Comparative Study of Conventional and Bevel Down Injection Techniques for Temple Augmentation

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The temple area is a critical site for aesthetic interventions due to its complex vascular and structural anatomy, necessitating techniques that minimize the risk of intravascular injections and associated complications such as vascular occlusion and blindness. This study compared perpendicular and oblique (bevel down) injection techniques using PCL(Polycaprolactone) fillers in cadaveric specimen, focusing on the distribution of the filler materials and three-dimensional elevation pattern.

A single cadaver head was utilized for a controlled study where PCL fillers were injected using a perpendicular technique on the left temple and an oblique technique on the right. Real-time ultrasound imaging was conducted during the injections to monitor filler placement. Pre- and post-injection volumetric changes were assessed through 3D scanning. Scanned data was rigidly aligned and restricted to the temple area for the shape analysis. Following preprocessing, the morphological changes resulting from two different injection methods were visualized separately as heatmaps, and their volumes were compared using superimposition of principal component analysis (PCA) result. The final filler distribution was verified through anatomical dissection.

Ultrasound imaging revealed that the oblique (bevel down) method facilitated a more uniform and extensive distribution of filler along the bone surface compared to the perpendicular method. The heatmap results from the 3D analysis indicated that the bevel-down method achieves a more uniform distribution of filler compared to the perpendicular injection. Additionally, the scatter plot derived from PCA results provided further evidence that the bevel-down method enables more even filler distribution over a broader area. Anatomical dissection confirmed a similar distribution pattern, showing a uniform dispersion of filler close to the bone surface, aligning closely with the ultrasound findings.

The bevel down injection technique offers a safer and more predictable distribution of filler material. By maintaining a consistent distance from potential vascular structures, this method potentially reduces the risk of intravascular complications, making it preferable for use in the anatomically complex temple area. The findings from both ultrasound, 3D analysis, and anatomical dissection support the adoption of the oblique technique in clinical practice to enhance safety and aesthetic results in non-surgical facial rejuvenation.

Keywords: Temple augmentation, PCL fillers, cadaver study, bevel down injection technique, ultrasound imaging, 3D scanning, minimally invasive procedure.

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I. Introduction

Temple augmentation has become increasingly significant in aesthetic medicine due to its crucial impact on facial harmony and youthful appearance. As individuals age, the temporal region often undergoes noticeable changes, including soft tissue atrophy, leading to a hollow or sunken appearance. This change can contribute to an aged and fatigued look, leading many patients to pursue cosmetic interventions to restore volume and achieve a more rejuvenated appearance (Breithaupt et al., 2015, Chundury et al., 2015, Kim et al., 2024).

The demand for temple augmentation is reflective of broader trends in cosmetic medicine. According to the American Society of Plastic Surgeons (ASPS), there has been a notable increase in the number of minimally invasive cosmetic procedures performed annually. In 2020, despite the disruptions caused by the COVID-19 pandemic, the ASPS reported a high volume of cosmetic procedures, with a substantial proportion being minimally invasive treatments. Soft tissue fillers, including those used for temple augmentation, ranked among the top five minimally invasive procedures performed, with millions of cases recorded annually. The preference for minimally invasive procedures is driven by the desire for natural-looking results and the avoidance of extensive surgical interventions (Statistics, 2020).

The temporal fossa, a shallow depression on the lateral aspect of the skull, is bounded superiorly by the superior temporal line, anteriorly by the frontal process of the zygomatic bone, and inferiorly by the zygomatic arch. This area exhibits a complex layered structure, comprising multiple distinct anatomical layers, and is richly vascularized with various clinically critical blood vessels (Kim et al., 2024).

The temple area exhibits a complex layered structure, arranged in the following order from superficial to deep: skin (epidermis and dermis), subcutaneous layer, superficial temporal fascia, subSMAS (sub superficial musculoaponeurotic system) fat layer, superficial layer of deep temporal fascia, temporal fad pad, deep layer of deep temporal fascia, temporal extension of buccal fat pad, temporalis muscle (superficial and deep), and bony surface. Each of these layers contains critical vascular and neural structures, which are crucial for both aesthetic and functional outcomes in medical interventions.

The complex network of arteries and veins supplies blood to the various anatomical layers, playing a pivotal role in maintaining homeostasis and clinical approaches. Proper knowledge of this vascular anatomy is essential for performing safe and effective interventions, such as filler injections, to avoid complications like vascular occlusion and subsequent tissue necrosis or blindness.

The temple area is particularly challenging due to its complex anatomy, which includes multiple layers of tissue and critical vascular structures. These factors necessitate advanced techniques and materials to ensure both effective and safe outcomes. The increasing prevalence of minimally invasive procedures, combined with the pursuit of natural aesthetic outcomes, has driven the demand for effective temple augmentation techniques (Nakajima et al., 1995, Raspaldo, 2008).

The superficial temporal artery (STA) is one of the terminal branches of the external carotid artery. It arises within the parotid gland and ascends over the zygomatic arch, branching out to supply the scalp and the superficial structures of the temple and forehead. The STA can be palpated as it crosses the zygomatic arch, making it a crucial landmark in the temple area (Kim et al., 2024, Nakajima et al., 1995). The STA is located within the superficial temporal fascia, which makes it accessible but also vulnerable during aesthetic procedures. It further divides into frontal and parietal branches, which supply the anterior and posterior scalp respectively (Kim et al., 2024, Nakajima et al., 1995).

The deep temporal arteries, consisting of the anterior and posterior branches (anterior deep temporal artery, ADTA; posterior deep temporal artery, PDTA), supplies deep portion of the temporalis muscle. These arteries originate from the maxillary artery, the branch of the external carotid artery, and ascend between the temporalis muscle and the bony surface of the temporal fossa. The ADTA typically courses anteriorly within the temporalis muscle, while the PDTA runs more posteriorly, supplying the posterior segment of the temporalis muscle. According to Bae et al., the depth of the DTAs from the bone varies significantly, which is crucial for avoiding vascular complications during augmentation procedures. This study identified a relatively safe zone for deep temple augmentation procedures at the level of the zygomatic tubercle. The area 1 cm posterior to the zygomatic tubercle was found to be free from the ADTA and PDTA, making it a safer region for deep filler injections. However, no such safe zone was identified at the level of the eyebrow, where the DTAs showed considerable variability in their locations (Bae et al., 2023).

Previous studies have demonstrated the effectiveness of using advanced imaging techniques, such as real-time ultrasound and 3 dimensional (3D) scanning, to enhance the safety and precision of filler injections. These techniques allow for the visualization of filler distribution and the avoidance of critical structures during the procedure (Kim et al., 2024). However, there remains a lack of consensus on the optimal injection technique for temple augmentation, particularly regarding the angle and approach of needle insertion (Müller et al., 2021).

This study addresses this gap by comparing the distribution patterns and safety profiles of PCL(polycaprolactone) fillers using two different injection techniques: perpendicular (vertical) and oblique (bevel down) methods. By utilizing a controlled cadaveric model and employing advanced imaging modalities, we aim to provide a comprehensive analysis of the morphological changes induced by each technique. The findings from this study will contribute to evidence-based practices in aesthetic medicine, enhancing the safety and efficacy of non-surgical facial rejuvenation procedures.

II. Materials and Methods

Subjects and Injection method

The cadavers used in the present study were legally donated to institutes and subjected to dissection of the temple area after receiving approval from the Surgical Anatomy Education Center, Yonsei University College of Medicine. The subjects had provided consent for donating their bodies for research purposes. The authors state that every effort was made to follow all local and international ethical guidelines and laws that pertain to the use of human cadaveric donors in anatomical research (Iwanaga et al., 2022).

The conventional perpendicular and the oblique bevel-down injection approaches were compared using two hemifaces from one 58-year-old male Korean cadaver. A commercial PCL filler material (Lafullen, Samyang Holdings Co., South Korea), for its visible color, was used in this study. The PCL filler (1.0 ml) was injected into each side via a 23-gauge needle. The same injector performed both injections to ensure consistency.

For the left temple, the needle was introduced perpendicularly to the temporalis muscular plane, 1 cm posterior to the zygomatic tubercle, and stopped only when the injector felt the needle tip touch the bone. This approach follows established anatomical guidelines that recommend targeting this specific area to avoid critical vascular structures and ensure precise filler placement (Bae et al., 2023). The bolus of filler was then injected.

For the right temple, the oblique technique was used. The bevel-up needle was placed more superior and posterior compared to the left side, at an angle of approximately 45 degrees relative to the temporalis muscular plane. When the bone was felt, the injector rotated the needle 180 degrees, resulting in the bevel-down tip at the periosteum level. The bolus of filler was then injected (**Figure 1A, B**).

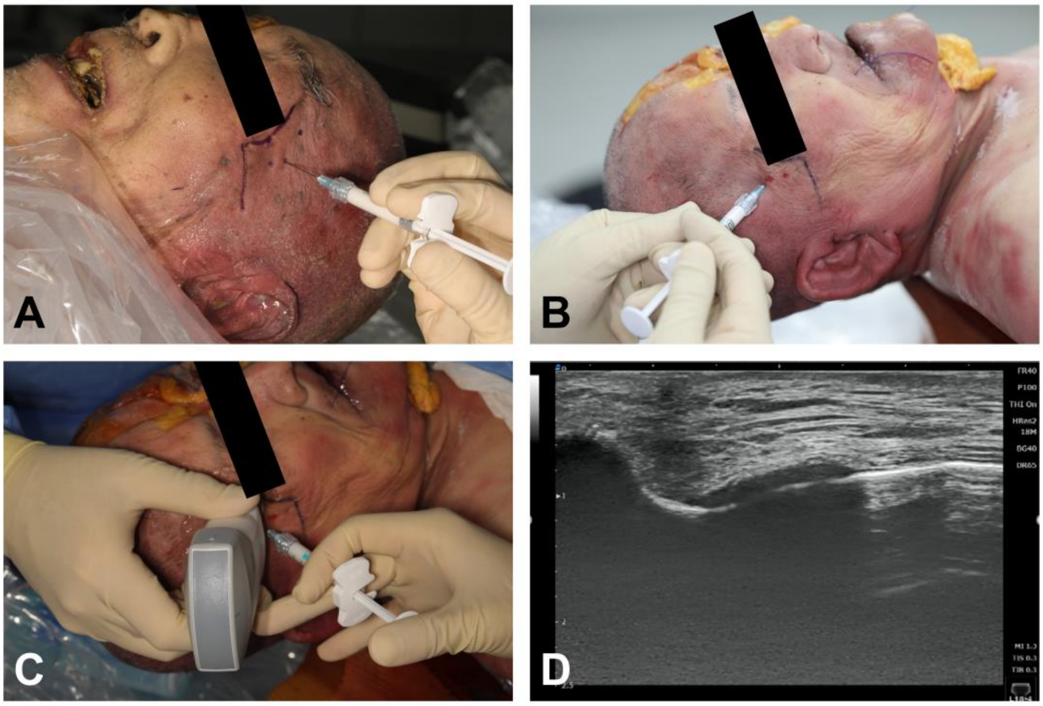

Figure 1. Injection procedures and ultrasound guidance for temple augmentation using PCL fillers.

(A) Perpendicular injection technique on the left temple (B) Oblique bevel-down injection technique on the right temple (C) Ultrasound-guided injection process (D)

Ultrasonographic image during the injection (B mode, transverse view, 15-MHz linear transducer)

During each injection process, ultrasound-guided injection was performed to confirm the position of the filler material (**Figure 1C, 1D**). Both cadaveric temples were analyzed using three methods: 3D scanning, ultrasound imaging, and dissection.

Part I: Three-dimensional Morphological Analysis

Three-dimensional (3D) scanning of a cadaver was conducted using Artec Space Spider 3D scanner (Artec 3D), which is renown for its high precision and resolution due to its blue light technology. The scanned data were subsequently used to evaluate the effects of different filler injection techniques. The cadaver was positioned supine on a dissecting table to facilitate an unobstructed scan of the anterior and lateral sections of the head, including the temple area. This positioning was crucial to maintain consistency and minimize movement during the scanning process. The Artec Studio 15 software (Artec 3D) was employed to remove noise and surrounding artifacts from the scans. The initial scan data were then exported in Polygon File Format (.ply). 3D scanning was conducted pre- and post-injection mentioned in Part I.

Data preprocessing

The data obtained through scanning may have intense noise or redundant mesh components irrelevant to anatomical features (ShapeWorks, 2024). Therefore, preprocessing is crucial to eliminate potential interference and to prepare data suitable for shape analysis and modeling. Preprocessing could be categorized into two primary processes: rigid registration and mesh cleaning.

Rigid registration

Both pre- and post-injection scan data underwent rigid alignment using Fiducial Registration Wizard module of software SlicerSALT (version 4.0.1, Kitware). Rigid alignment is a process where two or more different sets of points or shapes in different positions and orientations are aligned to match each other closely as possible through a combination of translation and rotation (Zelditch et al., 2004a). This process is important for accurate morphological analysis, as the failure to do so may result in positional discrepancies being distorted as morphological differences. In this study, total eight, clearly discernible landmarks were designated to align post-injection scan to pre-injection scan (**Figure 2**).

Mesh cleaning

Mesh cleaning was performed using the open-source 3D point cloud software CloudCompare (version 2.13), downloaded from (https://www.cloudcompare.org/). During this process, the rigidly aligned meshes were superimposed. Using the Segmentation module, redundant mesh components were removed again. Subsequently, the region of interest (ROI) was confined to the temple area using the same module. This allowed for a more precise morphological analysis of the temple by eliminating other parts of the head (**Figure 3**).

Figure 2. Initial landmarks employed for rigid registration. Landmarks that were discernable were designated. Designated landmarks are as follows: medial canthus (1), outer canthus (2), labial commissure (3), and otobasion inferius (4). While landmarks were depicted soley on the left side of the figure, they were also designated at equivalent locations on the right side.

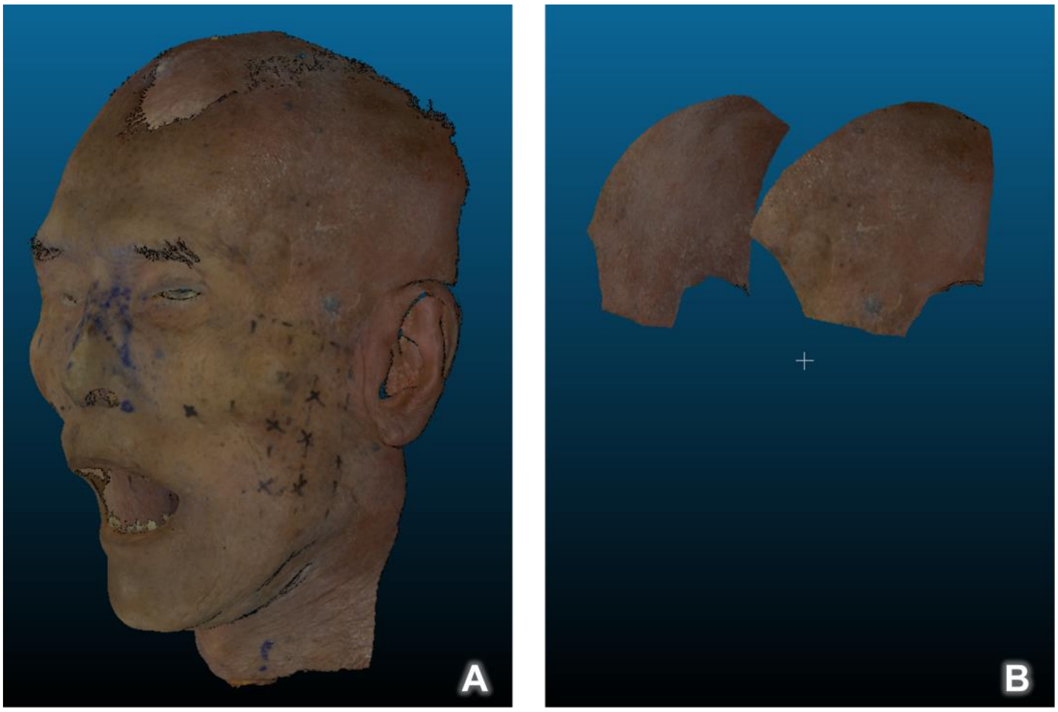

Figure 3. Rigidly aligned pre- and post- injection scan data (1). Region of interest confined to temple area by segmenting from original scan data (2).

Morphological Analysis

After preprocessing, the morphological changes of the temple after filler injection were analyzed in two ways: 3D mesh comparison and principal component analysis (PCA). Both procedures were done using CloudCompare (version 2.13).

3D mesh comparison

The Cloud-to-Mesh Distance tool in CloudCompare was employed to compute the distance between the vertices of the post-injection mesh (Compared mesh) and the nearest polygons of the pre-injection mesh (Reference mesh). This tool calculates the shortest distance from each vertex to the closest point on the mesh surface and visualizes these distances with color maps to highlight morphological deviations.

PCA

PCA is a statistical method used to reduce the complexity of high-dimensional data by transforming it into new coordinate system (Zelditch et al., 2004b). For PCA plotting, the left and right sides were segmented from the mesh confined to the ROI, and PCA analysis was conducted with PCA tool of CloudCompare. The results were exported in ASCII Polygon File Format, enabling the extraction of spatial distances between pre- and post-injection data for the first and second principal components (PCs).

These spatial distances were then visualized using scatter plots created with Python′s matplotlib library. Initially, scatter plots for the first and second PCs were generated for both left and right respectively to comprehend the shape patterns of each injection method. Subsequently, to compare the shape patterns of the different injection methods, the median of the PCA plot, which is located at different positions, were translated to the origin.

Part II: Ultrasonographic Analysis

For both the left (perpendicular) and right (bevel down) injection procedures, ultrasound-guided injections were performed to ensure precise placement of the filler material. The location of the filler material was monitored in real-time and recorded using a two-dimensional B-mode ultrasound device with a high-frequency (18 MHz) linear transducer (Sonimage HS1, KONICA MINOLTA, Tokyo, Japan).

The ultrasound gel (SONO JELLY, MEDITOP Corporation, Youngjin, Korea) was thickly applied to the skin surface to avoid exerting pressure on the tissues, ensuring accurate visualization without compression. During imaging, the transducer was positioned transversely to the injection site. At each reference point and line, the transducer was oriented so that the left side of the image indicated the direction of medial or superior. Ultrasound recordings were captured as continuous video format, which enabled the detailed analysis of the filler injection dynamics over time.

Part III: Cadaveric Dissection study

Following the injection procedures, a meticulous dissection study was conducted to evaluate the precise placement and distribution of the filler material within the anatomical structures of the temporal fossa. The dissection process began with a careful incision and retraction of the skin to expose the underlying subcutaneous tissue. Next, the subcutaneous tissue was gently dissected to reveal the superficial temporal fascia. This fascia was then meticulously lifted to access the subSMAS fat layer. Each layer was sequentially lifted in layer-by-layer manner and examined for the presence of the injected filler material.

After the dissection of the superficial layers, the deep temporal fascia was exposed and carefully removed. The temporalis muscle was then exposed and dissected with precision to identify the filler material within the muscle tissue. The position and distribution of the filler material within the temporalis muscle were meticulously recorded.

III. Results

Part I: Three- dimensional Morphological Analysis

Three-dimensional (3D) mesh comparison

The morphological changes in the left (perpendicular method) and right (oblique method) temple regions after filler injection were depicted (Figure 4). The regions with significant volume changes, indicated in red, are more extensive with the perpendicular injection compared to the oblique injection. This broader distribution occurred primarily in the anterior-posterior direction rather than the superior-inferior direction. Moreover, the heat map for the perpendicular method showed a smaller orange region between the yellow and red areas, indicating a more abrupt increase in volume. Conversely, the oblique method displayed a wider orange region, suggesting a more gradual volume increase compared to the perpendicular method. (Figure 4)

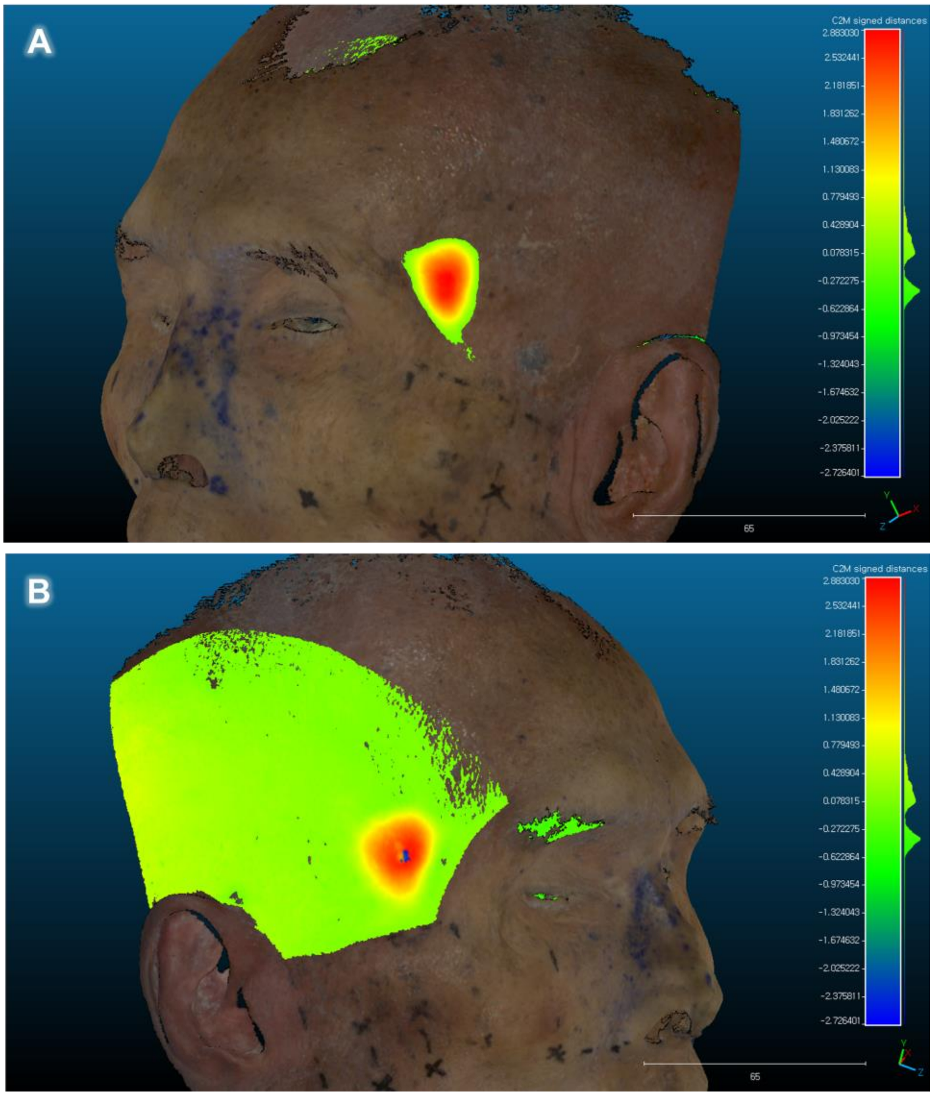

Figure 4. Filler injected perpendicularly (1) and obliquely (2). The extent of the change increases from blue to the most significant changes concentrated in red. The oblique injection of filler (2) demonstrates a more uniform distribution compared to the perpendicular injection (1).

Principal component analysis (PCA)

The extracted principal components (PCs) provide insight into the various morphological changes between pre- and post-injection scans. The first PC captures the direction of the highest variance in the data, followed by the second PC. In this study, PC 1 illustrates how the shape of the temple changes along the coronal plane after injection, while PC 2 reveals the shape changes in the transverse plane. On the scatter plot of each PC, the overlap of volume patterns from two different injection methods allows for instant comparison.

Firstly, the volume patterns of the perpendicular and oblique methods were compared in the coronal section (**Figure 5**). There were no significant differences in the height of the volume, although it appeared slightly higher with the perpendicular method. However, a notable morphological difference was observed in the width of the volume. The slope of the oblique method (red) exhibited a more gradual inclination, suggesting a more uniform dispersion of the filler by this method.

Secondly, the volume patterns of the two methods were also compared in the transverse section (**Figure 6**). Similar to the pattern observed in the coronal section, the oblique method dispersed the filler over a wider range compared to the perpendicular method. However, it is noteworthy that, unlike in PC 1, the slope patterns on either side of the apex differed in the oblique method. While PC 1 exhibited nearly identical slopes on either side of the apex, in PC 2, one side showed a markedly gentler slope compared to the perpendicular method, whereas the opposite side displayed a slope almost similar to that of the perpendicular method. Thus, unlike in PC 1, the even distribution of filler in the oblique method is not evident, and it can be interpreted that it was rather unevenly injected. Conversely, although the perpendicular method exhibited a steeper slope in volume pattern, it could be considered to have a more uniform distribution instead.

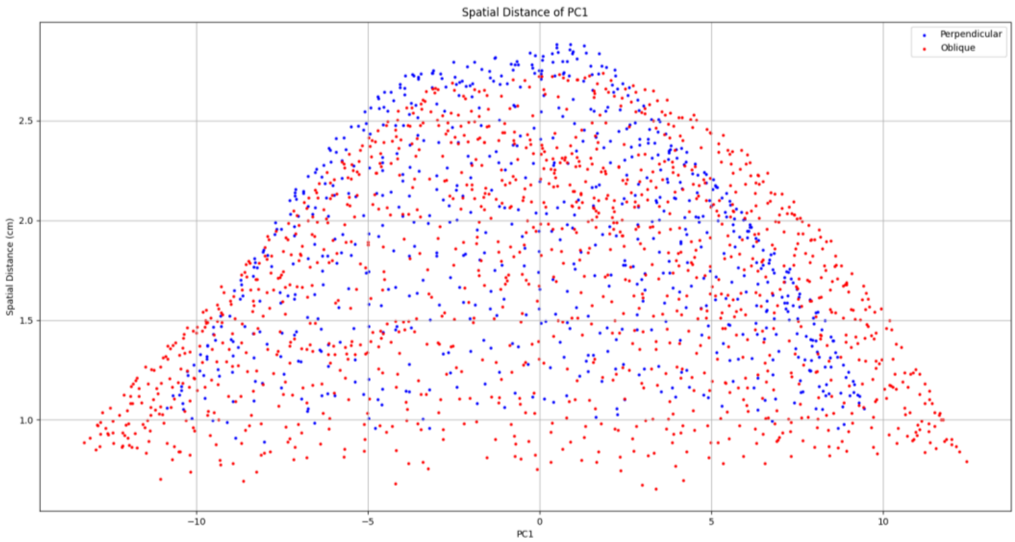

Figure 5. Volume pattern in the coronal plane (PC 1). Blue dots represent perpendicular injection, red dots represent oblique injection.

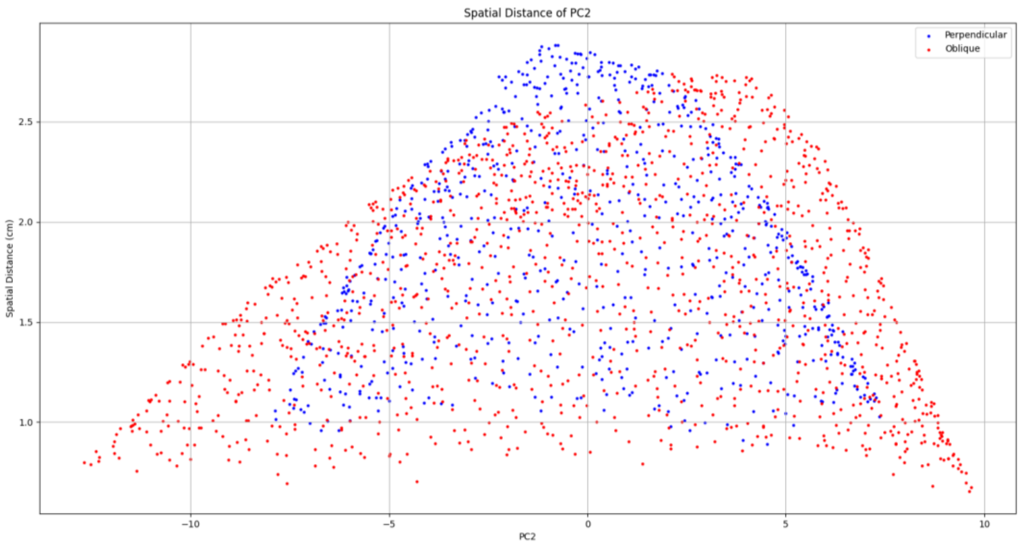

Figure 6. Volume pattern in the transverse plane (PC 2). Blue dots represent perpendicular injection, red dots represent oblique injection.

Part II: Ultrasonic Analysis

The ultrasonographic analysis provided insights into the dynamic distribution patterns of the filler material over time for both the perpendicular and oblique bevel-down injection techniques, as illustrated in **Figure 7**. The PCL filler material appears as a anechoic band or area with a hyperechoic boundary.

The sequential images of the perpendicular injection on left side reveal that the filler material remains concentrated in a narrow area, indicating a localized and confined distribution. The filler does not spread extensively, resulting in a more abrupt and limited elevation profile (**Figure 7A-D**). On the other hand, the sequential images of the oblique bevel-down injection on the right side reveal that the filler material spreads more evenly and extensively along the periosteal surface. The filler material is positioned directly above the bone with minimal intervening tissue layers, indicating a closer and more uniform application of the filler along the periosteal surface. This extensive and uniform spread results in a broader and smoother elevation profile (**Figure 7E-H)**.

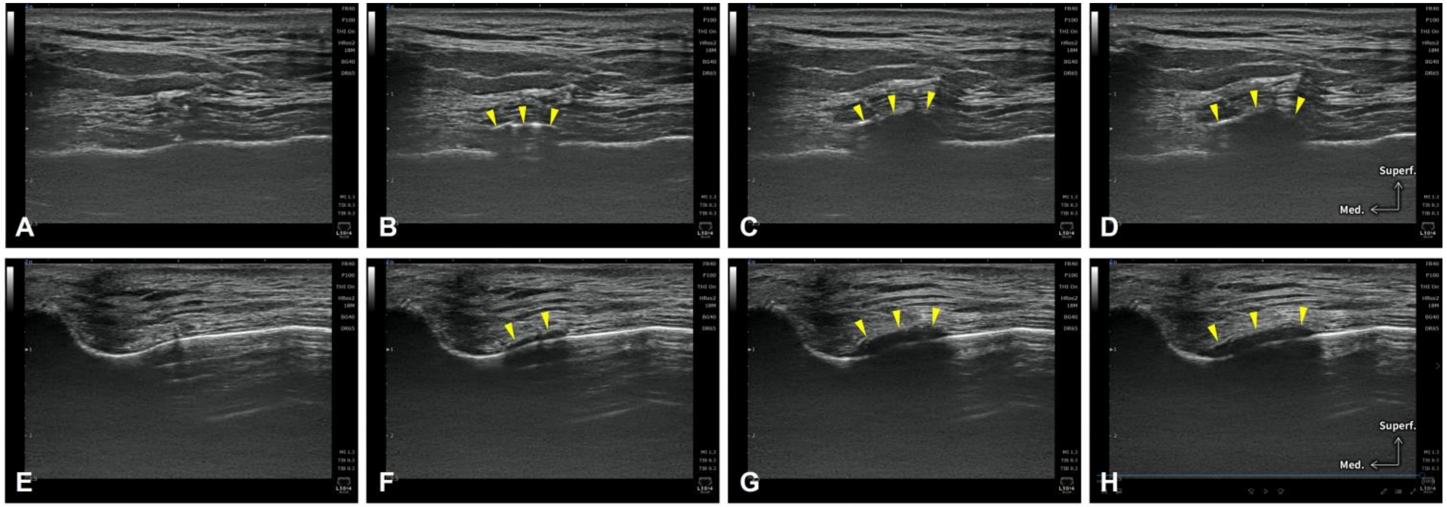

Figure 7. Ultrasonographic sequential images of filler material distribution in the temple area using perpendicular and oblique bevel-down injection techniques.

(A-D) Sequential ultrasound images of the perpendicular injection on the left temple (B mode, transverse view, 15-MHz linear transducer) (E-H) Sequential ultrasound images of the oblique bevel-down injection on the right temple (B mode, transverse view, 15-MHz linear transducer)

The yellow arrowheads indicate the PCL filler material bolus.

Part III: Cadaveric dissection study

The cadaveric study revealed distinct differences in the distribution and elevation patterns of the filler material between the perpendicular and oblique (bevel-down) injection techniques, as illustrated in **Figure 8**.

Perpendicular injection on the left temple resulted in a more localized and abrupt elevation of the tissue. This was characterized by a narrow and sharply elevated filler distribution, indicating a concentrated deposition of the material (**Figure 8A).** In contrast, the oblique bevel-down injection on the right temple produced a broader and more gradual elevation. The filler material spread more evenly across the area, demonstrating a smoother and wider distribution pattern (**Figure 8D**).

Furthermore, cross-sectional view of the injected sites provided additional insights. In the oblique bevel-down injection, the filler material was observed to be positioned directly above the bone, with minimal intervening tissue layers. This indicates a closer and more uniform application of the filler along the periosteal surface (**Figure 8E, 8F**). In comparison, the perpendicular injection left a noticeable layer of muscle tissue beneath the filler material, suggesting less precise placement relative to the bone surface (**Figure 8B,8C**)

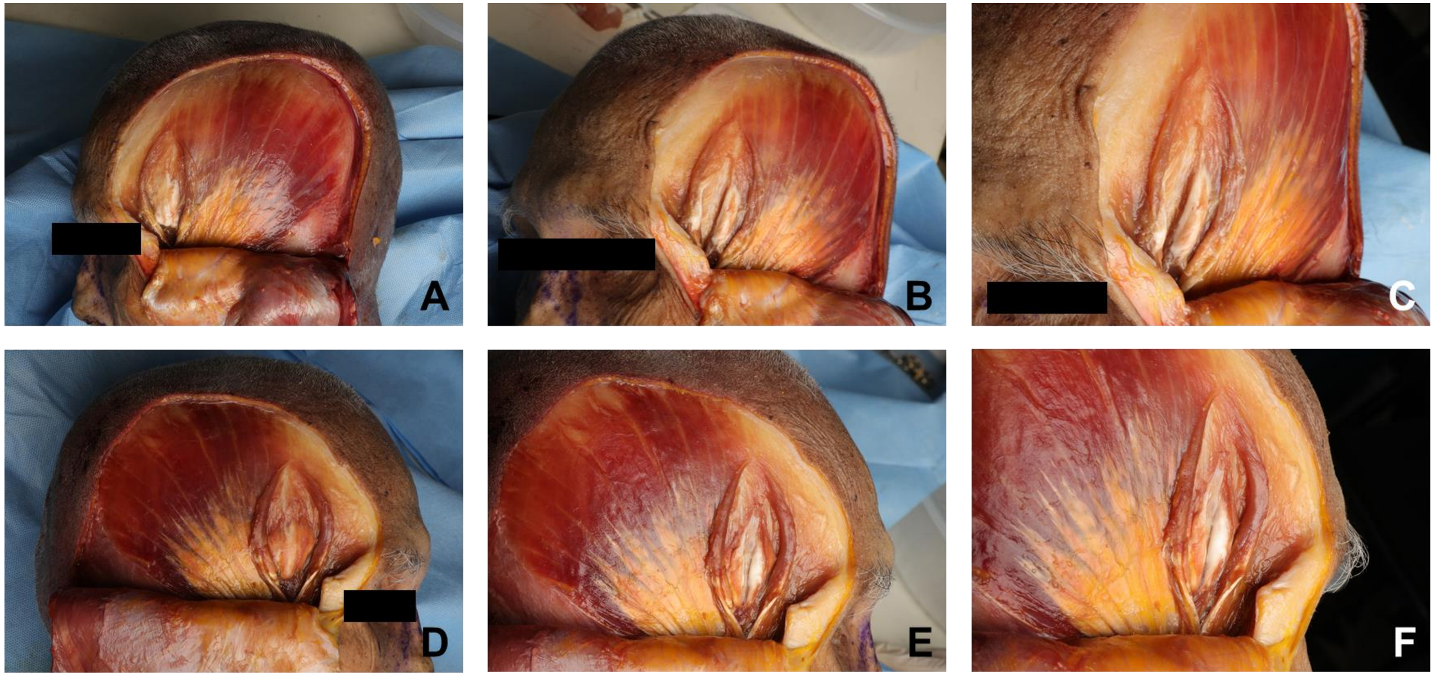

Figure 8. Distribution and cross-sectional analysis of filler material following perpendicular and oblique bevel-down injection techniques in a cadaveric study.

(A) Filler distribution of perpendicular injection on the left temple (B, C) Cross-sectional views of the left temple showing the filler distribution of perpendicular injection technique (D) Filler distribution of oblique bevel-down injection on the right temple (E, F) Cross-sectional views of the left temple showing the filler distribution of oblique bevel-down injection technique.

IV. Discussions

The temple area, with its complex vascular and anatomical structures, requires precise injection techniques to ensure safety and efficacy in aesthetic interventions. As individuals age, the loss of soft tissue in this region can lead to a sunken, aged appearance, prompting the demand for effective augmentation techniques. Traditional methods often include the use of superficial or subcutaneous injections, which involve placing the filler just beneath the skin or within the subcutaneous fat layer. These techniques allow for moderate volume restoration and are relatively safer due to their distance from deeper vascular structures (Cotofana et al., 2020, Müller et al., 2021). Another notable method involves injecting filler between the superficial temporal fascia and deep temporal fascia, which provides a stable and well-supported augmentation while avoiding the deeper vascular structures that pose higher risks, though accurately positioning the filler in this layer requires considerable experience and skill (Kim et al., 2024). Therefore, deep injections into the periosteal layer, performed by perpendicularly inserting the needle into the hollowed areas, have been widely practiced due to their relative safety and technical simplicity.

When performing deep injections near the periosteum, there is a risk of inadvertently puncturing or injecting filler material into the DTA. This can lead to serious complications, including vascular occlusion and subsequent tissue ischemia. In extreme cases, retrograde embolization can occur, where the filler material travels backward through the arterial network, potentially leading to blindness if the ophthalmic artery is affected (Yanyun et al., 2014, Park et al., 2014, Carle et al., 2014, Carruthers et al., 2014).

The DTA is travelling at varying depths within the temporalis muscle. At the level of the zygomatic tubercle, the anterior DTA (ADTA) is located at an average depth of approximately 1.7 mm, while at the level of the eyebrow, it is found at an average depth of about 1.3 mm. The posterior DTA (PDTA) is situated at an average depth of around 2.1 mm at the zygomatic tubercle level and approximately 2.0 mm at the eyebrow level. Considering the depth data of the DTA, the perpendicular injection technique may not always be sufficient to avoid the DTA due to the length of the needle's bevel. (Bae et al., 2022)

The findings of this study indicate that the bevel down injection technique provides a more precise placement of filler material directly on the bony surface of the temple region compared to the conventional perpendicular injection method. In our cadaveric study, the oblique bevel-down technique exhibited a broader and more even distribution of the filler material along the periosteal surface, minimizing the risk of filler migration and ensuring a more stable augmentation. Dissection results further revealed that in the bevel down injections, there was minimal muscle layer observed beneath the filler material, whereas in the perpendicular injections, a significant muscle layer was present deep to the filler material. This difference is likely attributed to the length of the needle's bevel, which affects the depth and precision of filler placement.

The ultrasonographic analysis corroborated the dissection findings, providing real-time visualization of the filler material's distribution during the injection process. The filler material injected using the bevel down technique was closely located to the bony surface with minimal intervening tissue layers. This precise placement was consistently observed throughout the injection process, confirming the effective guidance provided by the bevel down technique. In contrast, the perpendicular injection method showed a more localized and abrupt distribution pattern.

The 3D analysis further validated the advantages of the bevel down injection technique, demonstrating superior aesthetic outcomes compared to the perpendicular method. The heatmap and volumetric assessments indicated that the bevel down technique resulted in a smoother and more natural elevation profile. The filler material, when injected using the bevel down approach, exhibited a broader and more even distribution, seamlessly integrating with the surrounding surface. This technique facilitated a gentle and continuous transition between the treated and untreated areas, enhancing the overall aesthetic appearance. The principal component analysis (PCA) results supported these findings, showing that the bevel down technique enabled a more consistent and extensive filler placement across a larger area.

The filler distribution patterns according to each injection technique are illustrated in **Figure 9**. The bevel down technique, compared to the perpendicular injection, exhibits a more uniform and extensive filler distribution, resulting in a smoother and more natural elevation profile. This distribution minimizes the presence of intervening muscle layers beneath the filler material, which can lead to a more stable and aesthetically pleasing augmentation. Clinically, this means that the bevel down technique not only enhances the visual outcomes but also reduces the risk of complications such as intravascular injections and uneven contouring, making it a safer and more effective method for temple augmentation.

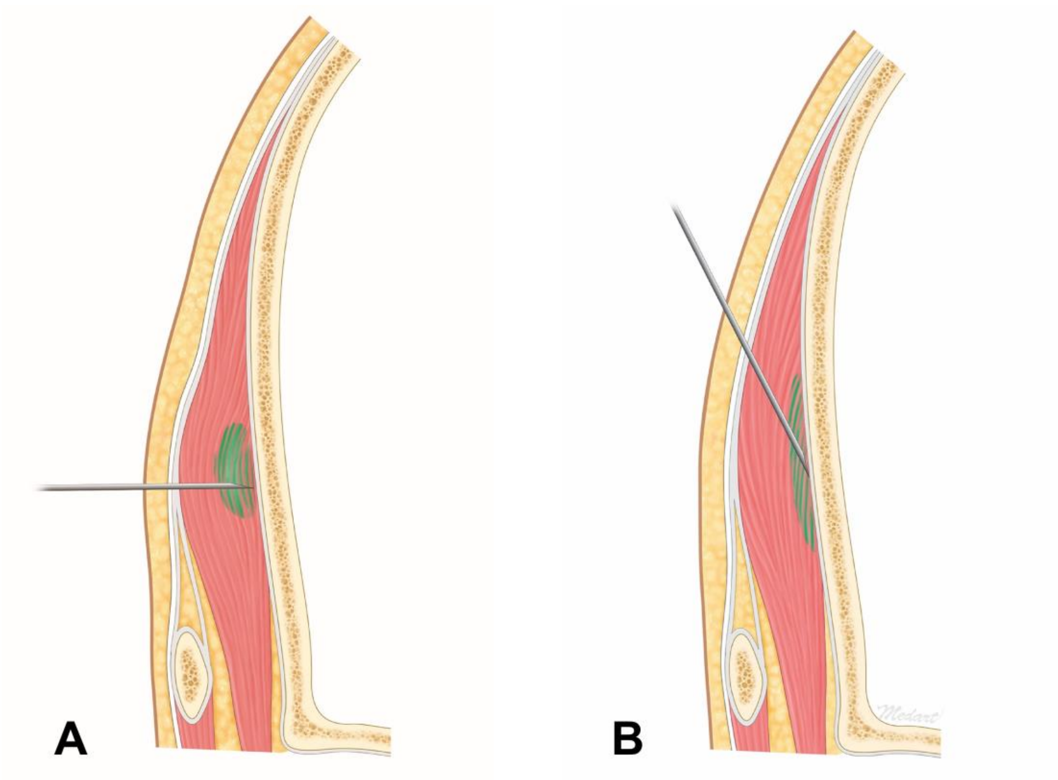

Figure 9. Illustration of filler distribution patterns for the two injection techniques.

(A) Perpendicular injection technique (B) Bevel down injection technique

Green area indicates the PCL filler material.

While this study provides valuable insights into the advantages of the bevel down injection technique, single cadaveric study may have limitation in generalizing these findings to a broader population. Future research should consider including a more diverse sample that encompasses various age groups and genders to enhance the applicability of the results. Additionally, to further validate the efficacy and safety of the bevel down injection technique, it is recommended that clinical trials be conducted in diverse clinical settings. Such studies would provide more robust and comprehensive data on the practical application of this technique, thereby refining best practices and ensuring optimal outcomes for temple augmentation procedures.

V. Conclusion

This study suggests that the bevel down injection technique for temple augmentation may offer improved efficacy and safety compared to the conventional perpendicular method. The bevel down technique facilitates a more precise and uniform distribution of filler material, closely located to the bony surface, as evidenced by both ultrasonographic and cadaveric analyses. This method results in a smoother and more natural elevation profile, potentially reducing the risk of complications such as intravascular injections and ensuring more stable and aesthetically pleasing outcomes. Further clinical trials in diverse settings are recommended to validate these findings and establish refined best practices for the use of the bevel down technique in clinical practice.

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Abstract (in Korean)

관자놀이 부위 증대를 위한 기존 주사법과 경사면 하방 위치 주사법의 비교 연구

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송세현

관자 부위는 미용적 시술에서 중요한 부위로, 복잡한 혈관, 층별 해부학적 구조로 인해 혈관 내 주사 및 관련 합병증(예: 혈관 폐쇄 및 실명)의 위험을 최소화하는 노력이 필요하다. 본 연구에서는 PCL 필러를 사용하여 시신을 대상으로 한 수직 주사법과 경사면 하방 위치 주사법을 비교하여 필러물질 분포와 조직 융기 양상에 중점을 두어 분석하였다.

단일 시신의 머리를 이용하여 PCL 필러를 왼쪽 관자부위에는 수직 주사법으로, 오른쪽 관자부위에는 경사면 하방 위치 주사법으로 주입하였다. 주사 동안 실시간 초음파 영상을 사용하여 필러의 위치를 모니터링하고 시간에 따른 필러 물질의 분포 패턴을 분석하였다. 주사 전후의 용적 변화를 3D 스캐닝을 통해 평가하였다. 스캔된 데이터는 형상 분석을 위해 관자 부위에 정렬 및 중첩하여 분석을

진행하였다. 전처리 후, 두 가지 다른 주사 방법에 의해 유도된 형태학적 변화를 각각 히트맵으로 시각화하고, 그 부피를 주성분 분석(PCA) 결과를 이용하여 비교하였다. 최종 필러 분포는 해부학적 해부를 통해 검증하였다.

초음파 영상에서 경사면 하방 위치 주사법이 수직 주사법에 비해 뼈 표면을 따라 더 균일하고 광범위한 필러 분포를 촉진하는 것을 확인하였다. 3D 분석의 히트맵 결과는 경사면 하방 위치 주사법이 수직 주사법에 비해 필러의 더 균일한 분포를 달성한다는 것을 보여주었다. 또한 PCA 결과에서 파생된 산점도는 경사면 하방 위치 주사법이 더 넓은 영역에 걸쳐 더 고른 필러 분포를 가능하게 한다는 추가 증거를 제공하였다. 해부학적 해부는 유사한 분포 패턴을 확인했으며, 필러가 뼈 표면에 가까이 균일하게 분포하여 초음파 결과와 밀접하게 일치하였다.

경사면 하방 위치 주사법은 더 안전하고 예측 가능한 필러 물질 분포를 제공한다. 잠재적인 혈관 구조로부터 일관된 거리를 유지함으로써, 이 방법은 혈관 관련 합병증의 위험을 줄일 수 있으며, 해부학적으로 복잡한 관자 부위에 사용하기에 더 적합하다. 초음파, 3D 분석 및 해부학적 해부 결과는 경사면 하방 위치 주사법을 임상 실습에 채택하여 최소침습적 시술에 있어 안전성과 심미적으로 바람직한 결과에 도움을 줄 것으로 예상된다.

핵심 되는 말 : 관자 부위 증강, PCL 필러, 시신 연구, 경사면 하방 위치 주사법, 초음파 영상, 3D 스캐닝, 최소침습적 시술.