, but is about the anatomical basis, the foundation for logical use of injectables.

FACIAL ANATOMY IN LAYERS

The soft tissue of the face is significantly more complex than elsewhere in the body because of the active movement that occurs over and around the bony cavities, orbital, and oral, in particular. This movement explains the muscle layer within the soft tissues that connects with the overlying skin. The muscle layer is the middle of the 5-layer construct of the facial soft tissues. These layers are (1) skin, (2) subcutaneous layer, (3) musculoaponeurotic, (4) subaponeurotic, containing ligaments and soft-tissue spaces, and (5) deep fascia.[3] The layers are interconnected and secured to the facial skeleton in specific areas by the network of retaining ligaments perpendicular to the layers and connect all layers to the deep fascia.[7] The deep fascia is the periosteum on the facial skeleton and the deep muscle fasciae (deep temporal and parotid-masseteric), where the skeleton is overlain by the masticatory structures.

Aging changes are seen in all layers of the facial soft tissue, as well as in the skeleton. There is a general thinning of the superficial layers and weakening of the retinacula cutis structure in the subcutaneous tissue with fat pad atrophy.[8] The reduction of volume of the face leads to a

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reduction of tissue tone and with that laxity of the retaining ligaments. Injectables should therefore be placed in the most appropriate level using techniques that are most suitable for the specific level.

THE LIGAMENTS AND THE CRANIOFACIAL SKELETON

The major ligaments in their passage from their fascial origin to the superficial musculoaponeurotic system (SMAS) are robust and do not undergo significant primary aging changes.[9] Most of the ligament change is in the multiple finer retinacular ligament branches from the SMAS through the subcutaneous layer to the dermis, which are more prone to the being weakened over time by repetitive movement.

AGING CHANGES AND THE LIGAMENTS

The 2 major ligaments supporting the facial soft tissues, the zygomatic and mandibular, develop minimal if any laxity between their origin and their connection with the SMAS, although some weakening of the mandibular ligament occurs superficial to the SMAS. The next strongest ligaments, the upper masseteric over the accessory lobe of the parotid and the upper key masseteric ligament, also show minimal change, in contrast to the masseteric ligaments below the oral commissure, which being in the most mobile area associated with jaw opening, have a tendency to weaken and stretch relatively early in the aging process, although less so in Asian faces.

AGING CHANGES MAY BE PRIMARY OR SECONDARY

Aging changes are seen, in varying degrees, in all the soft tissues, components at the multiple tissue levels. It is not yet well understood whether the changes occurring at a particular level are primary in that level or secondary to the changes that occur in the level immediately below. Because changes in one level impact on adjacent levels, it is logical to focus the correction on the level where the primary changes occur, which may also contribute to the improvement of the secondary changes at other levels. The one level where primary changes have been convincingly demonstrated to occur is the underlying facial skeleton.[3,10,11]

CHANGES DEEPER THAN THE SOFT TISSUES

Although a significant diminution of the facial volume occurs beneath the deep fascia, the visual impact of this is seen in the overlying soft tissues. These deep changes result from bone loss, atrophy of masticatory muscle, and deep fat changes. The facial skeleton changes profoundly with aging due to significant resorption in certain areas (Fig. 1). The resultant loss of bony projection and support gives the visual impression of sagging or descent of the overlying soft tissues. Because the ligaments strongly connect the soft tissues to the skeleton, the effect of skeletal shrinkage is transmitted.

SPECIFIC CHANGES OF THE FACIAL SKELETON

The greatest change occurs in the bones of dental origin, the maxillae and mandible, which recede in their anterior aspect (Fig. 2). This explains why the mid cheek is the facial area of most change and at a relatively young age. The considerable decrease

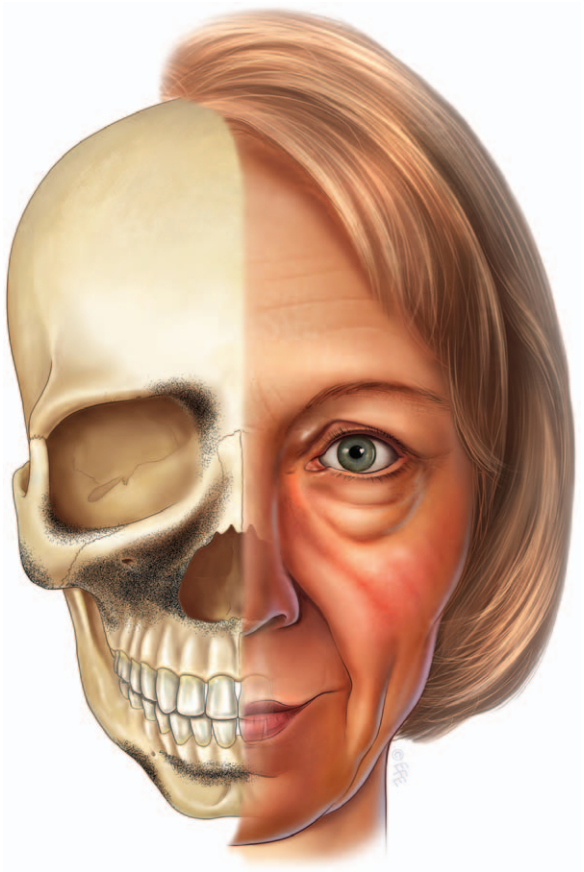

Fig. 1. The facial skeleton resorbs significantly with aging. This loss of support from the "foundation" of the face results in retrusion and "sagging" of the overlying soft tissues. Reprinted with permission from Dr. Bryan Mendelson & Dr. Chin-Ho Wong from Changes in the Facial Skeleton with Aging: Implications and Clinical Applications in Facial Rejuvenation. *Aesth Plast Surg* (2012) 36:753–760. ©2012 Mendelson, Wong.

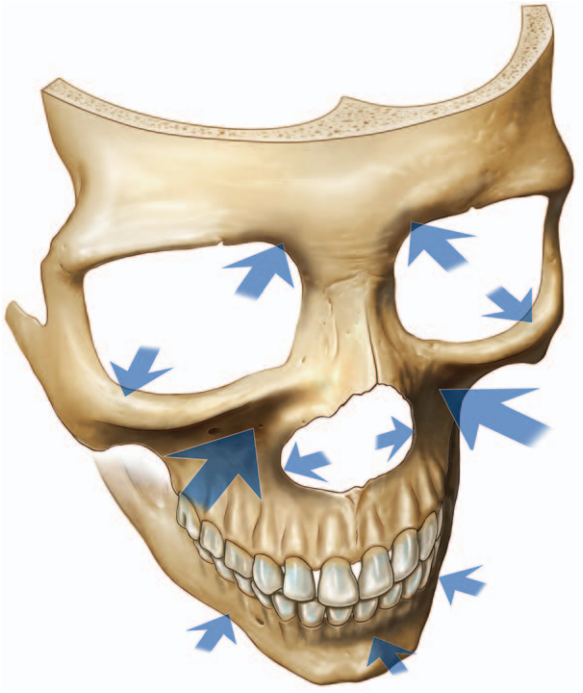

Fig. 2. The areas of the facial skeleton that selectively resorb with aging, with the size of the arrows indicating relative tendency for bone loss. These locations are the areas that should be specifically targeted for the use of injectables for skeletal augmentation. Reprinted with permission from Dr. Bryan Mendelson & Dr. Chin-Ho Wong from Changes in the Facial Skeleton with Aging: Implications and Clinical Applications in Facial Rejuvenation. *Aesth Plast Surg* (2012) 36:753–760. ©2012 Mendelson, Wong.

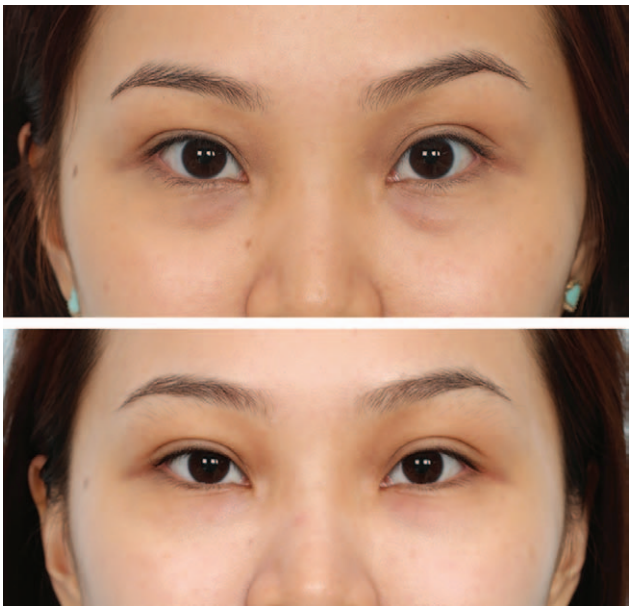

Fig. 3. A 26-year-old woman presents with eye bags and the complaints of looking tired. She has congenitally retruded maxilla with inadequate skeletal support. (*Above*) This resulted in premature manifestation of the eye bags and tired look. (*Below*) Correction achieved by preperiosteal (deep) placement of a soft hyaluronic acid filler (1 cc Restylane Vital Light) below the tear trough ligament to restore skeletal. A soft filler is preferred in for correction of the tear troughs to reduce palpability in this area of thin soft tissues.

of the maxillary angle, by about 10 degrees between young (less than 30) and old (over 60 years of age), results in significant loss of support for the soft tissues below the inferior orbital rim.[12,13] Although the changes of the bone projection are small, the impact is disproportionate because the overlying soft tissue of the lid cheek area is thinner and finer than elsewhere.[13,14] In addition, the orbital rim aperture undergoes change, with recession of the superomedial and inferolateral aspects, although this could reflect rounding of the edge of the rim.[12] Significantly, these changes reduce support of the orbital contents.

Enlargement of the piriform aperture from recession of the medial free edge of the maxilla results in posterior displacement of the alar base (relative to the fixed medial canthus). Deepening of the nasolabial groove also follows the bone loss here, although previously attributed solely to soft-tissue laxity and descent.

A reduction of all the mandibular proportions occurs, other than bigonial width. The reduction of both the posterior ramus height and the body length explains the increased obtuseness of the mandibular angle. Not unexpectedly, the soft-tissue support of the lower face is affected. In addition, specific stigmata may appear, such as the prejowl sulcus.[15–17]

CORRECTION OF SKELETAL SHRINKAGE

It is fundamental to appreciate that the reduction of anterior projection of the aging facial skeleton takes place immediately beneath the periosteum (layer 5), which being attached to the bone surface recedes with the bone and carries any ligamentous origins on it. That is, ligament origins recede with the bone. The ideal correction is to place appropriate "material" immediately subperiosteal to restore the missing volume, which in the process repositions the overlying periosteum and any ligament origins.[18] In practice, this is performed surgically by placing implants of various types.[19–25] When the pocket for the implant is being developed, the dissection of the periosteum off the surface of the resorbed bone results in the periosteum being elevated to its original, or higher position, where it becomes stabilized

Fig. 4. (*Above*) The patient presented with the eye bags and was not keen on surgery; 3 cc of fillers (1 cc Juvéderm Volbella over the tear trough, 1 cc of Juvéderm Ultra anterior maxilla, and 1 cc of Juvéderm Voluma over the zygoma) was used for maxilla and cheek augmentation. (*Below*) Six months after the treatment.

by resting on the surface of the implant. Unfortunately, it requires surgery for this subperiosteal dissection, which is not possible with the needle/cannula injections used in filler placement. The nearest possible nonsurgical procedure is to place the filler deep in the supraperiosteal plane. However, the effect is not the same, as it does not provide the secondary benefit of the subperiosteal volume in elevating the origins of the ligament and muscle, simultaneously with the periosteum elevation. This outward positioning provides the benefit of improving facial shape through the muscle and ligament vectors lower in the face.

This explains why deep filler placement, although effective to a degree, does not rejuvenate the way subperiosteal volume placement does. An example is the correction of the tear trough, where a small to moderate volume of deep filler inferior to the tear trough ligament improves the soft-tissue projection and effectively reduces sag of the orbicularis inferior to the ligament (Figs. 3 and 4).[26] This is up to the point that any posterior positioning of the now-tightened ligament limits the benefit. Similarly, in the treatment of deep

Fig. 5. (*Left*) The patient presents for full face rejuvenation with injectables. The Fortélis range for fillers was used. She was treated with 1 cc of filler in each temple, 1 cc in each mid cheek, 1 cc in the nasolabial folds and piriform aperture, and 1 cc in the nose (6 cc in total). (*Right*) Two months after the treatment.

nasolabial groove hollowing, a certain amount of deep filler provides effective camouflage, while it cannot replicate the effect of implants that elevate posteriorly positioned medial maxillary ligaments adjacent to the piriform aperture (Fig. 5).

CONCLUSIONS

The facial skeleton is an important specific target for volume replacement because significant bone shrinkage occurs, whose impact extends through to the overlying soft tissues. Because this contributes to the stigmata of the aging face, the filler practitioner should consciously address the primary aging changes of the skeletal foundation rather than simply filling the area. Deep filler injections correct some of the soft-tissue impact of moderate bone resorption and with lower risk than traditional, more superficial injections.

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PATIENT CONSENT

Patients provided written consent for the use of their images.

REFERENCES

1. Furnas DW. The retaining ligaments of the cheek. *Plast Reconstr Surg.* 1989;83:11–16.
2. Stuzin JM, Baker TJ, Gordon HL. The relationship of the superficial and deep facial fascias: relevance to rhytidectomy and aging. *Plast Reconstr Surg.* 1992;89:441–449; discussion 450.
3. Mendelson BC, Wong CH. Anatomy of the aging face. Ch. 6. Volume 2 Aesthetic. In: Warren RJ, Neligan PC, eds. *Plastic Surgery.* 3rd ed. Elsevier; 2013:79–92.
4. Sharabi SE, Hatef DA, Koshy JC, et al. Mechanotransduction: the missing link in the facial aging puzzle? *Aesthetic Plast Surg.* 2010;34:603–611.
5. Mendelson B, Wong CH. Changes in the facial skeleton with aging: implications and clinical applications in facial rejuvenation. *Aesthetic Plast Surg.* 2012;36:753–760.
6. Lambros V. Models of facial aging and implications for treatment. *Clin Plast Surg.* 2008;35:319–327; discussion 317.
7. Wong CH, Mendelson B. Facial soft-tissue spaces and retaining ligaments of the midcheek: defining the premaxillary space. *Plast Reconstr Surg.* 2013;132:49–56.
8. Rohrich RJ, Pessa JE. The fat compartments of the face: anatomy and clinical implications for cosmetic surgery. *Plast Reconstr Surg.* 2007;119:2219–2227; discussion 2228.
9. Brandt MG, Hassa A, Roth K, et al. Biomechanical properties of the facial retaining ligaments. *Arch Facial Plast Surg.* 2012;14:289–294.
10. Enlow DH. A morphogenetic analysis of facial growth. *Am J Orthod.* 1966;52:283–299.
11. Bartlett SP, Grossman R, Whitaker LA. Age-related changes of the craniofacial skeleton: an anthropometric and histologic analysis. *Plast Reconstr Surg.* 1992;90:592–600.
12. Kahn DM, Shaw RB Jr. Aging of the bony orbit: a three-dimensional computed tomographic study. *Aesthet Surg J.* 2008;28:258–264.
13. Mendelson BC, Hartley W, Scott M, et al. Age-related changes of the orbit and midcheek and the implications for facial rejuvenation. *Aesthetic Plast Surg.* 2007;31:419–423.
14. Pessa JE, Chen Y. Curve analysis of the aging orbital aperture. *Plast Reconstr Surg.* 2002;109:751–755; discussion 756.
15. Pessa JE, Slice DE, Hanz KR, et al. Aging and the shape of the mandible. *Plast Reconstr Surg.* 2008;121:196–200.
16. Fattahi T. The prejowl sulcus: an important consideration in lower face rejuvenation. *J Oral Maxillofac Surg.* 2008;66:355–358.
17. Shaw RB, Katzel EB, Koltz PF, et al. Aging of the mandible and its aesthetic implications. *Plast Reconstr Surg.* 2010:125:332.
18. Whitaker LA, Bartlett SP. Skeletal alterations as a basis for facial rejuvenation. *Clin Plast Surg.* 1991;18:197–203.
19. Terino EO. Alloplastic facial contouring: surgery of the fourth plane. *Aesthetic Plast Surg.* 1992;16:195–212.
20. Terino EO, Flowers RS. *The Art of Alloplastic Facial Contouring.* St. Louis, Mo.: Mosby; 2000.
21. Yaremchuk MJ. Facial skeletal reconstruction using porous polyethylene implants. *Plast Reconstr Surg.* 2003;111:1818–1827.
22. Yaremchuk MJ. *Atlas of Facial Implants.* Philadelphia, Pa.: Elsevier; 2007.
23. Waite PD, Matukas VJ. Zygomatic augmentation with hydroxylapatite: a preliminary report. *J Oral Maxillofac Surg.* 1986;44:349–352.
24. Byrd HS, Hobar PC, Shewmake K. Augmentation of the craniofacial skeleton with porous hydroxyapatite granules. *Plast Reconstr Surg.* 1993;91:15–22; discussion 23.
25. Mendelson BC, Jacobson SR, Lavoipierre AM, et al. The fate of porous hydroxyapatite granules used in facial skeletal augmentation. *Aesthetic Plast Surg.* 2010;34:455–461.
26. Carruthers JD, Glogau RG, Blitzer A; Facial Aesthetics Consensus Group Faculty. Advances in facial rejuvenation: botulinum toxin type a, hyaluronic acid dermal fillers, and combination therapies–consensus recommendations. *Plast Reconstr Surg.* 2008;121(5 Suppl):5S–30S; quiz 31S.