

Autogenous Fat Grafting for Chin Augmentation: A Preliminary Clinical Study of Cosmetic Outcome

Qianwen Wang, MD, Xin Guo, MD, and Jiaqi Wang, MD

Abstract: Preoperative evaluation and surgical details of chin fat augmentation aiming at increasing the projection of the original mentum are scarcely reported. Herein, the authors systematically reviewed the application of fat grafting for chin augmentation in our institution from 2010 to 2014. This percutaneously multi-layered fat-injection technology can be applied for chin augmentation for a subset of patients after strict selection, and the details of lipofilling technology and fat distribution vary depending on each individual patient's condition. Mentum can be augmented in the sagittal plane in different degrees, whereas the chin height seems unable to be effectively prolonged by lipofilling.

Key Words: Augmentation mentoplasty, autologous fat grafting, chin augmentation

Chin prominence plays an important role in the perception of facial aesthetics. For decades, implant insertion has been a popular operation to improve chin projection and to create symmetric facial proportions. Many alloplastic materials (eg, silicone, Gore-Tex, and Medpor) and some autologous grafts (eg, cartilage grafts and bone grafts) have been applied for augmentation mentoplasty; however, their implanting procedures require extensive dissection and may cause complications, such as rejection reactions, infection, bone absorption, implant movement, and nerve injury.

Autologous fat tissue is a widely used filler for soft-tissue augmentation in plastic surgery.^{1–13} Although the viability of fat grafting remains unpredictable, this relatively simple and low-risk procedure is popular among surgeons, as well as patients. It has been considered as the ideal soft-tissue filler^{7–9} and can provide long-lasting support to the soft tissue once surviving.^{5,6,9,11,12} To date, chin fat augmentation aiming at increasing the projection of the original mentum has scarcely been discussed, and this procedure should not be just considered as maintenance of soft-tissue volume loss. The purpose of the study was to review our experience of chin fat augmentation in details.

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PATIENTS AND METHODS

Patients

Between 2010 and 2014, we applied fat grafting to patients who presented mildly sagittal and/or vertical deficiencies of chin that were not accompanied by distinct maxillofacial deformities. The included 105 patients had one of the following conditions: simple microgenia (N = 64); mandibular advancement for moderate and severe retrognathia with results still inferior to their expectation (N = 11); removal of alloplastic chin implants (N = 16); and subsequent chin augmentation after rhinoplasty to ensure better facial balance (N = 14). The mean age of the patients was 29.4 (range: 19–41) years, and the mean body mass index was 25.2 (range: 21.2–30.6) kg/m².

The included patients were divided into 2 subgroups: Group A (N = 81): patients with expectation of chin projection increasing in the sagittal plane, and Group B (N = 24): patients with desire of chin prominence enlargement in both the sagittal and vertical directions.

All patients had been followed up. The aims of the follow-up included objective evaluation of the surgical outcomes and patients' subjective self-assessment, and to decide whether additional lipofilling was needed. The patients' self-assessment was classified into much improvement (reached or almost reached their expectation), improvement (positive change but much less than their expectation), and no change. Subsequent fat grafting was only performed on patients who felt that the former lipoinjection had a positive outcome and actively asked for further improvement or accepted our supporting recommendation. Patients with no improvement were advised not to get further grafting for fear of failure again.

Surgical Procedure

The donor site of fat tissue was the lower abdomen, flank, lateral thigh, or inner thigh. After tumescent anesthesia, fat harvesting was performed by a 2-mm sharp cannula connected to a 25-mL syringe. The aspirated fat tissue from the deep layer was washed with normal saline no more than twice. The washed lipoaspirate was dispensed into 5-mL syringes and further purified by gravity separation for 10 minutes.

Through a one-hole blunt cannula (0.8 mm in diameter), fat was injected percutaneously and placed subcutaneously and submuscularly. The first aim was to horizontally enlarge the chin pad. Chin projection was examined during lipofilling until the prominence of the mentum was considered sufficient. Care was taken for the superior border to not be beyond the mentolabial fold.

For patients with the wish of increasing chin height, the soft-tissue menton point was first located, and this point was then moved downward to the determined appropriate location by multi-layered fat injection. Around the new menton, fat tissue was transplanted toward the bilateral jaw line with gradual decrease of fat amount.

At last, after finishing the injection at static status, observation of whether there was any unevenness, was made while smiling; and this issue was addressed by microamount graft injections.

RESULTS

The numbers of patients who underwent 1, 2, and 3 lipoinjections were 35, 41, and 29, respectively. The respective amounts of each injection and the time intervals between every lipofilling are shown in Table 1. The mean follow-up period was 21 months (range: 7–37 months).

Presented in Table 2, for all patients, irrespective of how many fat injections they underwent, the percentages of patients with much improvement, improvement, and no change were 56.2% (N = 59),

TABLE 1. Total Fat Injection Amount and Interval of Injections According to Lipoinjection Numbers

No. of Lipofilling	No. of Patients	Fat Amount(mL), Mean (Range)	Interval of Injections (Months), Mean (Range)
1	35	4 (2–7.5)	
2	41	5.9 (3–9)	6.4 (3–19)
3	29	7.2 (4–11.5)	

35.2% (N = 37), and 8.6% (N = 9), respectively. The number of patients with much improvement of chin underwent 1, 2, and 3 lipoinjections were 10, 30, and 19, respectively. All patients with much improvement, belonged to Group A, whereas the patients in Group B reported different degrees of improvement of chin prominence in the horizontal plane and much less improvement in the vertical direction, indicating that the chin could be increased more effectively in the horizontal direction than in the vertical plane by lipotransfer.

Typical cases are shown in Figures 1-2. There were no major complications, such as infection, palpable scleroma, paresthesia, or chin drooping during any stage of the operations or follow-ups.

DISCUSSION

Not all patients are suitable for mentum lipofilling, so careful preoperative patient selection is crucial, as it contributes to surgical plan and foreseeability of the cosmetic outcome. Our objectives of chin lipofilling did not have distinct jaw deformities. It is impossible to achieve a beautiful chin profile only through fat grafting for patients with obvious retrognathia or distinctly shortened mandibular height because fat tissue is too soft to reshape a solid structure and augmenting mentum to a point exceeding a certain degree have risks of chin drooping and fat appearance.

The preoperative relationship of the mentum with the nose and lips should be assessed for further determining the required degree of chin projection. Chin prominence should not exceed the line perpendicular to Frankfurt plane through nasion.¹⁴ Another ideal facial plane, namely the Gonzalez-Ulloa line, a vertical line that extends down from the nasion to meet the Frankfurt plane, should meet or be close to the anteriormost part of mentum.¹⁵ At the most, these lines, however, should serve only as reference planes, as the analysis of facial aesthetics is more complex. The lower lip usually should have a similar prominence as the chin projection.¹⁶ Excessive protrusion of the lower lip can deepen the labiomental crease, and chin augmentation without considering the labiomental fold, may thus make it unaesthetically deeper.

The position and depth of the labiomental fold vary among individuals,¹⁶ and 2 fat pads, namely the superficial and submental fat pads, exist in the mental region.^{17,18} Absolute subdermal lipofilling may increase the risks of irregularity, chin drooping, and fat appearance, and thus, we place most of fat into the 2 chin fat pads, exerting much caution not to go up beyond the labiomental crease, as shallowing of the mentolabial sulcus can otherwise lead to



FIGURE 1. A 25-year-old woman desired for her chin enlargement in horizontal plane and then underwent twice lipofillings with an interval of 6 months. She also underwent lipofilling for correction of lacrimal grooves at the first surgery. The fat amount in the chin were 4 and 2.5 mL, respectively. She was satisfied with the outcome of the mentum, 23 months after the second operation. Her chin had a significant improvement in horizontal projection.

unaesthetic total lower face augmentation, especially in patients with a high labiomental fold. In very rare cases with distinct lower lip protrusion, fat grafting to shallow labiomental fold, however, can also result in acceptable outcomes. In addition, for patients with obesity or excess submental and neck adipose tissue, chin lipofilling should not be performed alone, as it may cause an unaesthetic fat-appearing profile from an overall perspective, but should rather be used to reinforce the effects of faciocervical liposuction.^{19,20}

Fat tissue can moreover be used to fill cleft chins. Cleft chin is characterized by a groove resulting from a lack of fusion of the paired mentalis muscles in the center of the mentum.¹⁶ In this muscle-deficient region, fat injection into the deep layer usually shows limited improvement to this trough, so subdermal fat injection should be emphasized. The groove can be flattened or shallowed at the static state; however, it may visualize again upon facial expressions as a result of mentalis muscle contraction.

The horizontal prominence of chin can be improved in various degrees by fat grafting. The ultimate limit of chin projection that can be aesthetically increased by lipofilling is estimated to be 3 to 5 mm, as we clinically observed. Exceeding that extremity through lipofilling may result in an unaesthetic fat-like appearance and chin ptosis. Another observation is that chin seems not be effectively prolonged in the vertical direction as all patients in Group B reported their vertical length of mentum were much inferior to their expectation after lipofillings. Possible reasons are as follows: first, adipose tissue, unlike alloplastic materials, is a soft-tissue filler and difficult to form into a stable structural support. Second,

TABLE 2. Outcomes of Patients' Subjective Self-Assessment

	1 Lipofilling Percentage (N)	2 Lipofilling Percentage (N)	3 Lipofilling Percentage (N)	Total Percentage (N)	Affiliation
Much improvement	9.5 (10)	28.6 (30)	18.1 (19)	56.2 (59)	Group A
Improvement	13.3 (14)	14.3 (15)	7.6 (8)	35.2 (37)	Group A and B
No change	8.6 (9)	—	—	8.6 (9)	Group A and B



FIGURE 2. A 23-year-old woman underwent fat grafting twice for the purpose of chin augmentation in both the horizontal plane and vertical direction with an interval of 9 months. The injected fat amount were 6.5 and 4.5 mL, respectively. During the 17-months follow-up, she had no significant complications and felt that the horizontal projection of chin was close to her expectation and the vertical prominence of mentum seemed to have no significant change.

the soft tissue of the chin has a broader range of movement in the horizontal plane than in the vertical direction, so adipose tissue can upheave the mentum more easily and bears lesser tissue tension in the horizontal plane than in the vertical direction. Fat retention may hence decrease because of the fact that adipose tissue injected into a tight region compresses more than that in a loose area, thus potentially resulting in poorer vascularization.

CONCLUSIONS

Fat grafting can be applied for chin augmentation for a subset of patients after strict selection. The adipose tissue mainly distributes in the subdermal and submuscular layers. The details of the injection technology and fat distribution vary depending on each individual patient's condition. In addition, the mentum can be augmented in the sagittal plane, whereas the chin height seems unable to be effectively prolonged by lipofilling.

REFERENCES

1. Fulton JE, Suarez M, Silverton K, et al. Small volume fat transfer. *Dermatol Surg* 1998;24:857–865
2. Donofrio LM. Techniques in facial fat grafting. *Aesthet Surg J* 2008;28:681–687
3. Cortese A, Savastano G, Felicetta L. Free fat transplantation for facial tissue augmentation. *J Oral Maxillofac Surg* 2000;58:164–169
4. Coleman SR. Structural fat grafting: more than a permanent filler. *Plast Reconstr Surg* 2006;118:108S–120S
5. Rusciani Scorza A, Rusciani Scorza L, Troccoli A, et al. Autologous fat transfer for face rejuvenation with tumescent technique fat harvesting and saline washing: a report of 215 cases. *Dermatology* 2012;224:244–250
6. Kanchwala SK, Bucky LP. Facial fat grafting: the search for predictable results. *Facial Plast Surg* 2003;19:137–146
7. Coleman SR. Structural fat grafts: the ideal filler? *Clin Plast Surg* 2001;28:111–119
8. Guererosantos J. Long-term outcome of autologous fat transplantation in aesthetic facial recontouring: sixteen years of experience with 1936 cases. *Clin Plast Surg* 2000;27:515–543

9. Bucky LP, Kanchwala SK. The role of autologous fat and alternative fillers in the aging face. *Plast Reconstr Surg* 2007;120:89S–97S
10. Kanchwala SK, Glatt BS, Conant EF, et al. Autologous fat grafting to the reconstructed breast: the management of acquired contour deformities. *Plast Reconstr Surg* 2009;124:409–418
11. Coleman SR. Hand rejuvenation with structural fat grafting. *Plast Reconstr Surg* 2002;110:1731–1744, discussion 1745–7
12. Erol OO, Gürelek A, Agaoglu G. Calf augmentation with autologous tissue injection. *Plast Reconstr Surg* 2008;121:2127–2133
13. Murillo WL. Buttock augmentation: case studies of fat injection monitored by magnetic resonance imaging. *Plast Reconstr Surg* 2004;114:1606–1614, discussion 1615–6
14. Gross EJ, Hamilton MM, Ackermann K, et al. Mersilene mesh chin augmentation. A 14-year experience. *Arch Facial Plast Surg* 1999;1:183–189, discussion 190
15. Gonzalez-Ulloa M. Quantitative principles in cosmetic surgery of the face (profileplasty). *Plast Reconstr Surg* 1962;29:186–198
16. Zide BM, Pfeifer TM, Longaker MT. Chin surgery: I. Augmentation—the allures and the alerts. *Plast Reconstr Surg* 1999;104:1843–1853, discussion 1861–2
17. Gierloff M, Stöhring C, Buder T, et al. The subcutaneous fat compartments in relation to aesthetically important facial folds and rhytides. *J Plast Reconstr Aesthet Surg* 2012;65:1292–1297
18. Rohrich RJ, Pessa JE. The anatomy and clinical implications of perioral submuscular fat. *Plast Reconstr Surg* 2009;124:266–271
19. Butterwick KJ. Enhancement of the results of neck liposuction with the FAMI technique. *J Drugs Dermatol* 2003;2:487–493
20. Haack J, Friedman O. Facial liposculpture. *Facial Plast Surg* 2006;22:147–153

Osteoradionecrosis of the Posterior Maxilla: A New Approach Combining Erbium: Yttrium Aluminium Garnet Laser and Bichat Bulla Flap

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Abstract: Osteoradionecrosis (ORN) of the jaw is a complication of radiation therapy for head and neck cancers. We report a case of ORN of the posterior maxilla treated with Er: YAG laser and a pedicled buccal fat pad (bichat bulla adipose) flap. A 69-year-old man presented complaining of pain on left maxilla. He had received high-dose radiotherapy (90 Gy) for squamous cell carcinoma of the

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left soft palate 2 years earlier. Clinical and radiographic examinations revealed ORN of the left maxillary molar region and maxillary sinusitis. Daily home care consisted of 0.9% saline irrigation and 0.8% H₂O₂ gel application. Sequestrectomy and tooth extraction were followed by debridement with Er: YAG laser and repair with a pedicled buccal fat pad flap. Complete resolution of ORN and maxillary sinusitis was established one year postsurgically. The excellent clinical outcome suggests that Er: YAG laser debridement and pedicled buccal fat pad flap are a viable option to treat ORN of the posterior maxilla.

Key Words: Buccal fat pad, laser solid-state, maxilla, osteoradionecrosis, surgical flaps

Osteoradionecrosis (ORN) is a potentially debilitating complication of radiation therapy for head and neck cancers.^{1–4} It is characterized by exposed bone that fails to heal during 1 month.⁵ Radiation damage causes hypovascularity by thrombosis, that determines hypoxia, and hypocellularity by cell death,⁶ which can result in a chronic nonhealing wound.⁵ The risk factors of ORN include age, sex, radiation dose, primary tumor site and stage, tumor location in relation to the maxilla, type of treatment and technique (external beam radiation, brachytherapy, chemotherapy, surgery, or combination therapy), tooth extraction or dental surgery before and after radiation, smoking, alcohol consumption, and systemic factors (ie, infection, immune deficiency, comorbidities, and malnutrition).⁷ High-dose irradiation (≥ 70 Gy) of the jaws significantly increases the risk of ORN.⁴

The pedicled buccal fat pad flap (BFP), also known as bichat bulla adipose flap, has been used for repair of persistent oroantral fistulas after tooth extractions in the maxillary molar region, facial augmentation procedures, treatment of oral submucous fibrosis,^{8,9} and closure of oroantral and oronasal communications secondary to oncologic resection.¹⁰ Er: YAG laser has already been applied for managing bisphosphonate-related osteonecrosis of the jaw (BRONJ).¹¹ Use of both Er: YAG laser and BFP to manage ORN of the jaws, however, has not been reported. This paper describes a case of ORN of the posterior maxilla treated with Er: YAG laser and a pedicled buccal fat pad.

MATERIALS AND METHODS

A 69-year-old man presented complaining of pain on left maxilla at the Operative Unit of Stomatology, San Gerardo Hospital, Monza, Italy. He had received two-dimensional head and neck radiotherapy (90 Gy) during 2 months for squamous cell carcinoma of the left soft palate 2 years earlier. Extraoral examination revealed a painful swelling in the left infraorbital region. Intraoral examination suggested ORN of the left maxillary molar region complicated by maxillary sinusitis (Fig. 1A). The diagnosis was confirmed by cone-beam computed tomography (Fig. 1H–I).

A combined medical and surgical approach was planned. The defect was irrigated weekly with 0.9% saline and 0.8% H₂O₂ gel was applied at the hospital. Daily home care included 0.9% saline irrigation after meals and 0.8% H₂O₂ gel application every 24 hours (Fig. 1B). Two surgeries were required. Antibiotics (875-mg amoxicillin + 125-mg clavulanic acid; 1 tablet every 12 hours from 48 hours before to 5 days after) were administered perioperatively. The first surgery involved sequestrectomy and tooth extraction under local anesthesia (Fig. 1C).



FIGURE 1. A, Initial intraoral view: superinfected osteoradionecrosis. B, Osteoradionecrosis after 7 days medical therapy before first surgery. C, Residual osteoradionecrosis after first surgery. D, Residual defect before second surgery (1 month after the first surgery). E, Er:YAG laser debridement and mobilization of a pedicled buccal fat pad flap for primary closure. F, Epithelialization of the flap after 15 days. G, Clinical complete resolution 1 year later. H–I, cone-beam computed tomography (CBCT) preoperative images. L–M, CBCT postoperative images 1 year later.

The second surgery was performed after 30 days, when the soft tissue healed sufficiently (Fig. 1D). Under local anesthesia (artaine HCl with 1:100,000 epinephrine) a crestal incision was made and a mucoperiosteal flap was elevated. Necrotic bone was removed by Er: YAG laser under continuous irrigation, using the following parameters: continuous mode; energy, 250 mJ; frequency, 20 Hz; and power, 5 W. Then, a periosteal releasing incision was made about 10 mm from the attached gingiva of the maxillary second molar. By dissection, the buccal fat pad was exposed and rotated onto the maxillary defect (Fig. 1E). The flap was anchored with 4/0 absorbable sutures to the surrounding tissue. The sutures were removed 15 days later to avoid flap dehiscence (Fig. 1F). Home care was continued until complete healing occurred.

RESULTS

The patient was recalled after 1 week, 15 days, and every 1 month up to 1 year after the second surgery. Clinical and radiographic examinations at 12 months revealed complete resolution of ORN (Fig. 1G) and maxillary sinusitis (Fig. 1L–M).

DISCUSSION

The pathogenesis, staging, and management of ORN have been widely discussed in the literature. Its treatment, however, remains controversial, ranging from conservative management with oral rinses (ie, chlorhexidine, H₂O₂) and local debridement to radical resection with microvascular free tissue transfer and reconstruction, often combined with long-term systemic antibiotic administration.¹² Hyperbaric oxygen therapy alone seems to be insufficient to control ORN progression.^{13,14} Gevorgyan et al⁷ emphasize the need for early and aggressive surgical treatment to prevent progression.

The extent of resection is determined by excising necrotic bone until a bleeding osseous margin is encountered.⁵ Er: YAG laser seems to induce more pronounced inflammatory infiltration,

revascularization, and fibroblastic reaction in the osseous margin than use of a surgical bur and CO₂ laser irradiation. The lack of a “smear layer” may also promote adhesion of blood elements at the start of healing. Granulation tissue rich in fibroblasts and osteoblasts has been noted 7 days after Er: YAG laser debridement.¹⁵

Gallego et al¹⁶ proposed pedicled buccal fat pad flap for treating BRONJ. As other types of flap, pedicled buccal fat pad flap ensures primary closure, adequate protection, and considerable blood supply during the initial stage of healing; moreover BFP serves as a reservoir of adipose-derived stem cells, which can form osteoid and differentiate into multiple mesodermal lineages.^{9,17}

In conclusion, the excellent outcome of the case implies that Er: YAG laser debridement and pedicled buccal fat pad flap are a viable solution for treating ORN of the posterior maxilla. Further studies are necessary to confirm the effectiveness of this technique.

REFERENCES

- Marx RE. Osteoradionecrosis—a new concept of its pathophysiology. *J Oral Maxillofac Surg* 1983;41:283–288
- Marx RE, Johnson RP. Studies in the radiobiology of osteoradionecrosis and their clinical significance. *Oral Surg Oral Med Oral Pathol* 1987;64:379–390
- Chrcanovic BR, Reher P, Sousa AA, et al. Osteoradionecrosis of the jaws—a current overview—part 2: dental management and therapeutic options for treatment. *Oral Maxillofac Surg* 2010;14:81–95
- Sasahara G, Koto M, Ikawa H, et al. Effects of the dose-volume relationship on and risk factors for maxillary osteoradionecrosis after carbon ion radiotherapy. *Radiat Oncol* 2014;9:92
- Zaghi S, Miller M, Blackwell K, et al. Analysis of surgical margins in cases of mandibular osteoradionecrosis that progress despite extensive mandible resection and free tissue transfer. *Am J Otolaryngol* 2012;33:576–580
- Nguyen MT, Billington A, Habal MB. Osteoradionecrosis of the skull after radiation therapy for invasive carcinoma. *J Craniofac Surg* 2011;22:1677–1681
- Gevorgyan A, Wong K, Poon I, et al. Osteoradionecrosis of the mandible: a case series at a single institution. *J Otolaryngol Head Neck Surg* 2013;42:46
- Amin MA, Bailey BM, Swinson B, et al. Use of the buccal fat pad in the reconstruction and prosthetic rehabilitation of oncological maxillary defects. *Br J Oral Maxillofac Surg* 2005;43:148–154
- Abad-Gallegos M, Figueiredo R, Rodríguez-Baeza A, et al. Use of Bichat's buccal fat pad for the sealing of orosinus communications. A presentation of 8 cases. *Med Oral Patol Oral Cir Bucal* 2011;16: e215–e219
- Egyedi P. Utilization of the buccal fat pad for closure of oro-antral and/or oronasal communications. *J Maxillofac Surg* 1977;5:241–244
- Vescovi P, Merigo E, Meleti M, et al. Surgical approach and laser applications in BRONJ osteoporotic and cancer patients. *J Osteoporos* 2012;2012:585434
- O'Dell K, Sinha U. Osteoradionecrosis. *Oral Maxillofac Surg Clin North Am* 2011;23:455–464
- Pitak-Arnop P, Sader R, Dhanuthai K, et al. Management of osteoradionecrosis of the jaws: an analysis of evidence. *Eur J Surg Oncol* 2008;34:1123–1134
- Wong AK, Schönmeier BH, Soares MA, et al. Hyperbaric oxygen inhibits growth but not differentiation of normal and irradiated osteoblasts. *J Craniofac Surg* 2008;19:757–765
- Pourzarandian A, Watanabe H, Aoki A, et al. Histological and TEM examination of early stages of bone healing after Er:YAG laser irradiation. *Photomed Laser Surg* 2004;22:342–350
- Gallego L, Junquera L, Pelaz A, et al. The use of pedicled buccal fat pad combined with sequestrectomy in bisphosphonate-related osteonecrosis of the maxilla. *Med Oral Patol Oral Cir Bucal* 2012;17: e236–e241
- Hicok KC, du Laney TV, Zhou YS, et al. Human adipose-derived adult stem cells produce osteoid in vivo. *Tissue Eng* 2011;10:371–380

A Preliminary Three-Dimensional Analysis of Nasal Aesthetics Following Le Fort I Advancement in Patients With Cleft Lip and Palate

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Abstract: Nasal aesthetic changes after cleft orthognathic surgery remain understudied. Previous scarring associated with prior cleft surgery may affect the predictability of outcomes after jaw surgery. This study evaluates changes in nasal aesthetics using three-dimensional photography after Le Fort I advancement in patients with nonsyndromic cleft-related maxillary hypoplasia.

Cephalometric parameters were recorded pre- and postoperatively. Three-dimensional photogrammetric imaging analyzed changes in interalar width (IAW), internostril width (INW), nasal tip projection (NTP), columellar length (CL), nasal labial angle (NLA), and nasal length (NL). Statistical significance between pre- and postoperative data was determined using *T*-tests for each parameter.

Eleven patients underwent either single piece Le Fort I osteotomy and advancement, (3 bilateral, 4 unilateral cleft lip, and palate), or 2-piece advancement (2 bilateral, 2 unilateral). Average nasal soft tissue changes were IAW 1.9 mm (0.4–4.2), INW –0.2 mm (–2.8 to 1.6), NTP –1.0 mm (–4.0 to 2.0), CL –0.7 mm (–2.9 to 1.5), NLA –0.2° (–13.9 to 15.1), and NL –0.7 mm (–4.3 to 1.5), (*P* = 0.001, 0.6, 0.08, 0.01, 0.9, 0.2). For single-piece osteotomy alone changes were IAW 2.1 mm (0.6–4.1), INW –0.6 mm (–2.8 to 1.7), NTP –1.9 mm (–4.0 to 0.3), CL –1.2 mm (–2.9 to 0.03), NLA –1.3° (–13.9 to 15.0), and NL –1.1 mm (–4.3 to 0.7), (*P* = 0.007, 0.3, 0.009, 0.0002, 0.7, 0.2). For 2-piece osteotomy alone changes were IAW 1.6 mm (–0.4 to 3.3), INW 0.5 mm (0.4–1.6), NTP 0.5 mm (–1.1–2.0), CL 0.2 mm (–1.4 to 1.5), NLA 2.8° (–7.6 to 10.1), and NL –0.1 mm (–1.4 to 1.5), (*P* = 0.2, 0.4, 0.5, 0.6, 0.5, 0.9).

Cleft-related scarring and malposition affect changes in nasal aesthetics following maxillary advancement that are different to the noncleft population. Two-piece Le Fort I increases variability of changes in nasal aesthetics compared with single-piece advancement.

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Key Words: Cleft maxillary hypoplasia, Le Fort I, nasal aesthetics, orthognathic surgery, three-dimensional photography

Orthognathic surgery, to correct any associated skeletal deficiencies, and rhinoplasty, to correct any nasal deformity related to clefting, are vital final steps in comprehensive cleft care. Orthodontic treatment alone is not sufficient in approximately 20% to 25% of patients in unilateral cleft conditions to treat any associated dentofacial skeletal deformities. As such, surgical correction of the class III malocclusion secondary to maxillary hypoplasia with a Le Fort I osteotomy and advancement at skeletal maturity is necessary.¹ This may be a 1-piece advancement or a 2-piece segmented Le Fort I if planned for maxillary expansion, occlusal plane leveling for open or deep bite correction, or for space closure after dental extraction in Class II correction.² Despite the general trend toward operation on the cleft lip nose deformity at the time of initial lip surgery, secondary surgery to further modify the nasal shape is often necessary with many patients desiring a more comprehensive correction in their teen years.³

The interplay of anatomy variables between midface advancement and rhinoplasty is inseparable. Established rationale is that the treatment of cleft nasal deformity begins with first correcting the skeletal base under the nose with orthognathic surgery because of the significant changes to nasal shape after advancement of the maxilla.^{1,3} Described secondary changes in the nasolabial region that have occurred following Le Fort I maxillary advancement include widening of the alar bases of the nose, upturning of the nasal tip, flattening and thinning of the upper lip, and downturning of the commissures of the mouth.^{4–9} Yet this traditional teaching of how midface advancement affects nasal aesthetics is largely based on studies in noncleft patients. For patients with cleft lip and palate the question remains as to whether these changes are maintained given the presence of aberrant anatomy, multiple prior surgical procedures and associated scarring.

Attempts to investigate soft tissue changes in response to maxillary advancement in patients with clefts have been limited to analysis of projection in photographs or cephalograms, or have been inconclusive in identifying changes in nasal aesthetics. In cephalometric studies by Kawauchi et al^{10,11} soft tissue response to maxillary advancement in cleft lip/palate patients was greater than in noncleft patients when comparing changes of the lip and nose for a specific movement of 5 mm maxillary advancement. Hui et al¹² also demonstrated, using cephalometrics, higher soft tissue to hard tissue movement ratios in response to maxillary advancement in cleft populations. Nonetheless, others using three-dimensional laser scanning have found that, even though surgery resulted in advancement of the upper lip and para-alar tissues and an increase in the relative prominence of the nose within the face, Le Fort I failed to correct lack of nasal projection in patients with clefts.^{13,14} These authors also attempted to use laser scanning to define nasal morphology changes following Le Fort I but found there was significant variation in the nasal response to maxillary advancement in the cleft patients studied such that no conclusions could be drawn.¹⁴ Similarly, Verzé et al¹⁵ have used three-dimensional laser scanning to evaluate facial soft tissue changes after Le Fort I advancement in patients with cleft lip and palate and those with nonclefted retrognathic dysplasia. They identified a decrease in alar base width and an increase in nasolabial angle following Le Fort I in patients with clefts versus an increase in alar base and an unchanged nasolabial angle in patients without clefts. Data, however, was not subjected to rigorous statistical analysis, but rather arbitrarily based on a difference of 1 mm for linear measurements and of 3 degrees for angular measurements. To address the limitations of these prior studies, we sought to better evaluate the changes in nasal tip position, tip rotation, and nostril shape using

three-dimensional photography after Le Fort I advancement osteotomies in patients with nonsyndromic cleft-related maxillary hypoplasia and class III malocclusion.

MATERIALS AND METHODS

Study Design/Population

This was a retrospective evaluation of subjects treated by the senior author (AK) over a 24-month period. Patients were included as study subjects if they had a class III skeletal malocclusion related to nonsyndromic cleft palate, underwent surgical correction via LF1 osteotomy, and had pre- and postoperative cephalometric and three-dimensional volumetric data for comparison. Noncleft patients, syndromic cleft patients, and those with incomplete records were excluded. The project was reviewed and sanctioned by the institutional review board for human studies at the Children's Hospital of Pittsburgh (PRO13010106).

Surgical Technique

Patients were treated in the dedicated craniofacial operating room suites under general nasotracheal anesthesia and prepped and draped in the customary fashion. A standard maxillary upper sulcus incision was used with a V-shaped extension anteriorly at the level of the frenulum. The maxilla was then fully degloved in the sub-periosteal plane to identify the bilateral nasal maxillary and the zygomatic maxillary buttresses. Next, after dissection of the pterygoid buttresses, a Le Fort I level osteotomy was then marked and then cut with a reciprocating saw. The pterygomaxillary buttresses were then osteotomized using a Kawamoto osteotome followed by mobilization of the Le Fort I segment after down fracture into a more advanced position. The patient was placed in a prefabricated splint and put in intermaxillary fixation with elastics. Posterior interferences were then taken down and then the cup of jaw was then placed into its new advancement position using a surgical splint and elastic intermaxillary fixation. Subsequently, 1.5 mm KLS Martin plates were then custom bent in an L fashion and placed with 2 screws on either side of the osteotomy on the nasomaxillary and zygomaticomaxillary buttresses bilaterally. After this, the patient was then released from intermaxillary fixation and the bite checked for centric relation and occlusion. A synch stitch was then placed with 3–0 nylon suture to control alar base width. Next, the lip was then closed using a 1 cm V-to-Y advancement at the central lip/frenulum area. Then, the upper maxillary sulcus incision was then approximated using a combination of interrupted 4–0 Vicryl and running 4–0 Vicryl sutures. For multi-segment procedures, the maxilla was segmented in the region of the prior cleft bone graft repair after down fracture. The segmented maxilla was then fully advanced, placed into intermaxillary fixation using a prefabricated splint, and then stabilized using a 1.5 mm transverse plate across the alveolar ridge and secured with multiple 5 mm, 1.5 mm screws. After release from intermaxillary fixation, the procedure was then completed in a similar fashion to a 1-piece unsegmented Le Fort I procedure.

Data Collection and Analysis

Cephalometric parameters were recorded pre- and postoperatively (overjet, overbite, soft tissue advancement). Three-dimensional photogrammetric imaging (Vectra XT Imaging System; Canfield Scientific, Inc., Fairfield, NJ) analyzed changes in nasal interalar width (IAW), internostril width (INW), nasal tip projection (NTP), columellar length (CL), nasal labial angle (NLA), and nasal length (NL) (Fig. 1). Data was analyzed collectively for the entire cohort of patients as well as in subgroup analysis for 1-piece and 2-piece Le Fort I procedures. Statistical significance between pre- and postoperative data was determined using *T*-tests for each parameter.

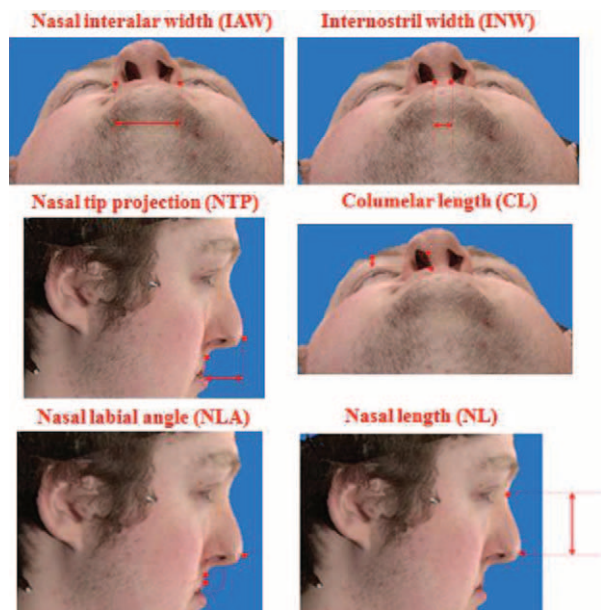


FIGURE 1. Parameters of nasal aesthetics measured: IAW, INW, NTP, CL, NLA, and NL. IAW, nasal interalar width; INW, internostril width; NTP, nasal tip projection; CL, columellar length; NLA, nasal labial angle; NL, nasal length.

RESULTS

Eleven patients underwent either single piece Le Fort I osteotomy and advancement, (3 bilateral, 4 unilateral cleft lip and palate), or 2-piece advancement (2 bilateral, 2 unilateral). Average age at orthognathic surgery was 18.1 years. Average three-dimensional photographic follow-up was 5.1 months. The average cephalometric advancement at maxilla central incisor edge was 6.4 mm. There was no significant difference in age at surgery, follow up, or cephalometric advancement between single- and 2-piece osteotomy.

For all data, when single-piece osteotomy and 2-piece osteotomy procedures are all included, the mean nasal soft tissue changes were IAW 1.9 mm (0.4–4.2), INW –0.2 mm (–2.8 to 1.6), NTP –1.0 mm (–4.0 to 2.0), CL –0.7 mm (–2.9 to 1.5), NLA –0.2° (–13.9 to 15.1), and NL –0.7 mm (–4.3 to 1.5), ($P=0.001, 0.6, 0.08, 0.01, 0.9, 0.2$). Thus a statistically significant increase in interalar width of mean 1.9 mm ($P=0.001$) and a statistically significant decrease in columellar length of mean 0.7 mm ($P=0.01$) was seen following Le Fort I advancement osteotomies in patients with nonsyndromic cleft-related maxillary hypoplasia with no other significant effect on other parameters of nasal aesthetics measured.

In subgroup analysis of single-piece osteotomy alone changes were IAW 2.1 mm (0.6–4.1), INW –0.6 mm (–2.8 to 1.7), NTP –1.9 mm (–4.0 to 0.3), CL –1.2 mm (–2.9 to 0.03), NLA –1.3° (–13.9 to 15.0), and NL –1.1 mm (–4.3 to 0.7), ($P=0.007, 0.3, 0.009, 0.0002, 0.7, 0.2$). Thus a statistically significant increase in interalar width of mean 2.1 mm ($P=0.007$), a statistically significant decrease in internasal width of mean 0.6 mm ($P=0.009$), and a statistically significant decrease in columellar length of mean 0.7 mm ($P=0.01$) was seen following single-piece Le Fort I advancement osteotomies in patients with nonsyndromic cleft-related maxillary hypoplasia with no other significant effect on other parameters of nasal aesthetics measured.

In subgroup analysis of 2-piece osteotomy alone changes were IAW 1.6 mm (–0.4 to 3.3), INW 0.5 mm (0.4–1.6), NTP 0.5 mm (–1.1 to 2.0), CL 0.2 mm (–1.4 to 1.5), NLA 2.8° (–7.6 to 10.1), and NL –0.1 mm (–1.4 to 1.5), ($P=0.2, 0.4, 0.5, 0.6, 0.5, 0.9$). Thus Le Fort I 2-piece advancement osteotomies in patients with

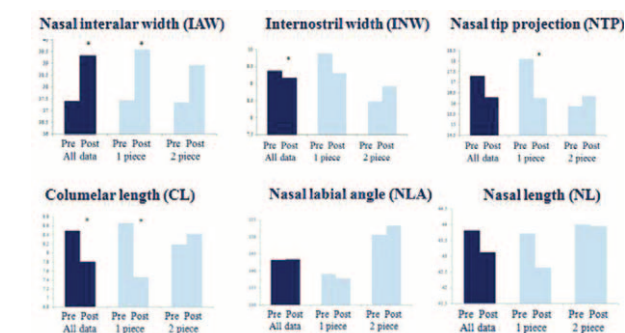


FIGURE 2. Changes in nasal aesthetics: nasal interalar width (all data: 1.9 mm (0.4–4.2), $P=0.001$; 1-piece: 2.1 mm (0.6–4.1), $P=0.007$; 2-piece: 1.6 mm (–0.4 to 3.3), $P=0.2$). Internostril width (all data: –0.2 mm (–2.8 to 1.6), $P=0.001$; 1-piece: –0.6 mm (–2.8 to 1.7), $P=0.3$; 2-piece: 0.5 mm (0.4–1.6), $P=0.4$). Nasal tip projection (all data: –1.0 mm (–4.0 to 2.0), $P=0.08$; 1-piece: –1.9 mm (–4.0 to 0.3), $P=0.009$; 2-piece: 0.5 mm (–1.1 to 2.0), $P=0.5$). Columellar length (all data: –0.7 mm (–2.9 to 1.5), $P=0.01$; 1-piece: –1.2 mm (–2.9 to 0.03), $P=0.002$; 2-piece: 0.2 mm (–1.4 to 1.5), $P=0.6$). Nasal labial angle (all data: –0.2° (–13.9 to 15.1), $P=0.9$; 1-piece: –1.3° (–13.9 to 15.0), $P=0.7$; 2-piece: 2.8° (–7.6 to 10.1), $P=0.5$). Nasal length (all data: –0.7 mm (–4.3 to 1.5), $P=0.2$; 1-piece: –1.1 mm (–4.3 to 0.7), $P=0.2$; 2-piece: –0.1 mm (–1.4 to 1.5), $P=0.9$).

nonsyndromic cleft-related maxillary had no statistically significant effect on parameters of nasal aesthetics measured. (Fig. 2)

DISCUSSION

In the unilateral cleft nasal deformity, the maxilla is laterally displaced and hypoplastic, resulting in lateral, inferior and posteriorly displaced ala. There is loss of nasal tip definition, obliquity of the alar facial angle, and septal deviation. For the bilateral deformity the premaxilla also distorts the columella, there is alar lidding, presence of a plica vestibularis, and loss of tip projection.^{3,16–18} Despite repair of the nose at the time of primary lip surgery, secondary comprehensive septorhinoplasty is often necessary at skeletal maturity to treat any residual nasal deformity that is worsened by maxillary hypoplasia.

The need for orthognathic surgery in patients with cleft lip and palate reported in the literature is variable up to 50% in bilateral patients.¹⁹ For those patients with dentofacial deformities that require Le Fort I maxillary advancement for optimal treatment, the changes in nasal aesthetics as described in the noncleft population including increased interalar width, increased internostril width, increased columellar length, and increased nasal labial angle may not be applicable.^{4–9} The current study sought to evaluate and identify clinically significant changes in nasal aesthetics in patients with nonsyndromic cleft lip and palate maxillary hypoplasia and class III malocclusion undergoing Le Fort I for complete dentofacial correction and compare those changes to existing noncleft nasal changes after maxillary advancement reported outcomes (Table 1).

TABLE 1. Changes in Nasal Aesthetics Following Le Fort I Advancement

	Cleft Population	Noncleft Population ^{4–9}
Nasal interalar width	Increased	Increased
Internostril width	Decreased/no change	Increased
Nasal tip projection	Decreased/no change	Increased/no change
Columellar length	Decreased	No change
Nasal labial angle	No change	Increased
Nasal length	No change	No change

Interalar width (IAW) is the distance from subalare, the alar base, on one side to that on the other. A wide interalar distance is a hallmark of the cleft nasal deformity which can persist even after primary surgical repair.²⁰ In the noncleft population an increase in interalar width is the most consistently reliable effect of Le Fort I advancement on nasal aesthetics.^{4–12} In fact, the base of the nose is usually widened in all patients regardless of the vector of surgical maxillary movement.⁷ In the noncleft population Betts et al⁷ found that narrow noses widened more than did broad noses following maxillary movement. Given the propensity for a broad nose in the cleft population, a decrease in relative widening of the alar bases for patients in our study may be expected. All patients undergoing single piece Le Fort I advancement in our study demonstrated an increase in interalar width and all but 1 patient undergoing 2-piece advancement also demonstrated an increase in interalar width. One patient that did not demonstrate an increase was essentially unchanged, measured at a decrease of 0.4 mm. Notably, this patient was had the second widest nose of our cohort preoperatively (38 mm). Furthermore, the greatest increase in interalar width (4.1 mm) was seen in a patient with amongst the narrowest preoperative interalar width (35 mm). Our sample size, however, is insufficient to reliably delineate a true significant trend in extent of alar change as a measure of preoperative interalar width. Nor can we decipher whether the relative changes seen are more or less pronounced than that in the noncleft population.

Internostril width represents the width of the columella and is the distance of subnasale, the base of the columella, on one side to that on the other. This, like interalar width, is routinely widened in the noncleft population following Le Fort I advancement. This finding was not replicated in our study of Le Fort I advancement in patients with a history of cleft palate. In fact, no statistical change was seen for this parameter when considering our cohort as a whole, nor in subgroup analyses of 1-piece and 2-piece procedures. In fact, for 7 out of 11 patients, the internasal width decreased, albeit by mostly small increments. One might speculate that this phenomenon is related to the interplay between scar tissue resulting from prior cleft lip/nose repair surgery, the pliability of this, propensity for this to contract or recoil and the undermining or release from adjacent tissue in dissection for maxillary advancement that may be contributing counteracting tension. It would be interesting to ascertain whether bilateral versus unilateral cleft aetiology or method of primary cleft lip/nose repair (ie, Mohler, Millard, etc.) differentially affected this, though again investigation of this is limited by our sample size.

Nasal tip projection, measured from subnasale, base of columella, to pronasale, the anterior most point or the nose, was described to either be unchanged or increased by Le Fort I maxillary advancement in studies in those without history of clefting. Again, and arguably for the same reasons outlined above for lack of reliable increase in internasal/columellar width, that is, columellar scarring and differences in interplay between any scar and adjacent supporting tissue, no consistent increase was seen with Le Fort I advancement in our cleft population. Rather, 9 out of 11 patients showed a decrease.

Collumellar length, measured from columellar base to height, as one might expect therefore given the observations of columellar width and nasal tip projection, though usually not changed by Le Fort I advancement in the noncleft population, demonstrated a statistically significant decrease in our study population as a whole and in subgroup analysis of single piece advancements. This relationship was not maintained in 2-piece procedures where most showed minimal change, minimal increase or minimal decrease such that no trend could be observed. Data presented here reflect means of both sides of the columellar for bilateral and means of columellar

length of the affected side as well as columellar length of the unaffected side in unilateral clefts. Our data did not demonstrate a difference between columaellar length on the affected versus non-affected side in unilateral clefts.

Nasal labial angle; that subtended by the points of subnasale, pronasale, and labiale superius (the midpoint of the upper lip) showed the greatest variation in our study population of any parameter measured. Hence, why there was no statistically significant trend towards an increase as seen in noncleft patients. Out of 11, 5 patients did show the expectant increase in angle seen in those without clefts, but 6 did not and this seems to be irrespective of the preoperative nasal labial angle acuity. As well as the aforementioned contributory role of postsurgical scarring, perhaps there is a contribution for the variation in nasal labial angle change from the degree of pre-existing three-dimensional malposition of anatomy.

Nasal length, the distance from nasion to pronasale was not changed by Le Fort I advancement in our study. This mirrors the stability of nasal length following maxillary advancement in noncleft populations. Measured changes in our study population were less than 2 mm, and hence not likely practically noticeable, in 9 out of 11 patients.

The key limitation of this study is the sample size. Our sample size is insufficient to determine whether greater changes in nasal aesthetics parameters are seen with greater maxillary advancement, for example. The small cohort is also prohibitory in performing meaningful subgroup analysis of the impact on our findings of cleft etiology, that is, bilateral versus unilateral, cleft lip and palate versus isolated cleft lip or isolated cleft palate, and extent of cleft by Veau classification, all of which we did not distinguish. A further limitation is that our follow up renders us unable to comment on the longevity of these findings and the potential for relapse to pre surgical values. A prospective study with more patients and longer follow-up to define these observations is needed.

Despite these limitations, the results of our study indicate that the increase in interalar width seen following maxillary advancement in the noncleft population is maintained in those with clefts. Our study, however, failed to replicate the increase in internostril distance, the increase in nasolabial angle or the increase in nasal tip projection. This difference may be related to many variables including the significant scarring in the lip and nasal regions from multiple prior procedures but causality remains to be definitively proven.

Our study noted that 2-piece Le Fort I increases the variability of changes in nasal aesthetics in all parameters compared with single-piece advancement, hence the lack of any statistically significant changes in this sub-group analysis. Although this study is limited by the small sample size and relatively short-term follow-up, it holds clinical significance in that midface advancement alone cannot be relied upon to reliable effect desired changes in nasal aesthetics as seen in the noncleft patient populations after maxillary advancement. Rather, these patients will need definitive septorhinoplasty which, given this lack of change, could potentially be performed concomitantly with orthognathic surgery in contrast to the traditional teaching of staged procedures.

CONCLUSIONS

Prior cleft-related surgery with secondary nasal scarring and associated malposition affect changes in nasal aesthetics following maxillary advancement. Patients with cleft lip and palate demonstrate a predictable increase in interalar width and decrease in columellar length as well as a trend to decrease nasal tip projection following Le Fort I osteotomy. Segmentation of Le Fort I osteotomy into two pieces increases the variability of changes in nasal

aesthetics and therefore predictability of outcomes when compared with single-piece advancement.

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REFERENCES

1. Kumar A, Gabbay JS, Nikjoo R, et al. Improved outcomes in cleft patients with severe maxillary deficiency after Le Fort I internal distraction. *Plast Reconstr Surg* 2006;117:1499–1509
2. Erbe M, Stoelinga PJW, Leenen RJ. Long-term results of segmental repositioning of the maxilla in cleft palate patients without previously grafted alveolo-palatal clefts. *J Craniomaxillofac Surg* 1996;24:109–117
3. Stal S, Hollier L. Correction of secondary deformities of the cleft lip nose. *Plast Reconstr Surg* 2002;109:1386–1394
4. Mansour S, Burstone C, Legan H. An evaluation of soft-tissue changes resulting from Le Fort I maxillary surgery. *Am J Orthod* 1983;84:37–47
5. Rosen HM. Lip-nasal aesthetics following Le Fort I osteotomy. *Plast Reconstr Surg* 1988;81:171–179
6. O’Ryan F, Schendel S. Nasal anatomy and maxillary surgery. I. Esthetic and anatomic principles. *Int J Adult Orthodon Orthognath Surg* 1988;4:27–37
7. Betts NJ, Vig KW, Vig P, et al. Changes in the nasal and labial soft tissues after surgical repositioning of the maxilla. *Int J Adult Orthodon Orthognath Surg* 1992;8:7–23
8. Ryckman MS, Harrison S, Oliver D, et al. Soft-tissue changes after maxillomandibular advancement surgery assessed with cone-beam computed tomography. *Am J Orthodon Dentofacial Orthop* 2010;137:S86–S93
9. Honrado CP, Lee S, Bloomquist DS, et al. Quantitative assessment of nasal changes after maxillomandibular surgery using a 3-dimensional digital imaging system. *Arch Facial Plast Surg* 2006;8:26–35
10. Kawauchi M, Sachdeva R, Bossolla E, Mitani H, Wolford LM. Frontal and lateral changes in lip and chin morphology as a result of orthognathic surgery. Abstract presented at ADDR Annual Meeting Boston, MA: March 8–11, 1992.
11. Kawauchi M, Sachdeva R, Bossolla E, Vahadi A, Wolford LM. Nasal dimensional changes in response to maxillary surgery in the lateral and frontal perspective. Abstract presented at ADDR Annual Meeting Boston, MA: March 8–11, 1992.
12. Hui E, Hägg EUO, Tideman H. Soft tissue changes following maxillary osteotomies in cleft lip and palate and non-cleft patients. *J Craniomaxillofac Surg* 1994;22:182–186
13. McCance AM, Moss JP, Fright WR, et al. Three-dimensional analysis techniques-Part I: three-dimensional soft-tissue analysis of 24 adult cleft palate patients following Le Fort I maxillary advancement: a preliminary report. *Cleft Palate Craniofac J* 1997;34:36–45
14. Stewart A, McCance AM, James DR, et al. Three-dimensional nasal changes following maxillary advancement in cleft patients. *Int J Oral Maxillofac Surg* 1996;25:171–177
15. Verzé L, Bianchi FA, Ramieri G. Three-dimensional laser scanner evaluation of facial soft tissue changes after Le Fort I advancement and rhinoplasty surgery: patients with cleft lip and palate vs patients with nonclefted maxillary retrognathic dysplasia (control group). *Oral Surg Oral Med Oral Pathol Oral Radiol* 2014;117:416–423
16. Maull DJ, Grayson BH, Cutting CB, et al. Long-term effects of nasoalveolar molding on three-dimensional nasal shape in unilateral clefts. *Cleft Palate Craniofac J* 1999;36:391
17. McCollough EG, Mangap D. Systematic approach to correction of the nasal tip in rhinoplasty. *Arch Otolaryngol* 1981;107:12
18. Mulliken JB. Repair of bilateral complete cleft lip and nasal deformity: state of the art. *Cleft Palate Craniofac J* 2000;37:342
19. Daskalogiannakis J, Mehta M. The need for orthognathic surgery in patients with repaired complete unilateral and complete bilateral cleft lip and palate. *Cleft Palate Craniofac J* 2009;46:498–502
20. Fisher DM, Lo LJ, Chen YR, et al. Three-dimensional computed tomographic analysis of the primary nasal deformity in 3-month-old infants with complete unilateral cleft lip and palate. *Plast Reconstr Surg* 1999;103:1826–1834

Clinical and Radiologic Characteristics of Inferior Rectus Muscle Sheath Entrapment in Orbital Blowout Fracture

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Abstract: Blowout fracture is a common condition in the oculo-plastics clinic. One of the indications for its repair is entrapment of the inferior rectus muscle within the fracture site. Herein, the authors present 3 patients of inferior rectus muscle sheath entrapment without entrapment of the muscle itself. The outcome of treatment was excellent in all patients. The aim of this report is to present the special clinical and radiologic findings in such patients.

Key Words: Blowout fracture, inferior rectus, muscle entrapment, muscle sheath

Blowout fracture is a common condition faced by oculoplastic surgeons. The most common sites of fracture are the orbital floor and medial wall.¹ Orbital wall fractures most frequently occur in men, most commonly in the third decade of life. Orbital fractures are associated with other injuries, including other facial fractures and eye trauma in 70% of patients; damage rarely occurs in isolation.^{2,3} Imaging, especially computed tomography (CT) scan is required for evaluation of orbital fractures and demonstrates the characteristics of the injury, including size and location of the fracture and also entrapment of orbital tissues within the fracture.⁴ Entrapment of the inferior rectus muscle in the fracture site is a common event in such fractures and also an indication for early surgical repair, however, entrapment of the muscle sheath and perimuscular soft tissues within the fracture has not ever been described.

Herein, we present 3 patients with blowout orbital fractures accompanied by entrapment of inferior rectus perimuscular fascia and muscle sheath sparing of the bulk of the muscle. The aim of this report is to present the special clinical and radiologic findings of this condition and describe outcomes of treatment.

PATIENT 1

A 45-year-old man was presented 3 weeks after a car accident complaining of diplopia. Visual acuity was 20/20 in both eyes. Biomicroscopic examinations of the anterior segment and fundus examination were normal. Exophthalmometry revealed 3 mm of enophthalmos in his left eye. In straight gaze, the left eye had hypotropia, mild ptosis and a deep superior sulcus (Fig. 1A) and

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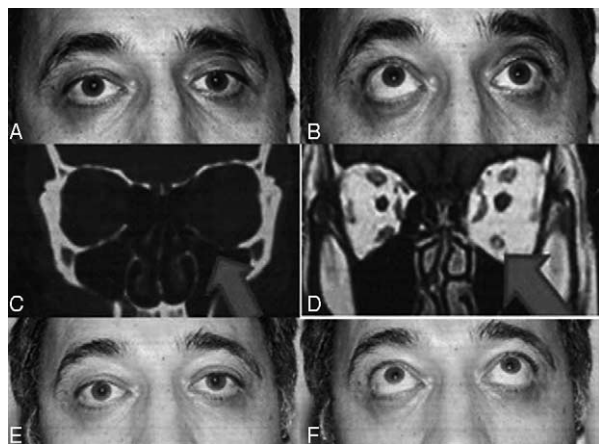


FIGURE 1. Patient 1, A, Appearance of the patient before surgery in primary gaze. B, Patient before surgery in upgaze. C, Coronal orbital CT scan showing the orbital floor fracture (arrow) without muscle entrapment. D, Coronal orbital MRI showing muscle rounding (arrow) without entrapment. E, The patient after surgery in primary gaze. F, Appearance of the patient after surgery in upgaze. CT, computed tomography; MRI, magnetic resonance imaging.

there was mild limitation in upward gaze (Fig. 1B). The patient had vertical diplopia, which was corrected with a 14 PD base up prism in front of the left eye. Forced duction test for elevation of the left eye was mildly positive.

Orbital floor fracture was observed on the coronal CT scan (Fig. 1C, arrow) with no sign of inferior rectus muscle entrapment. Magnetic resonance imaging (MRI) revealed roundness of the inferior rectus muscle (Fig. 1D). During surgery, muscle sheath entrapment with no impingement of the inferior rectus muscle itself was evident. The inferior rectus sheath was released and the maxillary bone fracture was repaired with a Medpor plate of 1.6 mm thickness (Porex Surgical Inc., College Park, GA). At the end of the surgery, forced duction test was negative.

Diplopia in primary gaze improved the day after surgery, and pseudoptosis and deep superior sulcus were also relieved. One month after surgery, diplopia had resolved and ocular movements were full in all gazes (Fig. 1E-F). Three months after surgery, exophthalmometric readings of both eyes were equal and during 8 years of follow-up, his condition was stable.

PATIENT 2

A 14-year-old boy was referred because of reduced vision and diplopia of 2 weeks' duration after his left eye was hit by his knee during exercise.

In ophthalmic examination, visual acuity was 20/20 in the right eye and 20/30 in the left eye. Subconjunctival hemorrhage was evident in his left eye. In biomicroscopic examination, microscopic hyphema was present in the anterior chamber of the left eye and 3 sites of iris sphincter rupture were also noted. Intraocular pressure was normal and posterior segment examination was unremarkable.

The left eye was hypotropic in primary position, which was corrected with an 8 PD base up prism in front of the left eye. There was a mild limitation in upward gaze but no limitation in downward gaze (Fig. 2A-C). Exophthalmometry, revealed 2 mm of enophthalmos in his left eye. Forced duction test for elevation of the left eye was mildly positive.

Fracture of the left orbital floor with entrapment of soft tissues was demonstrated in the coronal view of CT scan (Fig. 2D). In addition it was noted that the inferior rectus muscle has changed

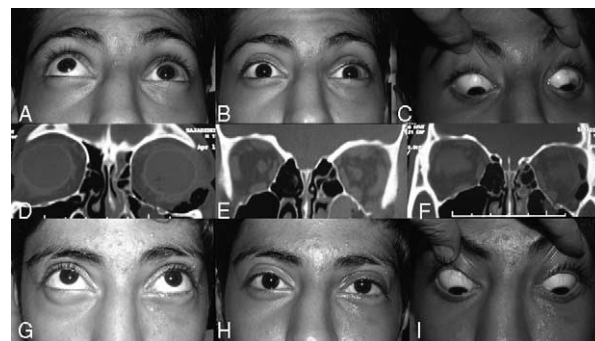


FIGURE 2. Patient 2, A, Appearance of the patient before surgery in upgaze. B, Appearance of primary position before surgery. C, Downgaze before surgery. D-F, Coronal orbital CT scan in different levels showing orbital floor fracture and air in the orbit together with muscle rounding without entrapment. G, Patient's appearance after surgery in upgaze. H, The patient after surgery in primary gaze. I, Downgaze after surgery. CT, computed tomography.

from its normal flat configuration to a round shape in these sections but it was not grossly entrapped (Fig. 2E-F).

Orbital floor repair surgery was performed via a subciliary incision. After exposure of the orbital floor fracture, there was no evidence of inferior rectus muscle entrapment and the entrapped soft tissues were easily released and forced duction test changed to negative. The fracture was repaired with a Medpor plate with 1.6 mm thickness.

The day after surgery, the patient did not complain of diplopia in primary position. Two months following surgery, no enophthalmos was detected and the eyes were aligned (Fig. 2H). In addition, limitation in upward gaze was resolved (Fig. 2G) and there was no limitation in downgaze (Fig. 2I). He was stable after 3 years of follow up.

PATIENT 3

A 10-year-old boy was presented with double vision and abnormal eye movements since 4 weeks ago following a car accident injury. Visual acuity was 20/20 in both eyes and biomicroscopic examination and funduscopy were unremarkable. A significant chin up posture was evident (Fig. 3D) and there was right hypotropia of 10 PD and moderate limitation of elevation and no limitation in depression in the right eye (Fig. 3A-C). Exophthalmometry values were equal in 2 eyes.

Orbital CT scan demonstrated a trap door orbital floor fracture, perimuscular soft tissue involvement, and rounding of the inferior rectus muscle on related sections (Fig. 3E-F). Forced duction test was performed after the patient was anesthetized in the operating

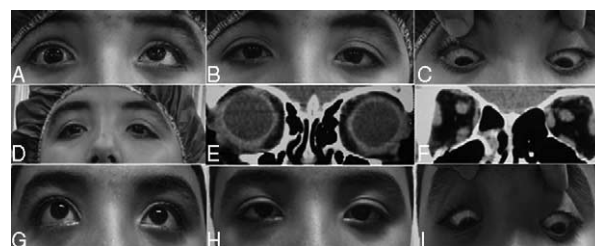


FIGURE 3. Patient 3, A, Patient's appearance before surgery in upgaze. B, Patient before surgery in primary position. C, Patient before surgery in downgaze. D, Chin up posture before surgery. E-F, Coronal orbital CT scan in 2 levels showing the trapdoor floor fracture and muscle rounding without entrapment. G, Patient after surgery in upgaze. H, Patient after surgery in primary gaze. I, Patient after surgery in downgaze. CT, computed tomography.

room and showed mild limitation in upward gaze. Orbital exploration was performed through a transconjunctival incision. Perimuscular soft tissue was found to be entrapped within the fracture site, which was released easily and subsequently forced duction was free. A 1 mm orbital Medpor sheet was placed over the fracture site.

Two weeks after the operation, diplopia was completely relieved and right eye movements were perfect (Fig. 3G-I). He remained normal and free of symptoms after 1-year follow-up.

DISCUSSION

Inferior rectus muscle entrapment is a well-known complication of orbital blowout fractures, but entrapment of inferior rectus sheath and perimuscular fascia without involvement of the muscle itself, has not ever been described.

Enophthalmos is a prominent clinical presentation in many patients with blowout fractures and is related to orbital volume expansion and herniation of orbital contents into adjacent spaces.⁵ Enophthalmos in our patients was mild probably because of minimal involvement of orbital soft tissues.

Other important preoperative findings in our patients included mild to moderate limitation of upward gaze, slight positivity of the forced duction test, and lack of significant downward limitation. Extraocular movement limitations usually result from muscle entrapment, muscle injury, nerve damage, and incarceration of the soft tissues adjacent to the muscles.⁶ Patients with inferior rectus muscle entrapment demonstrate hypotropia in primary gaze accompanied by limitation of upgaze above the midline and significant positive forced duction test.⁷ Even though our patients experienced hypotropia of the involved eyes in primary position, upward gaze restriction was modest and forced duction test was only slightly positive, which confirm the lack of entrapment of the muscle belly. In addition, intact downward rotation of eyes suggests lack of significant trauma to the inferior rectus muscle.

An interesting radiologic finding noted on CT scan of all 3 subjects was rounding of the Inferior rectus muscle section, which may be the result of traction from the incarcerated perimuscular tissues on the muscle belly. Some authors have proposed that disruption of the orbital periosteum and subsequent soft tissue herniation can cause a change in the position and resting shape of extraocular muscles. In addition, rounding of the inferior rectus muscle section may be a predictor of traumatic enophthalmos.^{8,9} Suggested mechanisms of rounding of the inferior rectus muscle section include intramuscular hemorrhage and edema, loss of orbital bone and soft tissue support, the effect from gravity, and muscle foreshortening after retro-displacement of the globe.¹⁰

In a survey of patients with blowout fractures, Gilbard et al classified the patients, according to the position of the inferior rectus muscle in relation to the fracture site. They found 3 distinct categories of fractures. In the first group (termed “free”) the muscle was not continuous with any bone density. In the second group (termed “hooked”), the inferior rectus was in continuity with bone along one side, leaving the majority of the muscle continuous only with soft tissue or fat densities. In the third group, the muscle was entrapped by bone both nasally and temporally.¹¹ Clinical and radiologic findings of our patients are compatible with the second (hooked) group of Gilbard’s classification. He believed that diplopia and positive FDT are found in all patients in the hooked group at presentation; however, these findings will resolve within 1 month in all subjects and therefore suggested that these patients be treated conservatively. In contrast to this recommendation, diplopia, movement limitation and positive FDT did not resolve in our patients spontaneously and all of them required surgical intervention.

The significant intraoperative finding was that despite a time interval of a few weeks since the incident, entrapped tissues were

released easily and forced duction became completely negative. This is in contrast with patients in whom muscle tissue entrapment is present and the results of surgery are not as favorable. Full recovery of diplopia and upward limitation of movement after surgery without inducing limitation in down gaze were noticeable postoperative findings in all of our patients. This also indicates the absence of inferior rectus muscle manipulation during surgery.

In conclusion perimuscular fascia and muscle sheath entrapment sparing the muscle belly is a rare form of blowout fracture that causes diplopia with special clinical and radiographic presentations. Preoperative identification of these patients may have prognostic significance for surgery and final outcomes.

REFERENCES

1. Smith B, Regan WF Jr. Blow-out fracture of the orbit: mechanism and correction of internal orbital fracture. *Am J Ophthalmol* 1957;44:733–739
2. Kelley P, Crawford M, Higuera S, et al. Two hundred ninety-four consecutive facial fractures in an urban trauma center: lessons learned. *Plast Reconstr Surg* 2005;116:42e–47e
3. Mucci B. A new perspective on blow-out fracture of the orbit. *Injury* 1997;28:555–556
4. Cruz A, Eichenberger G. Epidemiology and management of orbital fractures. *Curr Opin Ophthalmol* 2004;15:416–421
5. Lee JW, Chiu HY. Quantitative computed tomography for evaluation of orbital volume change in blow-out fractures. *J Formos Med Assoc* 1993;92:349–355
6. Manson PN. Facial fractures. In: Mathes SJ, ed. *Plastic Surgery*. 2nd ed. Philadelphia, PA: Elsevier Inc; 2006:264–305
7. Hall LS, McCann JD, Goldberg RA, et al. Strabismus after orbital fractures and sinus surgery. In: Rosenbaum AL, Santiago AP, eds. *Clinical Strabismus Management: Principles and Surgical Techniques*. Philadelphia, PA: Saunders; 1999:309–322
8. Banerjee A, Moore CC, Tse R, et al. Rounding of the inferior rectus muscle as an indication of orbital floor fracture with periorbital disruption. *J Otolaryngol* 2007;36:175–180
9. Chiasson G, Matic DB. Muscle shape as a predictor of traumatic enophthalmos. *Craniomaxillofac Trauma Reconstr* 2010;3:125–130
10. Matic DB, Tse R, Banerjee A, et al. Rounding of the inferior rectus muscle as a predictor of enophthalmos in orbital floor fractures. *J Craniofac Surg* 2007;18:127–132
11. Gilbard SM, Mafee MF, Lagouros PA, et al. Orbital blowout fractures. The prognostic significance of computed tomography. *Ophthalmology* 1985;92:1523–1528

Analysis of Long-Term Prognosis and Prognostic Predictors in Severe Brain Injury Patients Undergoing Decompressive Craniectomy and Standard Care

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Abstract: Decompressive craniectomy (DC) is widely used to treat acute subdural haematoma and hemispheric swelling following traumatic brain injury (TBI). The therapeutic effect of DC on severe TBI treatment is still controversial. The aim of our study was to evaluate effectiveness of DC treatment and seek some prognostic

predictors. According to the therapy method, we divided the patients into 2 groups: DC group and standard care group. Between 2010 and 2014, a total number of 223 severe TBI patients, containing 112 patients undergoing DC and 111 patients undergoing standard care, were enrolled into the study according to Glasgow Coma Scale (GCS). The long-term prognosis was evaluated by Extended Glasgow Outcome Scale 12 months after discharging from hospital. We used univariate analysis and receiver operating characteristic curves to explore prognostic predictors. The results showed that patients in the DC group had a lower mortality, but there was no statistical significance in long-term prognosis between these 2 groups. It seemed that admission GCS, platelet, neutrophile granulocyte, total protein, and albumin were associated with long-term prognosis in DC group and reactivity of pupils in standard care group. Simultaneously, using the multivariable logistic regression model, we confirmed that admission GCS and albumin were independent prognostic predictors for patients undergoing DC, and reactivity of pupils for those undergoing standard care. Our data suggested that DC was an effective therapy for severe TBI patients in reducing mortality, but it failed to improve long-term prognosis. Through our study, we could comprehend the characteristics of the 2 treatments and provide more scientific individuation therapy for severe TBI patients.

Key Words: Decompressive craniectomy, long-term prognosis, prognostic predictors, traumatic brain injury

In developing countries, the incidence of traumatic brain injury (TBI) is rapidly rising. In some countries, one in every 200 families suffers from severe TBI. The mortality of severe TBI is decreasing in recent years, but survivors face a lower life expectancy than the general population.¹ The dynamic pathophysiological process of TBI included 2 stages: the primary injury and the secondary injury. Brain oedema is the most vital component of the secondary injury which will increase intracranial pressure (ICP) and reduce cerebral perfusion. A series of physiological changes following brain oedema give rise to unfavourable prognosis.² Even though, medical and surgical therapies are performed to minimize brain injury, the management of TBI remains a major public health problem at the present time.

Decompressive craniectomy (DC), as an effective surgical management of reducing intracranial pressure, has been recommended as a second-tier treatment for intracranial hypertension in severe TBI and also frequently undertaken for acute subdural haematoma, severe contusions, and unihemispheric swelling

after TBI. Although DC is conformed to be one of the most effective treatments in reducing ICP,³ the study of Cooper⁴ showed that the DC group may be associated with a worse functional outcome than the standard care group. This trial was of high quality. However, the evidences of the study were insufficient, and the reasons are as follows. The definition of thresholds for medically refractory intracranial hypertension was uncertain. The study was difficult to generalize all patients with severe nonpenetrating TBI. More patients in DC group than patients in standard care group had fixed or dilated pupils that may affect the results. Bilateral craniectomy performed in the trial was associated with a higher complication rate. The time interval from the head injury to subsequent surgery was too long. Therefore, the effect of DC in severe TBI is still indeterminacy.

Hence, we retrospectively enrolled severe TBI patients to assess the therapeutic effect and meanwhile prolonged the revisit time to 12 months after discharging from hospital and added some new valuation indicators such as the cerebral mass lesion of patients. We also analyzed the prognostic predictors which may provide us with another avenue to re-recognize the DC treatment for severe TBI patients.

METHODS

Patient Eligibility

From January 2010 to April 2014, we retrospectively collected a total number of 1780 adults with TBI in Tianjin Medical University General Hospital, China. Men and nonpregnant women were enrolled into the trial if they were between the ages of 18 and 59 years and had a severe traumatic brain injury defined as a score of 3 to 8 on Glasgow Coma Scale (GCS). Patients were excluded if they had dilated pupils, spinal cord injury, or cardiac arrest on admission or had dyskinesia before injury. Data collection and analysis were approved by the ethics committee of Tianjin Medical University. An informed consent was signed by each patient or patient's legal representative before enrollment.

Data Collection

Data collection was performed retrospectively from review of medical charts and a database. Patients were recruited from this database on the basis of diagnoses. All patients were reviewed on the basis of medical files, laboratory test results (in acute period about 2–3 days), operation reports, intensive care nursing records. Relatives of patients were also contacted to obtain missing data, especially concerning the long-term prognosis or for patients living far from the hospital. Demographic data of the patient's age, sex, etc. were recorded, and hospital data including the GCS on admission, the presence of unilateral or bilateral reactive pupils, etc. were also recorded. All initial imaging examinations were reviewed with description of the lesions.

Medical Treatment

DC was performed to remove the skull, depending on the location and volume of hematoma (supratentorial ICH >30 mL). The volume of hematoma was calculated through computed tomography (CT) scan. The choice of therapeutic schemes was dependent on the needs of patients' relatives and the condition of patients. Therapeutic schemes including head elevation, sedation, hyperosmolar therapy (using 20% mannitol every 6 hours or every 8 hours), cerebral spinal fluid (CSF) drainage (insertion of a catheter through a ventriculostomy into the anterior horn of one of the ventricles) adopted to keep intracranial pressure below 20 mm Hg. Patients in standard care group were cured following by clinical practice guidelines⁵ recommended by the Brain Trauma

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Foundation, and hyperosmolar therapy was performed based on imaging and clinical examination.

Prognosis Measures

The revisit was implemented by telephone after patient discharging from hospital until 12 months. The original primary prognostic indicators were mortality and the proportion of patients with an unfavorable prognosis, a component of death, a vegetative state or severe disability (a score of 1–4 on the Extended Glasgow Outcome Scale) assessed with the use of a structured, validated telephone questionnaire.⁶ Extended Glasgow Outcome Scale (GOSE) ranges from 1 to 8, with lower scores indicating a poorer functional outcome. Secondary outcomes were the numbers of days in the ICU and the hospital, the days of mechanical ventilation. All assessments of GCS and GOSE were operated by 2 neurosurgeons separately.

Statistical Analysis

Shapiro–Wilk test was used to evaluate whether data fit the normal distribution. According to the type of variables, the clinic information of the patients was presented as number (%), means $\pm$ SD, or median (interquartile range [IQR]). The differences between DC group and standard care group, favorable, and unfavorable groups were compared by the Pearson χ^2 test, Student unpaired *t* test, or Mann–Whitney *U* test. A multiple logistic regression model was performed to evaluate the independent predictors of long-term prognosis. Odds ratios (OR) and 95% confidence interval (CI) were reported. Receiver operating characteristic (ROC) curves and the areas under the curves (AUC) were used to predict long-term prognosis. All analyses were carried out in SPSS for windows version 16.0 (SPSS Inc, Chicago, IL) and *P* < 0.05 was considered statistically significant.

RESULTS

Patient's Basic Characteristics

A total of 1780 TBI patients were enrolled in the database. According to the inclusion and exclusion criteria, a total of 223 patients, containing 112 severe TBI patients undergoing DC and 111 patients undergoing standard care, were enrolled in the study. The basic characteristics were no statistical difference between DC and standard care groups (Table 1).

Long-Term Prognosis

As shown in Table 2, 12 months after discharging from hospital, the mortality in DC group was lower than standard care group, but DC failed to improve the long-term prognosis according to the GOSE. There was no statistical difference in days in the ICU and the total time in the hospital. Days of mechanical ventilation in DC group were longer than standard group.

Variables Associated With Long-Term Prognosis

As shown in Table 3, admission GCS, platelet, neutrophile granulocyte, total protein, and albumin were associated with long-term prognosis according to GOSE in DC group. Moreover, reactivity of pupils was associated with long-term prognosis according to GOSE in standard care group.

Predictors for Long-Term Prognosis

Based on the previous results, we analyzed potential predictors for long-term prognosis in DC group by ROC curves and AUC. In DC

group, the analysis identified positive correlation predictors: admission GCS = 5.5, total protein = 53.05 g/L, albumin = 29.05 g/L, platelet = 127.5×10^9 /L as the cutoff points for sensitive and specific long-term prognosis thresholds (AUC of admission GCS = 0.678 ± 0.050 , 95% CI = 0.579–0.777, *P* = 0.001, sensitivity = 69.8%, specificity = 57.6%, AUC of total protein = 0.699 ± 0.049 , 95% CI = 0.620–0.795, *P* = 0.001, sensitivity = 90.6%, specificity = 39%, AUC of albumin = 0.692 ± 0.049 , 95% CI = 0.596–0.788, *P* = 0.001, sensitivity = 88.7%, specificity = 37.3%, AUC of platelet = 0.623 ± 0.053 , 95% CI = 0.520–0.727, *P* = 0.025, sensitivity = 80.7%, specificity = 27.1%). And the negative correlation predictors was neutrophile granulocyte = 75.64×10^9 /L as the cutoff point for a sensitive and specific long-term prognosis threshold (AUC = 0.6481 ± 0.025 , 95% CI = 0.539–0.743, *P* = 0.01, sensitivity = 83.1%, specificity = 41.5%) (Fig. 1).

Analysis of Independent Predictors for Long-Term Prognosis

According to the previous results, we added some predictors to adjust our identified predictors. In the DC group, using a multi-variable logistic regression model, albumin (OR = 1.121, 95% CI = 1.001–1.151, *P* = 0.004) and GCS (OR = 1.414, 95% CI = 1.079–1.853, *P* = 0.012) were independently associated with long-term prognosis after adjustment of age, platelet, neutrophile granulocyte, and pre-op pupil reaction (Table 4). And in standard care group, pupil reaction (OR = 3.584, 95% CI = 1.027–12.501, *P* = 0.045) was independently associated with long-term prognosis after adjustment of age, platelet, neutrophile granulocyte, pupil reaction, and albumin (Table 5).

DISCUSSION

Role Decompressive Craniectomy Plays in the Treatment of Severe Traumatic Brain Injury Patients

A series of clinical studies demonstrated that DC is one of the most effective treatments in decreasing intracranial pressure (ICP).^{3,7} A multicenter randomized controlled trial (RCT) by Cooper⁴ conformed that early DC was associated with unfavorable prognosis. Given the deficiencies mentioned above, we prolonged the revisit time from 6 months to 12 months. We found DC failed to improve long-term prognosis but had the ability to reduce the mortality compared to standard care group (especially for the admission GCS < 5 TBI patients, the data were not shown). Meanwhile, DC was unable to shorten days of ventilation, days of ICU, and days of hospitalization. DC could enhance the brain perfusion, relieve the brain pressure, and reduce the risk of cerebral hernia. Meanwhile, DC allowed the expansion of the swollen brain outside the skull and caused axonal stretch^{8,9} which in turn caused neural injuries.^{10–12} Alterations in cerebral blood flow and metabolism may also be relevant.^{13,14} Furthermore, harmful complications caused by DC also accounted for the unfavorable prognosis.^{15,16} So we recommended DC should be performed as a second-tie therapy for life saving and reducing ICP not first-tie therapy for severe TBI patients.

Prognostic Predictors in Severe Traumatic Brain Injury

The present studies have indicated that there are associations between some clinical indicators and prognosis of TBI.¹⁷ But, there are few studies focusing on finding different clinical indicators between TBI patients undergoing operation and standard care.

TABLE 1. Basic Characteristics of Patients (GCS3-8)

Variables	DC	Standard Care	P Value*
Characteristic	112	111	
Age, yr			0.267
Median	50	44	
Interquartile range	33.25–55	33–52	
Male sex, no. (%)	92 (82.14)	82 (70.87)	0.136
Glasgow Coma Scale [†]			0.890
Median	6	6	
Interquartile range	4–7	4–7	
Reactivity of pupils, no. (%)			0.243
One or both reactive	78 (69.6)	85 (76.6)	
None reactive	34 (30.4)	26 (23.4)	
Cause of injury, no. (%)			0.213
Traffic accident	51 (45.5)	63 (56.8)	
High falling injury	15 (13.4)	14 (12.6)	
Other	46 (41.1)	34 (30.6)	
Hypotension, no. (%)	13/112 (11.6)	15/111 (13.5)	0.668
Traumatic subarachnoid hemorrhage, no. (%)	44 (39.3)	51 (45.9)	0.342
Traumatic contusion or hematoma, no. (%)	49 (43.8)	44 (39.6)	0.534
Injury Severity Score [‡]			0.080
Median	22	26	
Interquartile range	0–34	12–35	
Marshall class, no. (%) [§]			0.101
I (%)	2/112 (1.8)	4/111 (3.6)	
II (%)	25/112 (22.3)	28/111 (25.2)	
III (%)	27/112 (24.1)	25/111 (22.5)	
IV (%)	30/112 (26.8)	38/111 (34.2)	
V (%)	26/112 (23.2)	11/111 (9.9)	
VI (%)	2/112 (1.8)	5/111 (4.5)	

DC, decompressive craniectomy.

* All *P* values were calculated with the use of the χ^2 test to compare proportions or the Wilcoxon rank-sum test to compare distributions.[†] The overall score on the Glasgow Coma Scale ranges from 3 to 15, with lower scores indicating reduced levels of consciousness.[‡] The injury severity score ranges from 0 to 75, with higher scores indicating greater injury severity.[§] The Marshall classification is based on findings on computed tomography, with higher class indicating greater injury severity.**TABLE 2.** Primary and Secondary Prognosis

Variables	DC	Standard Care	P Value*
Days of mechanical ventilation			
median	1	0	<0.001
Interquartile range	0–2	0–1	
Days of ICU stay			0.053
median	10	7	
Interquartile range	4–19	3–14	0.684
Days of hospitalization			
median	22.5	26	
Interquartile range	9.25–60.25	7–50	
Extended Glasgow Outcome Scale			
Score, no. (%)			0.012
1 (dead)	36/112 (32.1)	54/111 (48.6)	
2 (vegetative state)	5/112 (4.5)	7/111 (6.3)	0.152
3 (lower severe disability)	11/112 (9.8)	5/111 (4.5)	
4 (upper severe disability)	7/112 (6.3)	4/111 (3.6)	
5 (lower moderate disability)	9/112 (8.0)	5/111 (4.5)	
6 (upper moderate disability)	9/112 (8.0)	7/111 (6.3)	
7 (lower good recovery)	15/112 (13.4)	12/111 (10.8)	
8 (upper good recovery)	20/112 (17.9)	6/111 (13.0)	
Unfavorable score of 1 to 4-no. (%)	30/56 (53.6)	17/111 (15.3)	

* All *P* values were calculated with the use of χ^2 test to compare proportions or Wilcoxon rank-sum test to compare distributions.

TABLE 3. Relationship of Variables to the GOSE of TBI Patients Undergoing DC or Standard Care at 1 Year Following Univariate Analysis

Variables	DC			Standard Care		
	Favorable	Unfavorable	P Value*	Favorable	Unfavorable	P Value*
Age, yr Mean $\pm$ SD	44.6 $\pm$ 12.6	44.4 $\pm$ 12.7	0.946	42.2 $\pm$ 9.5	43.0 $\pm$ 12.7	0.700
Glasgow Coma Scale			0.013			0.891
Median	7	5		6	5	
Interquartile range	5–8	4–7		4–7	4–7	
Male sex, no. (%)	43 (81.1)	48 (81.4)	0.976	28 (68.3)	54 (77.1)	0.306
Days of ICU stay, mean $\pm$ SD	16.8 $\pm$ 13.2	14.8 $\pm$ 23.8	0.590	11.8 $\pm$ 15.6	11.2 $\pm$ 13.7	0.824
Days of hospitalization			0.466			0.141
median	31	23		36	26	
Interquartile range	14–78.0	15.5–57.0		19–73	13–46.5	
Open craniocerebral injury, no. (%)	24 (45.3)	32 (54.2)	0.344	12 (29.3)	23 (32.9)	0.695
Reactivity of pupils, no. (%)			0.812			0.033
One or both pupils	36 (67.9)	42 (71.2)		36 (87.8)	49 (70.0)	
Neither pupil	17 (32.1)	18 (28.8)		5 (12.2)	21 (30.0)	
Injury severity score			0.936			0.092
Median	22	22		29	24	
Interquartile range	0–35	0–33		14–41	6–34	
Hypotension, no. (%)	4 (7.5)	9 (15.3)	0.204	8 (19.5)	7 (10.0)	0.157
Traumatic subarachnoid hemorrhage, no. (%)			0.218			0.056
	24 (45.3)	20 (33.9)		14 (34.1)	37 (52.9)	
White cell, $10^9/L$, mean $\pm$ SD	12.07 $\pm$ 6.06	13.15 $\pm$ 6.75	0.377	11.34 $\pm$ 4.47	13.94 $\pm$ 5.99	0.585
Red cell, $10^{12}/L$, mean $\pm$ SD	3.57 $\pm$ 0.72	3.84 $\pm$ 0.84	0.064	3.98 $\pm$ 0.72	3.90 $\pm$ 1.08	0.653
Hemoglobin, g/L, mean $\pm$ SD	109.70 $\pm$ 22.69	115.95 $\pm$ 26.49	0.185	119.66 $\pm$ 20.64	114.77 $\pm$ 23.12	0.266
Platelet, $10^9/L$, mean $\pm$ SD	247.17 $\pm$ 128.14	194.27 $\pm$ 97.48	0.015	254.90 $\pm$ 124.32	232.51 $\pm$ 154.46	0.431
Neutrophile granulocyte, $10^9/L$, mean $\pm$ SD	76.87 $\pm$ 13.33	82.99 $\pm$ 9.56	0.006	82.22 $\pm$ 9.51	81.10 $\pm$ 14.88	0.665
APTT-Sec - Mean $\pm$ SD	27.48 $\pm$ 7.28	33.79 $\pm$ 25.09	0.080	28.23 $\pm$ 8.08	32.05 $\pm$ 12.88	0.090
PT-Sec, mean $\pm$ SD	12.10 $\pm$ 1.58	12.46 $\pm$ 1.96	0.284	11.73 $\pm$ 0.99	12.25 $\pm$ 2.59	0.141
PT-INR, mean $\pm$ SD	1.06 $\pm$ 0.12	1.07 $\pm$ 0.17	0.622	1.03 $\pm$ 0.09	1.08 $\pm$ 0.21	0.104
Fibrinogen, g/L, mean $\pm$ SD	2.27 $\pm$ 1.33	2.08 $\pm$ 1.69	0.504	2.72 $\pm$ 1.00	2.67 $\pm$ 1.60	0.864
Ddimer, ng/mL			0.770			0.155
Median	2952	3342		2167	4125	
Interquartile range	1166–8667	1409–6691		1112–5250	1240–8649	
TT-Sec, mean $\pm$ SD	16.98 $\pm$ 2.56	18.92 $\pm$ 11.56	0.233	17.89 $\pm$ 5.12	19.12 $\pm$ 5.88	0.269
Total protein, g/L, mean $\pm$ SD	64.13 $\pm$ 8.36	59.71 $\pm$ 11.41	0.020	63.9 $\pm$ 9.28	61.81 $\pm$ 11.10	0.312
Albumin, g/L, mean $\pm$ SD	35.87 $\pm$ 5.60	32.22 $\pm$ 7.55	0.005	36.78 $\pm$ 6.74	34.90 $\pm$ 6.65	0.208
Globulin, g/L, mean $\pm$ SD	28.25 $\pm$ 5.40	27.44 $\pm$ 6.26	0.472	26.88 $\pm$ 6.01	26.64 $\pm$ 6.65	0.848

* All P values were calculated with the use of the χ^2 test to compare proportions or the Wilcoxon rank-sum test to compare distributions.

Therefore, we retrospectively examined a set of 25 potential predictors in DC and standard care groups. It turned out that admission GCS, platelet, neutrophile granulocyte, total protein, and albumin were correlated to long-term prognosis in DC group and reactivity of pupils in standard care group.

The prognosis of TBI could be predicted by GCS.¹⁸ We found that GCS was a prognostic predictor to severe TBI patients undergoing DC. Bernardino et al¹⁹ investigated GCS score <6

increased 7-folds risk of complications incidence rate in severe TBI patients postdischarge, which was consistent with our results. We also discovered GCS was an independent prognostic predictor in DC group. This may indicate that impact of GCS on DC patients was not influenced by other clinical factors.

Similarly, we found low level of neutrophile granulocyte was associated with favorable prognosis of patients undergoing DC. Neutrophils had connections with inflammatory conditions of the brain and recruited to brain injury site in acute traumatic period.²⁰ Several studies had found that excessive activation of polymorphonuclear neutrophil (PMN) may result in secondary brain injury.²¹ Thus, high level of neutrophile granulocyte may contribute to unfavorable prognosis of TBI patients.

Pupil reactivity was correlated to prognosis that had been reported in previous reports, including TBI studies.²² It was believed that most patients who had both pupils fixed had unfavorable prognosis. However, Carter et al reported that nearly 20% of patients with bilaterally absent pupillary response had favorable prognosis.²³ According to our results, pupil reactivity had relation with prognosis in standard care group and was an independent

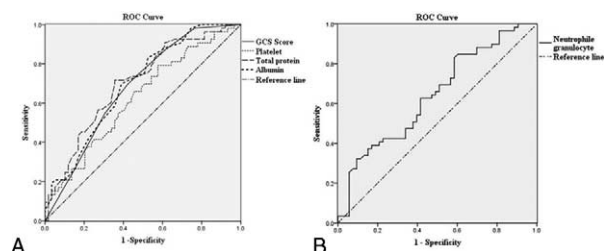


FIGURE 1. The model of ROC curves was performed in DC (A,B). DC, decompressive craniectomy; ROC, receiver operating characteristic.

TABLE 4. Multivariable Logistic Regression for Factors Associated With Long-Term Outcome in DC Group

Variable	Crude		Adjusted	
	OR* (95% CI) [†]	P [‡]	OR (95% CI)	P [‡]
GCS	1.504 (1.181–1.914)	0.001	1.414 (1.079–1.853)	0.012
Age	1.001 (0.972–1.031)	0.945	1.000 (0.965–1.036)	0.993
Platelet	1.004 (1.001–1.008)	0.020	1.002 (0.998–1.006)	0.349
Neutrophile granulocyte	0.954 (0.920–0.988)	0.009	0.973 (0.936–1.012)	0.168
Pre-op pupil reaction	0.857 (0.383–1.920)	0.708	0.598 (0.228–1.571)	0.297
Albumin	1.087 (1.037–1.213)	0.007	1.121 (1.001–1.151)	0.004

* Odd ratio for a low incidence of disease is the accurate estimates value of relative risk. When the value is equal to 1, the factor has no influence on the incidence of disease, when greater than 1, it means a protective factor, otherwise it is a risk factor.

[†] Confidence interval can be used to estimate the population parameter. The narrower scope is the reliability of the sample indicators to estimate the population parameter is better.

[‡] All P values were calculated with the use of multivariable logistic regression to test the statistical difference of the variables.

predictor. The impact of pupil reactivity on DC patients may be affected by other clinical factors.

Albumin plays an important role in many physiological functions.²⁴ There was a decline of serum albumin in TBI patients. P38 mitogen activated protein kinase was the action target of albumin and the activation of myosin light chain kinase following TBI may lead to damage blood–brain barrier (BBB).²⁵ The damage of BBB integrity might be the reason for unfavorable prognosis of TBI caused by reduced albumin. Performing surgery, such as DC, could aggravate the decline of albumin because invasive procedure increased extravasation of albumin. Our results showed that low concentration of albumin predicted unfavorable prognosis of severe TBI patients and was an independent predictor in DC group. Albumin played an important role in the prognosis of patients undergoing DC. The results also raised a question whether albumin level should be elevated and what is the best level. A clinical trial²⁶ reported that in critically ill patients with TBI, fluid resuscitation with albumin was associated with higher mortality rates than saline. This may be caused by the increase of intracranial pressure. On the contrary, there were evidences that showed albumin administration in combination with a neutral to a slightly negative fluid balance was associated with low mortality in patients with severe TBI.²⁷ Based on related studies and our results, low level of serum albumin was a risk factor for long-term prognosis of TBI. Although this viewpoint was still controversial, we believe that it would be better to maintain a moderately high level of serum albumin for severe TBI patients.

Recent studies had confirmed that coagulopathy had a close connection with the prognosis of TBI patients.²⁸ That may

be associated with the development of many secondary complications.²⁹ We found that in DC group platelet count was associated with long-term prognosis rather than other coagulation indicators, which indicated that platelets count may be a more sensitive prognostic predictor for severe TBI patients undergoing DC. Meanwhile, there was no connection between coagulopathy and prognosis of TBI patients undergoing standard care, which may mean that the factors of coagulopathy had a tighter relation with DC. A question whether platelet transfusion was necessary for severe TBI patients undergoing DC was raised. Fewer studies had demonstrated the risks of platelet transfusions. Some researchers recommended transfusion of platelets was needed when platelet counts were less than $100 \times 10^9/L$ in TBI patients compared with $50 \times 10^9/L$ in other categories of diseases.³⁰ Our results showed that platelet = $127.5 \times 10^9/L$ was the cutoff point for long-term prognosis predictor. The appropriate transfusion threshold (e.g., INR and platelet count) for TBI patients was still controversial. We believed that many clinical factors should be taken into account for the decision to perform a transfusion.

CONCLUSION

DC may be an effective therapy method for severe TBI patients to decrease mortality, but it failed to improve long-term prognosis of severe TBI patients, especially for low GCS patients. By analyzing the prognostic predictors, we found the differences between 2 therapeutic groups, which may help us to comprehend the characteristics of the 2 treatments and provide more scientific individualization therapy for severe TBI patients.

TABLE 5. Multivariable Logistic Regression for Factors Associated With Long-Term Outcome in Standard Care Group

Variable	Crude		Adjusted	
	OR* (95% CI) [†]	P [‡]	OR (95% CI)	P [‡]
GCS	1.028 (0.832–1.269)	0.800	0.900 (0.704–1.150)	0.399
Age	0.994 (0.961–1.028)	0.718	0.993 (0.959–1.028)	0.675
Platelet	1.001 (0.998–1.004)	0.430	1.001 (0.998–1.004)	0.633
Neutrophile granulocyte	1.007 (0.977–1.038)	0.663	1.017 (0.984–1.051)	0.323
Pre-op pupil reaction	3.086 (1.063–8.960)	0.038	3.584 (1.027–12.501)	0.045
Albumin	1.034 (0.981–1.090)	0.208	1.012 (0.955–1.074)	0.678

* Odd ratio for a low incidence of disease is the accurate estimates value of relative risk. When the value is equal to 1, the factor has no influence on the incidence of disease, when it is greater than 1, it means a protective factor; otherwise, it is a risk factor.

[†] Confidence interval can be used to estimate the population parameter. The narrower scope is the reliability of the sample indicators to estimate the population parameter is better.

[‡] All P values were calculated with the use of multivariable logistic regression to test the statistical difference of the variables.

REFERENCES

1. Baguley IJ, Nott MT, Howle AA, et al. Late mortality after severe traumatic brain injury in New South Wales: a multicentre study. *Med J Australia* 2012;196:40–45
2. Chesnut RM, Marshall LF, Klauber MR, et al. The role of secondary brain injury in determining outcome from severe head injury. *J Trauma* 1993;34:216–222
3. Aarabi B, Hesdorffer DC, Ahn ES, et al. Outcome following decompressive craniectomy for malignant swelling due to severe head injury. *J Neurosurg* 2006;104:469–479
4. Cooper DJ, Rosenfeld JV, Murray L, et al. Decompressive craniectomy in diffuse traumatic brain injury. *N Engl J Med* 2011;364:1493–1502
5. Cooper DJ, Rosenfeld JV, Murray L, et al. Early decompressive craniectomy for patients with severe traumatic brain injury and refractory intracranial hypertension: a pilot randomized trial. *J Crit Care* 2008;23:387–393
6. Pettigrew LE, Wilson JT, Teasdale GM. Reliability of ratings on the Glasgow Outcome Scales from in-person and telephone structured interviews. *J Head Trauma Rehabil* 2003;18:252–258
7. Whitfield PC, Patel H, Hutchinson PJ, et al. Bifrontal decompressive craniectomy in the management of posttraumatic intracranial hypertension. *Br J Neurosurg* 2001;15:500–507
8. Cooper PR, Hagler H, Clark WK, et al. Enhancement of experimental cerebral edema after decompressive craniectomy: implications for the management of severe head injuries. *Neurosurgery* 1979;4:296–300
9. Stiver SI. Complications of decompressive craniectomy for traumatic brain injury. *Neurosurg Focus* 2009;26:E7
10. Chung RS, Staal JA, McCormack GH, et al. Mild axonal stretch injury in vitro induces a progressive series of neurofilament alterations ultimately leading to delayed axotomy. *J Neurotrauma* 2005;22:1081–1091
11. Staal JA, Dickson TC, Gasperini R, et al. Initial calcium release from intracellular stores followed by calcium dysregulation is linked to secondary axotomy following transient axonal stretch injury. *J Neurochem* 2010;112:1147–1155
12. Tang-Schomer MD, Patel AR, Baas PW, et al. Mechanical breaking of microtubules in axons during dynamic stretch injury underlies delayed elasticity, microtubule disassembly, and axon degeneration. *FASEB J* 2010;24:1401–1410
13. Timofeev I, Czosnyka M, Nortje J, et al. Effect of decompressive craniectomy on intracranial pressure and cerebrospinal compensation following traumatic brain injury. *J Neurosurg* 2008;108:66–73
14. Matsunaga S, Shuto T, Kawahara N, et al. Gamma Knife surgery for metastatic brain tumors from primary breast cancer: treatment indication based on number of tumors and breast cancer phenotype. *J Neurosurg* 2010;113(Suppl):65–72
15. Yang XF, Wen L, Shen F, et al. Surgical complications secondary to decompressive craniectomy in patients with a head injury: a series of 108 consecutive cases. *Acta Neurochirurgica* 2008;150:1241–1247
16. Honeybul S. Complications of decompressive craniectomy for head injury. *J Clin Neurosci* 2010;17:430–435
17. Steyerberg EW, Mushkudiani N, Perel P, et al. Predicting outcome after traumatic brain injury: development and international validation of prognostic scores based on admission characteristics. *PLoS Med* 2008;5:e165
18. Balestreri M, Czosnyka M, Chatfield DA, et al. Predictive value of Glasgow Coma Scale after brain trauma: change in trend over the past ten years. *J Neurol Neurosurg Psychiatry* 2004;75:161–162
19. Berardino M, Morrone O, Sciacca PF, et al. Discharge criteria from intensive care unit in brain injured patients. *Acta Neurochirurgica* 2004;146:453–456
20. Kumar A, Loane DJ. Neuroinflammation after traumatic brain injury: opportunities for therapeutic intervention. *Brain Behavior Immunity* 2012;26:1191–1201
21. Junger WG, Rhind SG, Rizoli SB, et al. Prehospital hypertonic saline resuscitation attenuates the activation and promotes apoptosis of neutrophils in patients with severe traumatic brain injury. *Shock* 2013;40:366–374
22. The Brain Trauma Foundation. The American Association of Neurological Surgeons. The Joint Section on Neurotrauma and Critical Care. Pupillary diameter and light reflex. *J Neurotrauma* 2000;17:583–590
23. Carter BG, Butt W, Taylor A. Bilaterally absent pupillary responses: not always a bad sign. *Anaesthesia Intensive Care* 2007;35:984–987
24. Kragh-Hansen U. Molecular aspects of ligand binding to serum albumin. *Pharmacol Rev* 1981;33:17–53
25. Rossi JL, Ralay Ranaivo H, Patel F, et al. Albumin causes increased myosin light chain kinase expression in astrocytes via p38 mitogen-activated protein kinase. *J Neurosci Res* 2011;89:852–861
26. Myburgh J, Cooper DJ, Finfer S, et al. Saline or albumin for fluid resuscitation in patients with traumatic brain injury. *N Engl J Med* 2007;357:874–884
27. Rodling Wahlstrom M, Olivecrona M, Nystrom F, et al. Fluid therapy and the use of albumin in the treatment of severe traumatic brain injury. *Acta Anaesthesiol Scand* 2009;53:18–25
28. Whittaker B, Christiaans SC, Altice JL, et al. Early coagulopathy is an independent predictor of mortality in children after severe trauma. *Shock* 2013;39:421–426
29. Etemadzeia H, Baharvahdat H, Shariati Z, et al. The effect of fresh frozen plasma in severe closed head injury. *Clin Neurol Neurosurg* 2007;109:166–171
30. Ozier Y. Blood transfusion and adjunctive therapy in the bleeding trauma patient. *Transfus Clin Biol* 2008;15:240–245

Virtual Resection and Subsequent Design of a Patient-Specific Alloplastic Implant in the Preoperative Planning and Surgical Treatment of a Venous Malformation of the Zygoma

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Abstract: The authors present here the case of a 63-year-old female who developed a venous malformation of the left zygoma. These lesions are typically managed with nonoperative treatment, until or unless overt complicating symptoms require more aggressive surgical intervention. Reconstruction of the zygoma represents a challenge for the operating surgeon, considering its complex three-dimensional anatomy. Traditionally, the surgeon would estimate the appropriate margins of resection intraoperatively, and then

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design a construct to fit the defect using autologous bone grafts, allografts, or one of the various available alloplastic materials; however, for this patient preoperative virtual surgical planning was used. Using reconstructed three-dimensional images from the patient's maxillofacial computed tomography scan, the margins of the excision were virtually defined and the lesion "excised" during a preoperative planning session based on the specifications of the reconstructive surgeon. This process then allowed the design and production of custom osteotomy guides, and a patient-specific polyetheretherketone (PEEK) implant to match the resulting defect. The authors believe this methodology allows for a more efficient and precise overall procedural experience and reconstructive result, and has innumerable potential applications in the surgical treatment of craniofacial abnormality.

Key Words: Craniofacial tumors, intraosseous venous malformation, patient-specific implant, vascular lesions, virtual surgical planning

Intraosseous venous malformations are uncommon vascular lesions that rarely involve the midface, with only 35 cases involving the zygoma previously reported in the literature.^{1–3} The treatment of primary vascular malformations is highly variable; however, for intraosseous venous malformations, the mainstay of treatment is surgical excision with clear margins.^{1,4} Secondary to the inherent complexity of the three-dimensional anatomy, reconstruction of midface defects, specifically of the zygoma, remains a challenge for craniofacial surgeons in restoring adequate function and cosmesis. Reconstruction of these complex defects using autografts, allografts, xenografts, and various alloplasts have all been described within the literature.^{4,5}

The recent development of virtual surgical planning (VSP), the use of computer-assisted design/computer-assisted manufacturing software, and the use of custom made patient-specific implants (PSI), have begun to dramatically alter the reconstructive approach to defects of the craniofacial skeleton. We present a surgical approach that uses VSP for the treatment of a venous malformation of the zygoma in which we virtually design and simulate the surgical resection, and then generate a defect-specific alloplastic implant to complete the reconstruction.

CLINICAL REPORT

A 63-year-old female was referred to our reconstructive craniofacial surgery clinic with a history of an intraosseous venous malformation of the left zygoma. She had previously undergone multiple debulking and recontouring procedures; however, presented to us with interval progression of the mass, and complained of pain and discomfort in the area of the lesion. On examination, the patient was found to have a palpable, tender mass along the zygomaticotemporal suture. Previous computed tomography (CT) images and pathology reports were reviewed, and were consistent with her established diagnosis. The patient was offered complete resection with immediate reconstruction using a virtually planned defect-specific polyetheretherketone (PEEK) implant.

A high-resolution noncontrast CT using ultrathin cut (1.25 mm) images was obtained as part of the preoperative workup, from which a three-dimensional image was generated. The scan revealed a 1.7 × 2.6 × 2.4 cm expansile osseous lesion at the junction of the lateral and anterior wall of the left maxillary sinus and anterior margin of the left zygomatic arch, with an apparent mass effect upon the inferolateral aspect of the left globe. With the help of Medical Modeling's (Golden, CO) biomedical engineers, the three-

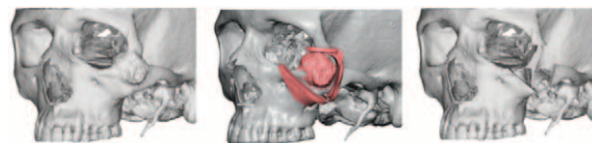


FIGURE 1. Preoperative three-dimensional renderings of the patient's maxillofacial computed tomography scan depicting the left zygomatic intraosseous venous malformation (left), the virtually designed osteotomy guide (center), and the virtual defect with the specified margins of resection (right).

dimensional rendering of the patient's preoperative anatomy was then used to define the margins of resection, and virtually excise the lesion based on the senior author's specifications (Fig. 1). With the exact measurements and dimensions of the virtually specified area of resection, the manufacturer was able to generate a patient-specific guide for the intraoperative osteotomies, and to design a precisely matched PEEK PSI (KLS Martin Group, Jacksonville, FL) (Fig. 2).

Intraoperatively, we began the dissection through coronal incision, and the plane along the superficial layer of the deep temporal fascia was developed to gain access to the zygomatic arch. The cutting guide was positioned, and used to mark the sites of the osteotomies as designed during the virtual planning session. Once the mass was resected, the PEEK implant was positioned and fixated with monocortical screw to reconstruct the defect. Postoperative CT imaging confirmed the accuracy of the reconstruction (Fig. 3), and the patient has had an uncomplicated postoperative course for >15 months without signs of recurrence, and with an excellent cosmetic result.

DISCUSSION

Intraosseous venous malformations are a rare and unique entity. These lesions are most commonly found in the vertebral bodies and calvaria, but they do occasionally occur in the midface, and have been reported previously to involve the zygoma.^{1,2} They are benign, slow growing lesions, the vast majority of which are asymptomatic and discovered incidentally; however, they may occasionally cause pain, swelling, tenderness, or facial deformity. Due to the benign nature of these lesions, management largely depends on symptomatic manifestation, or any cosmetic deformity that may be present.¹ Even in lesions involving the maxillofacial skeleton, conservative measures such as observation are typically used prior to the consideration of more invasive interventions; however, with complicated lesions that produce mass effect, hemorrhage, pain, proptosis, visual disturbances, or cosmetic deformity, surgical management is ultimately required.^{1,3,6}

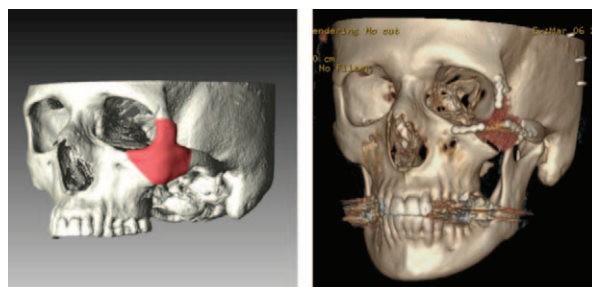


FIGURE 2. Preoperative three-dimensional rendering depicting the virtually designed defect-specific implant (left), and postoperative three-dimensional reconstruction of the patient's maxillofacial computed tomography (CT) scan depicting the polyetheretherketone (PEEK) patient-specific implant (PSI) after resection of the lesion and reconstruction of the zygomatic defect (right).



FIGURE 3. Preoperative image of the patient prior to resection of her left zygomatic intraosseous venous malformation (left), and postoperative image of the patient following resection of the lesion and subsequent reconstruction (right).

Previously described strategies for the treatment of craniofacial intraosseous venous malformations include partial resection with superficial osteotomies, or en bloc resection with immediate reconstruction.^{1,3,7} In consideration of these treatment options, the surgeon must weigh the increased rates of recurrence associated with partial resection against the potential postoperative morbidity that can occur with an en bloc resection; to this point, however, the mainstay of surgical treatment has involved complete primary resection, followed by immediate reconstruction with autologous bone grafts.^{1,7}

The complex three-dimensional structure of the zygoma, however, creates a challenging dilemma, and complicates the efforts of the reconstructive surgeon to achieve the desired functional and/or aesthetic results. The versatile technology associated with VSP, although, provides a solution to a number of inherent surgical issues associated with complex cases such as these, and is beginning to find an expanded role in the reconstruction of all areas of the craniofacial skeleton. To date, a variety of materials, including autografts, allografts, xenografts, and alloplasts have been described for use in the reconstruction of various craniofacial defects in association with this technology.^{4,5,8,9} PEEK, which was used in this case, is an alloplastic material that possesses appropriate strength, stiffness, and durability, as well as an excellent biocompatibility profile.⁸

There have been 2 similar cases reported in the literature wherein the reconstructive surgeons made use of preoperative CT-based modeling and implant design for reconstruction of the zygoma. In 2009, Arribas-Garcia et al¹⁰ described a case of zygomatic reconstruction using a predesigned alloplastic prosthesis—a methyl methacrylate implant designed using a CT-based model of the contralateral zygoma. And in 2012, Scolozzi⁴ reported on the use of computer-designed PEEK PSI based on mirroring computational planning for maxillofacial reconstruction.

The protocol described in this case designed with the assistance of Medical Modeling and KLS Martin Group, however, uses a digital three-dimensional model formatted from high-resolution CT images to virtually define the area of bony resection, and thereby generate custom osteotomy guides, as well as the PEEK PSI used for reconstruction. This strategy allows for immediate reconstruction in a single-stage procedure with accurate, predefined marginal excision, generates a more precise alloplastic prosthesis compared with previously documented techniques, and it does so with an overall relative decrease in operative time.

CONCLUSION

This advance in virtual preoperative surgical planning provides the opportunity for innumerable new applications in craniomaxillofacial reconstructive procedures. Precise marginal resection of lesions and reconstruction of the resulting defect can be implemented via use of a virtual defect in conjunction with patient-specific osteotomy guides and alloplastic implants. We believe the successful implementation of this protocol will lead to greater subsequent use of this innovative technology to treat patients with functional and cosmetic defects of the craniofacial skeleton.

REFERENCES

1. DeFazio MV, Kassira W, Camison L, et al. Intraosseous venous malformations of the zygoma: clarification of misconceptions regarding diagnosis and management. *Ann Plast Surg* 2014;72:323–327
2. Srinivasan B, Ethunandan M, Van der Horst C, et al. Intraosseous ‘haemangioma’ of the zygoma: more appropriately termed venous malformation. *Int J Oral Maxillofac Surg* 2009;38:1066–1070
3. Cheng NC, Lai DM, Hsie MH, et al. Intraosseous hemangioma of the facial bone. *Plast Reconstr Surg* 2006;117:2366–2372
4. Scolozzi P. Maxillofacial reconstruction using polyetheretherketone patient-specific implants by “mirroring” computational planning. *Aesth Plast Surg* 2012;36:660–665
5. Binder WJ. Custom-designed facial implants. *Facial Plast Surg Clin North Am* 2008;16:133–146
6. Pinna V, Clauser L, Marchi M, et al. Haemangioma of the zygoma: case report. *Neuroradiology* 1997;39:216–218
7. DeFazio MV, Kassira W, Camison L, et al. Intraosseous venous malformations of the zygoma: clarification of misconceptions regarding diagnosis and management. *Ann Plast Surg* 2014;72:323–327
8. Scolozzi P, Martinez A, Jaques B. Complex orbito-fronto-temporal reconstruction using computer-designed PEEK implant. *J Craniofac Surg* 2007;18:224–228
9. Kim MM, Boahene KD, Byrne PJ. Use of customized polyetheretherketone (PEEK) implants in the reconstruction of complex maxillofacial defects. *Arch Facial Plast Surg* 2009;11:53–57
10. Arribas-Garcia I, Alcala-Galiono A, Garcia AF, et al. Zygomatic intraosseous hemangioma: reconstruction with an alloplastic prosthesis based on a 3-D model. *J Plast Reconstr Aesthet Surg* 2010;63:451–453

Does the Type of Maxillomandibular Deformity Influence Complication Rate in Orthognathic Surgery?

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Purpose: Patients may encounter various complications during and after orthognathic surgery. The aim of this study was to compare the prevalence of complications in various skeletal deformities to see if an association exists.

Materials and Methods: This retrospective cohort study assessed patients in 2 groups. Group 1 had class III skeletal deformity and group 2 had class II skeletal deformity with vertical maxillary excess (VME). Complications were studied in 2 stages: Stage 1 included perioperative and immediate (first 24 hours) postoperative complications namely difficult intubation, blood transfusion, bad splits, pain, and postoperative airway problems. Stage 2 included

postoperative complications (from 24 hours up to 6 months after surgery namely bad splits and relapse). Age, sex, operation time, and the amount of jaw movements were considered as variables. Types of skeletal deformity were predictive factor of the study.

Results: The authors studied 248 patients in 2 groups. In group 1, 13 (8.2%) patients needed blood transfusion during surgery up to 24 hours after operation and 27 (30%) patients in group 2. Analysis of data demonstrated a significant difference for blood transfusion between 2 groups ($P = 0.001$). In group 1, 8 (5.1%) patients had a difficult intubation compared with 13 (14.4%) patients in group 2.

Comparison of mandibular movement and maximum mouth opening (MMO) did not show significant differences between 2 groups ($P > 0.05$). The amount of maxillary movement and horizontal discrepancy were different statistically in 2 groups ($P < 0.05$). Analysis of the data showed a significant difference in intubation between the 2 groups ($P < 0.05$). There were no differences between the 2 groups for bad splits, postoperative airway problems, or paresthesia ($P > 0.05$). Results did not demonstrate a significant difference for pain between the 2 groups ($P > 0.05$).

Conclusions: Patients with class II skeletal deformity and VME may have higher risk of perioperative blood loss and difficult intubation compared with patients with class III skeletal deformity.

Key Words: Bad split, blood loss, orthognathic surgery, osteotomy

Orthognathic surgery involves surgical manipulation of the facial skeleton to restore the anatomic and functional relationships in patients with dentofacial skeletal abnormalities. Many types of osteotomies of the jaws have been introduced for this purpose. The Le Fort I osteotomy of the upper jaw and mandibular ramus osteotomy are the most frequently performed osteotomies.¹

Although orthognathic surgery has proven to be relatively safe,² patients who undergo maxillofacial orthognathic surgery may encounter various complications in perioperative and postoperative stages of treatment.³

Common complications, which may occur in orthognathic surgery consist of postoperative vascular disease, TMJ problems, nerve damage, infection, bone necrosis, periodontal disease, vision impairment, hearing problems, hair loss, and neuropsychiatric problems.⁴ Moreover, some complications can be fatal.⁵ Because of the wide range of complications, the surgeon should keep prevention protocols in mind and be prepared for the treatment in case a complication should occur.

The aim of this study was to see if complication rates differ in various maxillomandibular deformities.

MATERIALS AND METHODS

The investigators designed a cohort retrospective study. The study sample was derived from the population of patients who presented to the Department of Oral and Maxillofacial Surgery at our university for treatment of maxillofacial deformities between September 1, 2008 and December 31, 2013. The research was approved by the committee of medical ethics of our university. Patients eligible for inclusion had skeletal class II with vertical maxillary excess (VME) or class III deformity; all underwent bimaxillary osteotomy. All patients were ASA I category. Patients were excluded from the study if they had asymmetry, previous trauma or fracture of the mandible, previous orthognathic surgery, surgical augmentation, additional genioplasty, or congenital deformities. None of the patients had impact teeth in the osteotomy site of the mandible.

Patients were placed in 2 groups: patients in group 1 had class III skeletal deformity and underwent mandibular setback (bilateral sagittal osteotomy) and maxillary advancement (Le Fort 1 osteotomy). In group 2, the patients had class II skeletal deformity with VME and underwent mandibular advancement (bilateral sagittal osteotomy) and maxillary superior repositioning (Le Fort 1 osteotomy). The surgeries were done by a surgical team (the first author and his residents). Data were documented according to the review of a database collected contemporaneously.

Complications were studied in 2 stages:

Stage 1: perioperative and immediate postoperation (first 24 hours after the operation) complications.

Stage 2: postoperative complications (from 24 hours up to 6 months after surgery).

In stage 1, 4 complications studied were difficult intubation, bleeding, bad split, and airway problems.

Difficult intubation was defined as unsuccessful intubation at the first attempt.

Bleeding was designated as a need for blood transfusion up to 24 hours after the operation.

Bad splits were observed during the surgeries or detected on immediate postoperative routine radiographs (OPG and posterior–anterior cephalogram).

Postoperative airway problems were considered for patients who needed airway or respiratory support after extubation because of difficult airway, respiratory arrest, and pneumothorax.

Pain in 24 hours after surgeries according to visual analog scale (VAS) was determined in all patients (1–10).

In stage 2, the complications considered included: paresthesia of the inferior alveolar nerve and lingual nerve after 6 months and severe relapse requiring reoperation.

Age, sex, the amount of horizontal discrepancy, the amount of maxillary and mandibular movement, maximum mouth opening (MMO), and operation time were considered variable factors. Type of deformity was the predictive factor of the study and complications in stage 1 and 2 were outcomes of the study.

Anesthesia Protocol

All patients received Dexametazone (8 mg, IV, 30 minutes before surgeries) underwent hypotensive anesthesia. Hypotensive anesthesia was adjusted in relation to the patient's preoperative blood pressure and the necessary level for blood loss reduction in the surgical field. A mean arterial blood pressure (MAP) was 30% below a patient's usual MAP. Anesthesia was induced with intravenous propofol 2 mg/kg and fentanyl 0.5 mcg/kg and was maintained using total intravenous anesthesia with propofol infusion 100 mcg/kg and remifentanyl 0.2 to 0.3 mcg/kg/min. Atracurium

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0.5 mg/kg was used for endotracheal intubation. All of the anesthesia procedures were given by an anesthesiologist.

Surgical Approach

The incision was made over the anterior portion of the vertical ramus, extending to the mesial aspect of the first molar. Subperiosteal dissection was carried out down to the inferior border of the mandible, where a lateral channel retractor was placed. A long bur was used to make a horizontal bone cut through the medial cortex of the ramus, just above and approximately posterior to the lingula. The vertical cut was made through the buccal cortex, distal to the second molar or further anteriorly. The 2 osteotomies were then connected with a 701 fissure bur. The vestibular incision in the maxilla was made from the first molar to the contralateral first molar. The superior tissues were reflected subperiosteally, first at the piriform aperture margins. Then, lateral nasal and infraorbital regions were exposed and extended posteriorly to the zygomatic maxillary buttress. Two internal reference points intraorally were marked to determine anterior–posterior and vertical movements in each side of the maxilla. Osteotomy lines were made 5 mm superior to the apex of the teeth roots. After ending osteotomies and down fracture, the maxilla was mobilized and brought in the desirable position using an intermediate splint. Bone interferences were removed and the maxilla was fixed using 4 miniplates (4 holes L shape) with 4 screws (6 mm). The thickness of miniplates was 2 mm in all patients. A spreader and a narrow osteotome were used to separate the lateral cortex of the sagittal osteotomy and the osteotome was used to step along the connecting cuts to ensure that the split stayed close to the lateral cortex. Finally, the mandible was positioned in the final position and the condyle was positioned manually during fixation using a miniplate (4 holes with bar) and monocortical screws (8 mm) at each osteotomy site.

Statistical Analysis

The statistical analyses were performed using the statistical package SPSS. Fisher exact test was applied to compare complications in stage 1 and 2 between the groups. χ^2 test was used to compare sex. Age, MMO, pain, and operation time were evaluated using independent *t* test.

RESULTS

Two hundred sixty patients were operated, which only 248 patients had sufficient documents and completed follow-up time and 12 (4.61%) of the patients were removed from the study. We studied 248 patients in 2 groups. Group 1 (*N* = 158) consisted of 66 men and 92 women and group 2 (*N* = 90) had 34 men and 56 women. There was no significant difference between the 2 groups for sex (*P* = 0.316). The mean age was 24.16 ± 4.24 years in group 1 and 23.17 ± 4.02 years in group 2. Analysis of the data did not show a significant difference for age between the 2 groups (*P* = 0.488). The mean operation time was 166.89 ± 20.66 minutes in group 1 and 183.26 ± 26.04 minutes in group 2. There was a significant difference for the operation time between the 2 groups (*P* = 0.015). Comparison of mandibular movement and MMO did not show significant differences (*P* > 0.05). The amount of maxillary movement and horizontal discrepancy was different statistically in 2 groups (*P* < 0.05) (Table 1).

Forty (16.12%) of 248 patients needed blood transfusion in the both groups. In group 1, 13 (8.2%) patients needed blood transfusion during surgery up to 24 hours after operation and 27 (30%) patients in group 2. Analysis of data demonstrated a significant difference for blood transfusion between the 2 groups (*P* = 0.001) (Table 2).

TABLE 1. Comparison of Variables Between the 2 Groups

Variables	Group 1	Group 2	<i>P</i> Value
Sex	66 men, 92 women	34 men, 56 women	<i>P</i> = 0.316**
Age (years)	24.16 ± 4.24	23.17 ± 4.02	<i>P</i> = 0.488
Operation time (min)	166.89 ± 20.66	183.26 ± 26.04	<i>P</i> = 0.015*
MMO (mm)	39.8 ± 2.07	39.81 ± 2.53	<i>P</i> = 0.96
Horizontal discrepancy (mm)	6.95 ± 1.21	4.84 ± 0.87	<i>P</i> = 0.004*
Maxillary movement (mm)	3.17 ± 0.91	4.34 ± 1.78	<i>P</i> = 0.001*
Mandibular movement (mm)	3.79 ± 0.77	4.56 ± 0.63	<i>P</i> = 0.31

MMO, maximum mouth opening.

* Significant.

** χ^2 test.

In group 1, the mean of pain (VAS) was 5.8 ± 1.2 and 6.21 ± 1.08 in group 2. Result did not demonstrate a significant difference for pain (*P* = 0.1) (Table 2).

The results showed that 8 (5.1%) patients in group 1 and 7 (7.8%) patients in group 2 had a bad split. Comparison of data did not show a significant difference between the 2 groups in this respect (*P* = 0.275).

Eight (5.1%) patients in group 1 and 13 (14.4%) patients in group 2 had a difficult intubation. Analysis of the data showed a significant difference for difficult intubation between the 2 groups (*P* = 0.012).

Twelve (7.6%) patients in group 1 and 5 (5.6%) patients in group 2 had airway problems in the recovery room. Analysis of the data did not reveal a significant difference between the 2 groups in this regard (*P* = 0.611) (Table 2).

Twelve (7.6%) patients in group 1 and 10 (11.1%) patients in group 2 reported paresthesia after 6 months (*P* = 0.361).

Two patients (1.3%) in group 1 and 1 (1.1%) in group 2 needed reoperation (Table 3).

DISCUSSION

Complications may occur during or after orthognathic surgeries.⁵ Although the relative safety of such procedures has been confirmed by previous studies,^{6,7} the definition of what constitutes a

TABLE 2. Comparison of Study Outcomes in Stage 1 Between the 2 Groups

Outcomes	Group 1	Group 2	<i>P</i> Value
Blood transfusion	13 (8.2%)	27 (30%)	<i>P</i> = 0.001*
Difficult intubation	8 (5.1%)	13 (14.4%)	<i>P</i> = 0.012*
Bad split	8 (5.1%)	7 (7.8%)	<i>P</i> = 0.275*
Postoperative airway problems	12 (7.6%)	5 (5.6%)	<i>P</i> = 0.611*
Pain (VAS)	5.8 ± 1.2	6.21 ± 1.08	<i>P</i> = 0.1 ^{&}

VAS, visual analog scale.

* χ^2 test.

[&] Independent *t* test.

TABLE 3. Comparison of Outcomes in Stage 2 Between the 2 Groups

Outcomes	Group1	Group2	χ^2 Test
Paresthesia	12 (7.6%)	10 (11.1%)	<i>P</i> = 0.361
Relapse	2 (1.3%)	1 (1.1%)	*

* Insufficient cases.

complication in orthognathic surgery varies between researchers and this prevents clinicians to make a precise comparison.⁵ Various reports show the prevalence of complications in orthognathic surgeries.^{8,9} It is unclear if the prevalence rates of complications vary in various skeletal deformities or not.

The current study showed that patients with class II skeletal deformity and VME needed more blood transfusion than patients with class III skeletal deformity. The operation time, however, was different between the 2 studied groups. The longer operation time in patients with class II skeletal deformity and VME may play an important role in intraoperative bleeding. Choi et al¹⁰ demonstrated that intraoperative bleeding and operation time increased significantly in patients undergoing mandibular ramus osteotomy and Le Fort I osteotomy with maxillary setback. It could be hypothesized that the direction of the maxillary movement was effective on operation time as well as blood loss. Movement of the maxilla posteriorly and superiorly needs more bone removal and increases the risk of vascular injury in the posterior maxilla than simple maxillary advancement. Furthermore, accessibility for manipulation in the posterior maxilla is difficult and takes more time. The length of the operation played a major role in increasing complications in orthognathic surgery.¹¹ Also, the intraoperative bleeding observed in patients during Le Fort I or mandibular ramus osteotomies or both combined was less than the limits set for blood transfusion.¹² Rummasak et al¹³ showed patient's sex, experience of the surgeon, and operative time were effective on blood loss during orthognathic surgery. In our study, the overall transfusion rate was 16.12% that was higher than the previous reports in orthognathic surgeries with hypotensive anesthesia (0–8%).¹⁴ The higher frequency of blood transfusion may be because of the study, which was done in a trainer center (university hospital). Experience of surgeons may play an important role in time of surgeries, bad splints, and trauma during operations.

Bad split or fracture is a troublesome complication during sagittal split osteotomy (SSO).¹⁵ The incidence of bad splits in our study was 14.6%, which is within the range of previous reported studies (that varied between 0.21% and 22.72%).¹⁵ The exact combination of factors that result in a bad split is not clearly known yet.¹⁶ In our study, the prevalence of bad split was 5.1% to 7.8%. It seems that the prevalence of bad split was not different in skeletal class II or class III deformity. A recent study demonstrated that certain mandibular anatomic differences may increase the risk of a bad split during SSO.¹⁷

Difficult intubation was more common in patients with class II skeletal deformity than class III skeletal deformity for orthognathic surgery in our study. Airway volume and shape vary among the patients with different anteroposterior jaw relationships; airway shape but not volume differs with various vertical jaw relationships.¹⁸ Patients with class II skeletal deformity often have forward inclination of the airway; whereas skeletal class III patients have a more vertically oriented airway.¹⁸ Class III malocclusion is associated with a large and flat oropharyngeal airway compared with Class I and II malocclusions.¹⁹ Retrognathia is often associated with a difficult intubation.²⁰

Postoperative recovery complications were not different in patients with skeletal class II and class III deformities in this study. Also, orthognathic surgery can affect the posterior airway space (PAS) and is a major concern. The soft palate, tongue, hyoid bone, and associated muscles are attached directly or indirectly to the maxilla and the mandible.²¹ This means that the movement of the jaws will result in positional changes of the structures directly attached to the bone and change the tension of the attached soft tissue and muscle. This will result in an alteration in the volume of the nasal and oral cavities and PAS dimensions depending on the direction and magnitude of the skeletal movements.²¹ After mandibular setback, the tongue base is more posterior and the hypopharyngeal depth is

reduced. The bimaxillary surgery group also demonstrated a more posterior tongue base but without reduction of the hypopharyngeal depth. The mandibular setback patients are most at risk of obstructive sleep apnea, but compensatory changes in the soft palate morphology may explain its low occurrence in practice.²²

Sensory impairment of the inferior alveolar nerve is a complication of the SSO.²³ The patient usually reports varying degrees of numbness in the lower lip and chin, which occurs in 9% to 85% of the operated sides.²⁴ The wide variation in the incidence of this disturbance is because of the large variability in nerve function assessments and follow-up periods from study to study.²³ In our study, the prevalence was between 7.6% and 11.1% without a significant difference in patients with skeletal class II and III deformities. Teerijoki-Oksa et al²⁵ compared objective and subjective neurosensory testing and found that patient-reported sensory alteration was more frequent than abnormal test results for electrophysiological investigations at the 1-year follow-up visit. Thus, subjective reporting by patients is a valuable method for evaluating sensory dysfunction after SSO. The frequency of neurosensory disturbance after bilateral SSO in class III cases is dependent not only on the position of the mandibular canal, but also on the mandibular angle. A lateral course of the mandibular canal and an obtuse mandibular angle appeared to result in a high risk of injury to the inferior alveolar nerve.²⁶ In class II skeletal patients, the magnitude of the advancement affects post-surgical neurosensory disturbances after SSO.²⁷ Advancement of the jaw seemed to be related to higher neurosensory disturbance after BSSO compared with setback.²⁷

CONCLUSIONS

Patients with class II skeletal deformity and VME may have higher risk of perioperative blood loss and difficult intubation than patients with class III skeletal deformity. Types of skeletal deformities did not affect the prevalence of postsurgical neurosensory disturbance or recovery complications.

REFERENCES

- Piñero-Aguilar A, Somoza-Martín M, Gandara-Rey JM, et al. Blood loss in orthognathic surgery: a systematic review. *J Oral Maxillofac Surg* 2011;69:885–892
- Mahy P, Siciliano S, Reyckler H. Complications and failures in orthognathic surgery. *Rev Belge Med Dent (1984)* 2002;57:71–82
- Panula K, Finne K, Oikarinen K. Incidence of complications and problems related to orthognathic surgery: a review of 655 patients. *J Oral Maxillofac Surg* 2001;59:1128–1136
- Kim SG, Park SS. Incidence of complications and problems related to orthognathic surgery. *J Oral Maxillofac Surg* 2007;65:2438–2444
- Posnick JC. Complications associated with orthognathic surgery. *Principle and Practice of Orthognathic Surgery*. St. Louis, MO: Elsevier, Saunders; 2014:475–542
- Bhaskaran AA, Courtney DJ, Anand P, et al. A complication of Le Fort I osteotomy. *Int J Oral Maxillofac Surg* 2010;39:292–294
- elDeeb M, Wolford L, Bevis R. Complications of orthognathic surgery. *Clin Plast Surg* 1989;16:825–840
- Chow LK, Singh B, Chiu WK, et al. Prevalence of postoperative complications after orthognathic surgery: a 15-year review. *J Oral Maxillofac Surg* 2007;65:984–992
- Maurer P, Otto C, Eckert AW, et al. Complications in surgical treatment of malocclusions. Report of 50 years experience. *Mund Kiefer Gesichtschir* 2001;5:357–361
- Choi BK, Yang EJ, Oh KS, et al. Assessment of blood loss and need for transfusion during bimaxillary surgery with or without maxillary setback. *J Oral Maxillofac Surg* 2013;71:358–365
- Tabrizi R, Eftekharian HR, Langner NJ, et al. Comparison of the effect of 2 hypotensive anesthetic techniques on early recovery complications after orthognathic surgery. *J Craniofac Surg* 2012; 23:e203–e205

12. Piñero-Aguilar AI, Somoza-Martín M, Gandara-Rey JM, et al. Blood loss in orthognathic surgery: a systematic review. *J Oral Maxillofac Surg* 2011;69:885–892
13. Rummasak D, Apipan B, Kaewpradup P. Factors that determine intraoperative blood loss in bimaxillary osteotomies and the need for preoperative blood preparation. *J Oral Maxillofac Surg* 2011;69:e456–e460
14. Al-Sebaei MO. Predictors of intra-operative blood loss and blood transfusion in orthognathic surgery: a retrospective cohort study in 92 patients. *Patient Saf Surg* 2014;8:41–46
15. Chrcanovic BR, Freire-Maia B. Risk factors and prevention of bad splits during sagittal split osteotomy. *Oral Maxillofac Surg* 2012;16:19–27
16. Mensink G, Verweij JP, Frank MD, et al. Bad split during bilateral sagittal split osteotomy of the mandible with separators: a retrospective study of 427 patients. *Br J Oral Maxillofac Surg* 2013;51:525–529
17. Aarabi MA, Tabrizi R, Hekmat M, et al. Relationship between mandibular anatomy and the occurrence of a bad split upon sagittal split osteotomy. 2014;72:2508–25013
18. Grauer D, Cevdanes LCH, Styner MA, et al. Pharyngeal airway volume and shape from cone-beam computed tomography: Relationship to facial morphology. *Am J Orthod Dentofacial Orthop* 2009;136:805–814
19. Iwasakia T, Hayasaki H, Takemoto Y, et al. Oropharyngeal airway in children with Class III malocclusion evaluated by cone-beam computed tomography. *Am J Orthod Dentofacial Orthop* 2009;136:318.e1–318.e9
20. Kurtipek O, Isik B, Arslan M, et al. A study to investigate the relationship between difficult intubation and prediction criterion of difficult intubation in patients with obstructive sleep apnea syndrome. *J Res Med Sci* 2012;17:615–620
21. Lye KW. Effect of orthognathic surgery on the posterior airway space (PAS). *Ann Acad Med Singapore* 2008;37:677–682
22. Samman N, Tang SS, Xia J. Cephalometric study of the upper airway in surgically corrected class III skeletal deformity. *Int J Adult Orthodon Orthognath Surg* 2002;17:180–190
23. Politis C, Sun Y, Lambrechts I, et al. Self-reported hypoesthesia of the lower lip after sagittal split osteotomy. *Int J Oral Maxillofac Surg* 2013;42:823–829
24. Westermarck A, Bystedt H, von Konow L. Inferior alveolar nerve function after mandibular osteotomies. *Br J Oral Maxillofac Surg* 1998;36:425–428
25. Teerijoki-Oksa T, Jaaskelainen SK, Forsell K, et al. Recovery of nerve injury after mandibular sagittal split osteotomy. Diagnostic value of clinical and electrophysiology tests in the follow-up. *Int J Oral Maxillofac Surg* 2004;33:134–140
26. Yamauchi K1, Takahashi T, Kaneuji T, et al. Risk factors for neurosensory disturbance after bilateral sagittal split osteotomy based on position of mandibular canal and morphology of mandibular angle. *J Oral Maxillofac Surg* 2012;70:401–406
27. Kuroyanagi N1, Miyachi H, Ochiai S, et al. Prediction of neurosensory alterations after sagittal split ramus osteotomy. *Int J Oral Maxillofac Surg* 2013;42:814–822

Abstract: Snoring is caused by the vibration of structures of the oral cavity, such as the soft palate, uvula, tonsils, base of the tongue, epiglottis, and lateral pharyngeal walls. When these structures collapse and obstruct the airway, apnea occurs. Obstructive sleep apnea syndrome (OSAS) is characterized by repeated periods of upper airway obstruction, a decrease in arterial oxygen saturation, and interrupted sleep. The prevalence of OSAS is 1% to 5% in men and 1.2% to 2.5% in women. Crucial factors in deciding the surgical approach include a detailed ear–nose–throat examination, Muller maneuver, sleep endoscopy, and apnea hypopnea index scores. Accepted treatments include continuous positive airway pressure (CPAP), surgeries of the base of the tongue and/or palate, and multi-level surgeries. It, however, is important to continue to evaluate the efficacies of such procedures. The authors evaluated the outcomes of 23 patients who underwent surgery for OSAS, using preoperative and postoperative polysomnography (PSG) and the Epworth sleepiness scale (ESS). The results were compared before and after surgery. In all, 14 patients had lateral pharyngoplasty and 9 had uvulopalatopharyngoplasty (UPPP). The PSG and Epworth scale values were significantly lower in both groups, postoperatively. Patients indicated that their quality of life had improved. In conclusion, the surgeries were successful. In line with the literature, our results indicate that lateral pharyngoplasty and UPPP can be used in appropriate patients. Longer-term studies on more patients will provide more detailed information in the future.

Key Words: Lateral pharyngoplasty, sleep apnea, uvulopalatopharyngoplasty

Snoring is caused by the vibration of structures of the oral cavity, such as the soft palate, uvula, tonsils, base of the tongue, epiglottis, and lateral pharyngeal walls. When these structures collapse and obstruct the airway, apnea occurs. Obstructive sleep apnea syndrome (OSAS) is characterized by repeated periods of upper airway obstruction, a decrease in arterial oxygen saturation, and interrupted sleep.¹ The prevalence of OSAS is 1% to 5% in men and 1.2% to 2.5% in women.² Its pathophysiology is still subject to research, but the most accepted theory involves the facial skeleton and the soft tissues within the upper airway.

Although the application of continuous positive airway pressure (CPAP) has been the treatment of choice for high-grade OSAS patients, not all patients can receive this treatment and are given the choice of surgery. Common surgical treatment options include tongue base radiofrequency ablation (RFA), tonsillectomy,

Comparative Analysis of Lateral Pharyngoplasty and Uvulopalatopharyngoplasty Techniques With Polisomnography and Epworth Sleepiness Scales

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This study is approved by the Ethical Committee of Sisli Etfal Research Hospital with the registration number of 107.

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uvulopalatopharyngoplasty (UPPP), lateral pharyngoplasty, pillar implants, bimaxillary advancement, mandibular osteotomy, tongue base suspension, and partial glossectomy. The outcomes of these techniques are still being researched.³ Most surgeries that have been proposed for treating OSAS aim to decrease the inspiratory upper airway pressure by enlarging the pharyngeal lumen by removing soft tissues or stretching its surrounding structures.⁴ Lateral pharyngeal muscle wall collapse is important in the pathogenesis of OSAS.⁵ Uvulopalatopharyngoplasty is a specialized procedure that directly enlarges the upper airway, and lateral pharyngoplasty⁶ is also designed to enlarge the pharynx, creating lateral muscle flaps.

Evaluation of a patient with OSAS starts with a detailed ear–nose–throat examination, evaluation of mallampati classification and a Muller's maneuver using a flexible fibre optic nasopharyngolaryngoscope. In Muller's maneuver, the patient is asked to take a breath while the mouth is closed and the nose is pinched shut. This generates a negative pressure in the upper airway. In patients who just snore, there may be slight inward movement of the soft palate and the back of the throat but the glottis remains visible. Patients who have OSAS show varying degrees of collapse in the side walls of the velopharynx, at the base of the tongue, and at the back of the throat, which narrows the airway by more than 25%. Sleep endoscopy is helpful for finding the anatomic site causing obstruction; these may include uvulopalatal, oropharyngeal, tongue basal, and laryngeal sites. This procedure can help surgeons focus on the correct area for an accurate treatment.^{7,8} The success of such a surgery depends on accurately detecting the pathology causing OSAS and using an appropriate operative technique that is specific to that pathology.

In the current study, we compared the postoperative success of UPPP and lateral pharyngoplasty techniques using polysomnography (PSG) and Epworth sleepiness scales (ESS) on OSAS patients who had more than 50% uvulopalatal and pharyngeal obstruction.

MATERIALS AND METHODS

Ethical approval was given by the Sisli Etfal Training and Research Hospital Ethical Committee (107/2012). All patients gave their written consent. Patients who underwent surgery for OSAS between 2010 and 2011 were examined, and 23 patients with PSG-proven OSAS (apnea/hypopnea index > 5) who underwent either UPPP or lateral pharyngoplasty surgeries were included in the study. Patients' ages were between 18 and 65 and all had heavy-intermediate OSAS according to their PSG results. Continuous positive airway pressure had been recommended for all patients, but they either refused the procedure or could not use it. Patients with hypothyroidism, hyperthyroidism, metabolic diseases, class III obesity (body mass index over 40), nasal septal deviation, upper airway pathologies, CPAP use, or larynx or vocal cord pathologies and in whom tongue base RFA, thyrohyoid suspension, or any other surgery had been performed were excluded from the study. All patients' preoperative body mass indexes, mallampati scores, Epworth sleepiness scores, Muller's maneuver outcomes, and PSG results were noted. Patients were called for regular controls every 3 months postoperatively. There were no major complications. Patients were evaluated using PSG and Epworth scales at 20 to 24 months, postoperatively.

Patients were selected for pharyngeal surgery when on physical examination there was an excess of soft tissue within the oropharynx with the tongue in the mouth and relaxed, and with the mouth opened maximally. Selection criteria for the surgery were lateral peritonsillar narrowing, such that peritonsillar tissues pervaded a space greater than 25% of the pharyngeal space; enlarged tonsils with lateral impingement of greater than 50% of the distance between the left and right posterior tonsillar pillars, and a low soft palate preventing

visualization of the posterior pharyngeal wall. A total of 28 patients qualified, and they were randomly split into 2 surgical groups (14 in each) depending on the treatment they received: lateral pharyngoplasty and UPPP. Five patients, all from the latter group, however, were lost to follow-up and thus were excluded from the analyses. This left a total of 23 patients (14 in the lateral pharyngoplasty group and 9 in the UPPP group). All of them had narrowing or collapse in the retropalatal region without narrowing in the hypopharynx, both at rest and during the Muller maneuver, as assessed using fibre optic pharyngoscopy. All patients also had a 50% or greater obstruction and collapse in the uvulopalatal and pharyngeal regions, and mallampati scores higher than 3.

Patients were requested to use the ESS both preoperatively and at 20 to 24 postoperative months (Table 1).

In the PSG tests, standardized 12-channel electroencephalography, electrooculogram, electrocardiogram, electromyogram (jaw and tibialis anterior), thoracoabdominal movements, body position, oronasal air flow, and digital pulse oximetry measurements were noted. Apnea–hypopnea index (AHI) and minimum O₂ saturation values were used as evaluation parameters.

The 2 groups' preoperative and postoperative Epworth scores, AHI, and minimum O₂ values were compared. The changes within each group were also evaluated.

SURGICAL TECHNIQUES

All patients were operated on by the same surgeon. In the UPPP technique,⁹ minimal shortening of the soft palate in the midline was used. After a bilateral tonsillectomy, the triangle of mucosa and muscle (palatoglossus) was removed from the lateral free margin of the soft palate, and the wound was closed by traction and suturing of the palatopharyngeus muscle over it. In addition, a partial uvulectomy was performed.

In lateral pharyngoplasty,⁶ after tonsillectomy, the superior pharyngeal constrictor muscle within the tonsillar fossa (outer pharyngeal muscular layer) was sectioned and sutured to the anterior pillar to provide support to the lateral pharyngeal wall. Then, a Zplasty was performed between the lateral free margin of the soft palate and the palatopharyngeus muscle, providing lateral support to the soft palate. A partial uvulectomy was also performed.

STATISTICAL ANALYSIS

The distribution of variables was checked using the Kolmogorov–Smirnov test. Data were analyzed with the independent *t*-test and paired *t*-test. The χ^2 test, and when this test was not convenient, the Fischer test, was used. Correlation analysis was performed using Pearson correlation analysis. The SPSS 20.0 program was used for statistics.

TABLE 1. Epworth Sleepiness Scale (0: No Chance of dozing, 1: Slight Chance of Dozing, 2: Moderate Chance of Dozing, 3: High Chance of Dozing.)

Situation	Chance of Dozing
Sitting and reading	
Watching TV	
Sitting inactive in a public place (e.g., a theater or a meeting)	
As a passenger in a car for an hour without a break	
Lying down to rest in the afternoon when circumstances permit	
Sitting and talking to someone	
Sitting quietly after a lunch without alcohol	
In a car, while stopped for a few minutes in traffic	

TABLE 2. Ages and Pre- and Postoperative Mean AHI, O₂ Saturation and Epworth Scores for all Patients

		Minimum	Maximum	Mean $\pm$ SD
Age		31	55	43.13 $\pm$ 6.61
AHI	Preoperative	12	45	24.08 $\pm$ 10.31
	Postoperative	4	25	10.02 $\pm$ 5.29
O ₂ saturation (%)	Preoperative	73	97	84.00 $\pm$ 8.75
	Postoperative	80	97	88.39 $\pm$ 6.75
Epworth	Preoperative	11	20	15.22 $\pm$ 2.71
	Postoperative	3	10	6.13 $\pm$ 1.91

Age, AHI, O₂ saturation and Epworth score values.

RESULTS

Of the 23 patients, 4 were women and 15 were men (mean age, 43.1 years; Table 2).

The mean preoperative AHI of all patients was 24.08; the mean postoperative AHI was 10.02. The mean preoperative Epworth scale score of all patients was 15, and the mean postoperative Epworth scale score was 6. Apnea–hypopnea index (AHI) and Epworth scores of all patients dropped postoperatively, and this drop was statistically significant ($P < 0.05$) (Table 3).

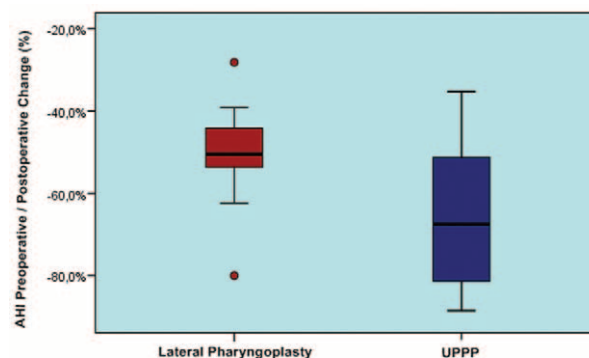
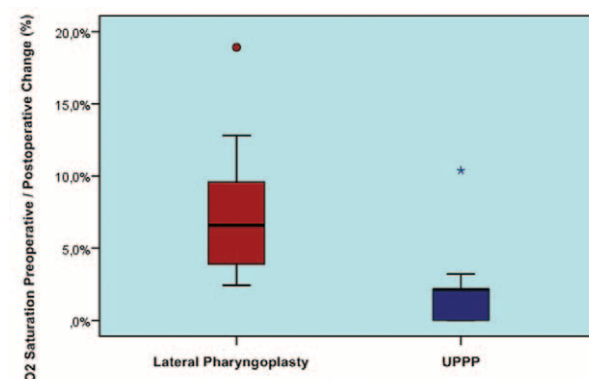
The mean preoperative AHI of lateral pharyngoplasty patients was 23.4 ± 9.9 , and the mean postoperative AHI was 11.3 ± 5.6 . There was a statistically significant decrease in the AHI values of this group postoperatively ($P < 0.05$). The mean AHIs for the UPPP group were 25.1 ± 9.9 preoperatively and 8.0 ± 4.3 postoperatively, also a statistically significant decrease was observed ($P < 0.05$) (Table 3). There were no statistically significant differences between the 2 groups ($P > 0.05$) (Fig. 1).

The mean minimum O₂ saturation significantly increased postoperatively ($P < 0.05$) (Table 2) in both groups, but was significantly lower in the lateral pharyngoplasty group than in the UPPP group, both preoperatively (78.4 ± 4.4 versus 92.8 ± 6.1) and postoperatively (84.2 ± 4.5 versus 94.9 ± 3.9) ($P < 0.05$). The preop/postop O₂ saturation increment rate was significantly higher in the lateral pharyngoplasty group than in the UPPP group ($P < 0.05$) (Fig. 2).

The Epworth scores of the lateral pharyngoplasty and UPPP groups were 15.3 ± 2.9 and 15.1 ± 2.6 preoperatively and 6.8 ± 1.8 and 5.1 ± 1.6 postoperatively, respectively. They did not differ significantly between the groups preoperatively but were significantly higher in the lateral pharyngoplasty group postoperatively. The scores, however, significantly decreased within each group postoperatively ($P < 0.05$) (Table 3). The preop/postop rate of decrease was significantly lower in the lateral pharyngoplasty group (Fig. 3).

TABLE 3. Pre- and Postoperative Mean AHI, O₂ Saturation and Epworth Scores for Each Surgical Technique

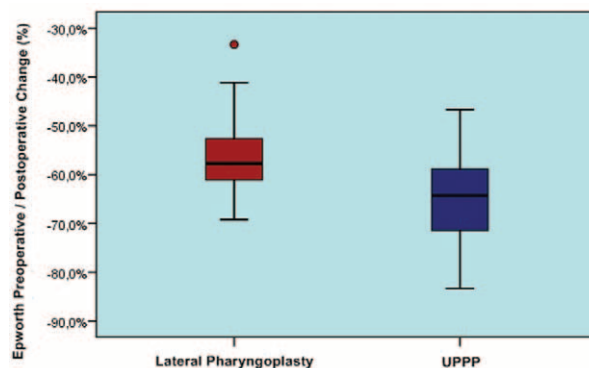
		Lateral Pharyngoplasty Mean $\pm$ SD	UPPP Mean $\pm$ SD	P
AHI	Preoperative	23.4 $\pm$ 9.9	25.1 $\pm$ 11.4	0.702
	Postoperative	11.3 $\pm$ 5.6	8.0 $\pm$ 4.3	0.146
O ₂ saturation	Preoperative	78.4 $\pm$ 4.4	92.8 $\pm$ 6.1	0.000
	Postoperative	84.2 $\pm$ 4.5	94.9 $\pm$ 3.9	0.000
Epworth	Preoperative	15.3 $\pm$ 2.9	15.1 $\pm$ 2.6	0.884
	Postoperative	6.8 $\pm$ 1.8	5.1 $\pm$ 1.6	0.037

AHI, O₂ saturation and Epworth score changes for Lateral Pharyngoplasty and UPPP.**FIGURE 1.** Preoperative and postoperative AHI changes. AHI, apnea–hypopnea index.**FIGURE 2.** Preoperative and postoperative O₂ saturation changes.

DISCUSSION

The prevalence of OSAS is approximately 1% to 5% of the adult population.² The golden standard for diagnosis of OSAS is PSG.¹⁰ Obstructive sleep apnea syndrome is classified as mild, moderate, or severe according to AHI values. The Epworth sleepiness score is also an important parameter as these correlate with AHI and minimum O₂ saturation.¹¹

The pathologies and treatment options for OSAS remain under debate. Because upper airway regions cause OSAS, there are many options for treatment. Continuous positive airway pressure is the first choice for high-level OSAS patients. Other options, ranging from relatively less morbid treatments such as tongue base RFA,

**FIGURE 3.** Preoperative and postoperative Epworth score changes.

tonsillectomy, UPPP, and lateral pharyngoplasty or pillar implants to much more invasive treatments, such as bimaxillary advancement, mandibular osteotomies, tongue base suspension, and partial glossectomy, have been advocated by many authors.^{12–14}

A 50% decrease in AHI in a patient with OSAS might be considered therapeutic success. The American Academy of Sleep Medicine defines success as a patient with no more OSAS symptoms and an AHI under 5.³ The most commonly used criteria for success, however, are a 50% drop and an AHI under 5.

In the current study, the mean AHI significantly decreased and the mean minimal O₂ saturation significantly increased postoperatively, regardless of the operation conducted. This confirms the success of both lateral pharyngoplasty and UPPP for patients with obstruction at the uvulopalatal and pharyngeal level, with 50% or greater collapse in drug-induced sleep endoscopy.

Lateral pharyngoplasty and UPPP are surgical options for the same level of obstruction, and there were no significant differences in the rates of decrease in AHI values between the 2 techniques.

There continues to be debate over the efficacy of OSAS surgeries. Rotenberg et al¹⁵ reported in a retrospective review that between 1999 and 2005, 85% of 345 OSAS patients who were operated did not have successful outcomes. Of those, 80% had palatal surgery, but a postoperative drug-induced sleep endoscopy showed that 76% had pathologies of the tongue base and other areas. The most important point of this study is the importance of detailed preoperative inspections and detection of obstruction sites.

In the current study, the patients had 50% or greater collapse at the oropharynx; based on VOTE classification.¹⁶ None had septum deviation or other upper airway obstruction sites. We can safely state that our patients' AHI values decreased 50%, to less than 20, indicating that surgical success was achieved polysomnographically. The Epworth scores also significantly decreased.

Other studies have compared lateral pharyngoplasty and UPPP. Cahali et al¹⁷ operated on 27 OSAS patients, using lateral pharyngoplasty on 15 and UPPP on 12. They found that AHI and Epworth scores were significantly lower in the UPPP group.

There are more studies on UPPP, which is an older technique. Varendh et al¹⁸ studied 129 UPPP patients for 20 years and reported that 50% were satisfied with the results and 30% using CPAP. Karataylı et al¹⁹ combined UPPP with thyrohyoid suspension on 20 patients and reported a success rate of 90%. Lim et al²⁰ combined UPPP with tongue RFA and reported a success rate of 66%. Braga et al²¹ reported that UPPP is more effective when combined with other techniques. Mahakit et al²² found a 77.8% success rate with UPPP. Their follow-up period was between 25 and 37 months. Adding our results to these studies, we can say that UPPP is a safe choice for well-selected patients. Cahali et al¹⁷ reported favorable results with the lateral pharyngoplasty technique.

In the current study, there were no significant differences between the rates of decrease in AHI values between the groups. In addition, both groups had higher minimum O₂ saturation levels after surgery, although the increase in the lateral pharyngoplasty group was higher. Similarly, the Epworth sleepiness scores significantly decreased after surgery in both groups, but the decrease was higher in the lateral pharyngoplasty group.

Our study confirms that both techniques led to successful outcomes in our patient sample. We believe that multilevel surgery addressing all pathologic sites, combined with sleep endoscopy and Muller's maneuver, should be considered. More studies on more patients with control groups are needed.

CONCLUSIONS

Lateral pharyngoplasty and UPPP are successful surgical techniques when patients are thoroughly evaluated through detailed ear–nose–

throat examinations, sleep endoscopy, and Muller's maneuver, and the pathology is well addressed. Our results are consistent with those reported in the literature. A total of 23 patients with 2 years of follow-up, however, may not be enough to state a definitive result. Longer studies with more patients are always needed. In conclusion, we note that every patient must be considered personally. Not all OSAS patients need the same treatment. Each patient must always be thoroughly examined to identify an appropriate treatment.

REFERENCES

1. Friedman M, Tanyeri H, La Rosa M, et al. Clinical predictors of obstructive sleep apnea. *Laryngoscope* 1999;109:1901–1907
2. Duran J, Esnaola S, Rubio R, et al. Obstructive sleep apnea hypopnea and related clinical features in a population-based sample of subjects aged 30 to 70 yr. *Am J Respir Crit Care Med* 2001;163:685–689
3. Hobson JC, Robinson S, Antic NA, et al. What is "success" following surgery for obstructive sleep apnea? The effect of different polysomnographic scoring systems. *Laryngoscope* 2012;122:1878–1881
4. Thorpy M, Chesson A, Derderian S, et al. Practice parameters for the treatment of obstructive sleep apnea in adults: the efficacy of surgical modifications of the upper airway. *Sleep* 1996;19:152–155
5. Schwab RJ, Gupta KB, Gefter WB, et al. Upper airway and soft tissue anatomy in normal subjects and patients with sleep disordered breathing: significance of the lateral pharyngeal walls. *Am J Respir Crit Care Med* 1995;152:1673–1689
6. Cahali MB. Lateral pharyngoplasty: a new treatment for obstructive sleep apnea hypopnea syndrome. *Laryngoscope* 2003;113:1961–1968
7. American Thoracic Society Board Directors. Indications and Standards for use of nasal continuous positive airway pressure (CPAP) in sleep apnea syndromes. *Am J Respir Crit Care Med* 1994;150:1738–1745
8. Stradling JR. Obstructive sleep apnea. Definitions, epidemiology and natural history. *Thorax* 1995;50:683–689
9. Fairbanks DN. Operative techniques of uvulopalatopharyngoplasty. *Ear Nose Throat J* 1999;78:846–850
10. Practice Committee of the American Sleep Disorders Association. Practice parameters for the indications for polysomnography and related procedures. *Sleep* 1997;20:406–422
11. Bausmer U, Gouveris H, Selivanova O, et al. Correlation of the Epworth Sleepiness Scale with respiratory sleep parameters in patients with sleep-related breathing disorders and upper airway pathology. *Eur Arch Otorhinolaryngol* 2010;267:1645–1648
12. Raunio A, Rauhala E, Kiviharju M, et al. Bimaxillary advancement as the initial treatment of obstructive sleep apnea: five years follow-up of the pori experience. *J Oral Maxillofac Res* 2012;3:e5
13. Boyd SB, Walters AS, Song Y, et al. Comparative effectiveness of maxillomandibular advancement and uvulopalatopharyngoplasty for the treatment of moderate to severe obstructive sleep apnea. *J Oral Maxillofac Surg* 2013;71:743–751
14. Li S, Shi H. Lingual artery CTA-guided midline partial glossectomy for treatment of obstructive sleep apnea hypopnea syndrome. *Acta Otolaryngol* 2013;133:749–754
15. Rotenberg B, Hu A, Fuller J, et al. The early postoperative course of surgical sleep apnea patients. *Laryngoscope* 2010;120:1063–1068
16. Kezirian EJ, Hohenhorst W, de Vries N. Drug-induced sleep endoscopy: the VOTE classification. *Eur Arch Otorhinolaryngol* 2011;268:1233–1236
17. Cahali MB, Formigoni GG, Gebrim EM, et al. Lateral pharyngoplasty versus uvulopalatopharyngoplasty: a clinical, polysomnographic and computed tomography measurement comparison. *Sleep* 2004;27:942–950
18. Varendh M, Berg S, Andersson M. Long-term follow-up of patients operated with Uvulopalatopharyngoplasty from 1985 to 1991. *Respir Med* 2012;S0954-S6111
19. Karataylı-Özgürsoy S, Demireller A. Hyoid suspension surgery with UPPP for the treatment of hypopharyngeal airway obstruction in obstructive sleep apnea. *Ear Nose Throat J* 2012;91:358–364

20. Lim DJ, Kang SH, Kim BH, et al. Treatment of obstructive sleep apnea syndrome using radiofrequency-assisted uvulopalatoplasty with tonsillectomy. *Eur Arch Otorhinolaryngol* 2012;270:585–593
21. Braga A, Carboni LH, do Lago T, et al. Is uvulopalatopharyngoplasty still an option for the treatment of obstructive sleep apnea? *Eur Arch Otorhinolaryngol* 2012;270:549–554
22. Mahakit P, Siriputhorn P, Chalermwattanachai T. Tonsillectomy with uvulopalatopharyngoplasty and tongue base surgery for treatment of obstructive sleep apnea. *J Med Assoc Thai* 2012;95(Suppl 5): S111–S115

The Efficacy of Levobupivacaine Hydrochloride–Dexamethasone Infiltration for Post-Tonsillectomy Pain in Adults

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Objective: The aim of the study is to evaluate the efficacy of peritonsillar infiltration of a levobupivacaine hydrochloride and dexamethasone combination for post-tonsillectomy pain in adult patients.

Methods: A total of 40 patients were included in this double-blind, randomized, and placebo-controlled study. The patients were equally randomized into 2 groups by means of sealed envelopes. The study group (SG) received peritonsillar levobupivacaine hydrochloride and dexamethasone infiltration and the control group (CG) received peritonsillar saline infiltration. Pain scores at the second, fourth, eighth, 12th, 16th, and 24th hours and the second to seventh days after operation were recorded by the patients in each group using a visual analog scale. Duration of surgery and the total amount of blood loss during the surgery were also recorded for each patient.

Results: All pain scores in the SG were lower than those in the CG; however, the difference was significant at the second, 12th, and 16th hours, and the second and third day ($P < 0.05$). Postoperative morbidity parameters, including otalgia, nausea, vomiting, fever, halitosis, and bleeding were similar between the 2 groups. Total amount of analgesic consumption in the SG was significantly lower than in the CG on each day of the week after tonsillectomy.

Conclusions: Peritonsillar infiltration of a levobupivacaine hydrochloride and dexamethasone combination may provide pain

reduction and decrease analgesic consumption in the postoperative period after adult tonsillectomy.

Key Words: Adult, dexamethasone, levobupivacaine hydrochloride, postoperative pain, tonsillectomy

Throat pain after tonsillectomy causes severe morbidity in patients, which may lead to decreased oral intake, dehydration, secondary infection, and bleeding.^{1,2} Pain after tonsillectomy is believed to be initiated by local tissue damage that causes the liberation of inflammatory mediators, and is continued by the stimulation of C-fiber afferents located in the peritonsillar space. Pharyngeal muscle spasms and local nerve irritation also contribute to triggering pain.^{3,4}

Levobupivacaine hydrochloride is a newer S-enantiomer of bupivacaine that has long-lasting activity with low cardiac and neurologic toxicities.⁵ Dexamethasone is a synthetic glucocorticoid that has a strong antiinflammatory effect with a long half-life of 36 to 72 hours. Preoperative peritonsillar infiltration of a levobupivacaine hydrochloride and dexamethasone combination was found to be an effective method of pain control in children.⁶ In the current study, we aimed to evaluate the efficacy of a levobupivacaine hydrochloride and dexamethasone combination on post-tonsillectomy pain and morbidity in adult patients, because adults have more severe pain and longer recovery after tonsillectomy. To the best of our knowledge, the current study is the first randomized, double-blind, and placebo-controlled study to investigate the efficacy of peritonsillar infiltration of a levobupivacaine hydrochloride and dexamethasone combination in adult patients during a 1-week period.

MATERIALS AND METHODS

This prospective, randomized, double-blinded, and placebo-controlled study was conducted in the Department of Otorhinolaryngology Head and Neck Surgery of the Kayseri Training and Research Hospital between February 2014 and October 2014. A total of 40 patients who were admitted for tonsillectomy were randomly divided into the study group (SG) and the control group (CG) by means of sealed envelopes. The SG received levobupivacaine hydrochloride and dexamethasone sodium phosphate infiltration to peritonsillar fossae and the CG received saline injection. The indications for tonsillectomy were recurrent tonsillitis and/or tonsillar hypertrophy with obstructive symptoms. A written informed consent was obtained from the patients and the study protocol was approved by the Ethics Committee of the Kayseri Erciyes University School of Medicine (Turkey) (Reference:2014/161). The criteria for exclusion were as follows: patients age <18 and >60 years, allergy to any drugs used during the study, chronic analgesic intake, presence of severe systemic disease, or any coagulation disorder, or history of peritonsillar abscess.

All procedures were performed under general anesthesia using a standard anesthetic protocol. No patient received premedication. Following induction of anesthesia with 2.5 mg/kg propofol, neuromuscular relaxation was achieved with 0.6 mg/kg rocuronium. After endotracheal intubation, anesthesia was maintained with sevoflurane combined with nitrous oxide in oxygen. Additional boluses of rocuronium were injected if necessary.

All surgical procedures were performed by the same surgeon. The study drug consisted of 4 ml of 5% levobupivacaine hydrochloride (Chirocaine 5 mg/ml; Abbot, Nycomed Pharma AS NO-2418 Elverum, Norway) and 2 ml of dexamethasone sodium phosphate (Dekort 4 mg/ml; Deva Holding, Istanbul, Turkey).

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Injections were performed with straight 27-G needles using an aspiration-injection technique. A total 3 ml of drug mixture was infiltrated into the tonsillar fossae at 3 injection points as follows: 1 ml to the superior pole, 1 ml to the inferior pole, and 1 ml between these two. Sharp dissection tonsillectomy with bipolar coagulation for hemostasis was performed 5 minutes after the injection. The identical procedure was also performed for the contralateral side. In the CG, a total of 6 ml of 0.9% saline solution was infiltrated as the study drug in the same manner to the tonsillar fossae and the rest of the surgical steps were the same as for the SG. Solutions for the study were prepared by the same anesthesiologist, who was not included in the postoperative evaluation, and neither the surgeon nor the patients were aware of the content of the injected solution. Duration of surgery and the total amount of blood loss during the surgery were recorded for each patient. All patients were administered amoxicillin–clavulanic acid suspension (40 mg/kg/day) 2 times daily. A maximum of 500 mg paracetamol 4 times daily were also given to patients for pain control if they had pain.

A visual analog scale graded from 0 to 10 points was used to evaluate the postoperative pain of the patients. Pain scores at the second, fourth, eighth, 12th, 16th, and 24th hours and the second to seventh days after the operation were recorded by the patients using a visual analog scale. Postoperative morbidity, including otalgia, nausea, vomiting, fever, halitosis, and bleeding was also written on a diary questionnaire form by the patients during the 1 week after surgery. Total amount of analgesic consumption was also documented on the diary questionnaire.

Statistical analysis was performed using the Statistical Package for the Social Sciences (v. 15; SPSS Inc., Chicago, IL). A 2-tailed unpaired Student *t* test was used to compare the parametric conditions of the 2 groups and χ^2 for comparison of categorical variables. Mann-Whitney test was carried out for nonparametric conditions. Data are presented as mean $\pm$ SD and a *P* value less than 0.05 was considered significant for all comparisons.

RESULTS

The demographic and operative data (age, sex, operation time, and blood loss) of the patients are shown in Table 1 and there was no significant difference between SG and CG in these parameters ($P > 0.05$).

The postoperative pain scores for the SG and CG at the second, fourth, eighth, 12th, 16th, and 24th hours and the second to seventh days are reported in Table 2. All pain scores in the SG were lower than those in the CG; however, the difference was significant at the second, 12th, and 16th hours, and the second and third day between the groups ($P < 0.05$).

The results of postoperative morbidity parameters are shown in Table 3. There was no statistical difference between the groups in terms of postoperative morbidity parameters ($P > 0.05$). Total amount of analgesic consumption in the SG was significantly lower than in the CG on each day of the week after the tonsillectomy

TABLE 1. Demographic and Operative Data (n, Mean $\pm$ SD)

	Study Group (N = 20)	Control Group (N = 20)	<i>P</i> Value
Age (years)	25.2 $\pm$ 8.1	23.5 $\pm$ 6.9	0.48
Sex	11 F, 9 M	12 F, 8 M	1
Operation time (min)	29.7 $\pm$ 8.5	29 $\pm$ 8.3	0.78
Blood loss (ml)	32.2 $\pm$ 14.2	30 $\pm$ 14.3	0.62

F, female; M, male.

TABLE 2. Pain Scores for SG and CG (Mean $\pm$ SD) after Tonsillectomy

	Study Group (N = 20)	Control Group (N = 20)	<i>P</i> Value
2nd hour	5.4 $\pm$ 2.9	7.4 $\pm$ 2.2	0.021
4th hour	5.5 $\pm$ 2.5	6.5 $\pm$ 2.7	0.232
8th hour	5.6 $\pm$ 2.4	6.8 $\pm$ 2.1	0.123
12th hour	5.3 $\pm$ 2.5	7 $\pm$ 2.5	0.047
16th hour	4.7 $\pm$ 2.4	6.9 $\pm$ 2.5	0.009
24th hour	5.3 $\pm$ 2.7	6.5 $\pm$ 2.6	0.168
2nd day	5.7 $\pm$ 2	7.1 $\pm$ 2.1	0.043
3rd day	4.4 $\pm$ 2.3	5.8 $\pm$ 1.7	0.048
4th day	4.5 $\pm$ 2.6	5.6 $\pm$ 2.3	0.171
5th day	4.6 $\pm$ 2.9	5.5 $\pm$ 2.8	0.302
6th day	4.4 $\pm$ 3.1	5.5 $\pm$ 2.2	0.209
7th day	3.8 $\pm$ 2.7	4.8 $\pm$ 2.3	0.243

CG, control group; SG, study group;

(Table 4). There were no complications associated with the levobupivacaine hydrochloride and dexamethasone combination in the SG.

DISCUSSION

Pain control after tonsillectomy constitutes a major problem in adult patients and there are many studies in the literature conducted with different protocols to investigate the efficacy of local anesthetic or steroid application on pain relief after tonsillectomy.^{3,7–9} A great majority of these studies were performed in children. Studies based on the efficacy of the newer local anesthetics on post-tonsillectomy pain and comorbidities in adult patients are insufficient in the literature.

The analgesic effect of levobupivacaine hydrochloride infiltration in adult patients with otolaryngological pathologies was investigated in only a few studies. Kasapoğlu et al¹⁰ investigated the efficacy of levobupivacaine hydrochloride infiltration on post-tonsillectomy pain relief in adults in a single-blinded, randomized, and controlled study design. They found pain scores to be significantly lower after levobupivacaine hydrochloride infiltration compared with the CG in the first 24 hours and concluded that more in-depth, double-blinded, and placebo-controlled studies are required to elucidate its long-term benefits. In another study, Tatar et al¹¹ demonstrated that the infiltration of levobupivacaine hydrochloride alone, and in particular with the combination of steroids in patients undergoing modified radio frequency-assisted uvulopalatoplasty allowed less postoperative pain.

Preoperative infiltration of corticosteroids alone or in combination with local anesthetics has been shown to reduce surgical morbidities, including pain after head–neck procedures,^{7,12,13} but studies conducted with levobupivacaine hydrochloride and dexamethasone are very few in the literature and mainly performed in children. Aysenur et al¹⁴ evaluated the effects of preemptive

TABLE 3. Postoperative Data Related to Morbidity

	Study Group (N = 20)	Control Group (N = 20)	<i>P</i> Value
Nausea	7	8	1
Vomiting	0	1	1
Fever	4	5	1
Otalgia	11	15	0.32
Halitosis	8	8	1
Bleeding	1	2	1

TABLE 4. Total Amount of Analgesic Consumption

	Study Group (N=20)	Control Group (N=20)	P Value
1st day	2.2 ± 1	2.9 ± 0.9	0.027
2nd day	2.1 ± 0.9	2.85 ± 1	0.035
3rd day	1.8 ± 1.2	2.7 ± 1.3	0.043
4th day	1.8 ± 1.2	2.6 ± 1.2	0.035
5th day	1.6 ± 1.2	2.4 ± 1	0.040
6th day	1.2 ± 1.1	2.3 ± 1.2	0.006
7th day	1.05 ± 1	2.1 ± 1.2	0.005

local infiltration of dexamethasone versus levobupivacaine hydrochloride on postoperative pain and morbidity in 60 pediatric adenotonsillectomy patients. They concluded that peritonsillar dexamethasone infiltration was more effective than both levobupivacaine hydrochloride and saline in reducing post-tonsillectomy pain. In another study, Basuni et al⁶ reported that addition of dexamethasone to levobupivacaine hydrochloride for preoperative peritonsillar infiltration has better postoperative analgesic effects than intravenous dexamethasone combined with peritonsillar levobupivacaine hydrochloride infiltration in children. There was no significant difference in postoperative emesis, fever, and halitosis between the groups in their study.

Warnock and Lander¹ reported that considerable pain lasted for more than 7 days after tonsillectomy, with the most intense pain being seen in the first 3 days, whereas for the following 4 days, there was a gradual decline in pain sensitivity. Therefore, the follow-up period of the patients after tonsillectomy was maintained to the seventh day in the current study. Preincisional peritonsillar infiltration of a levobupivacaine hydrochloride and dexamethasone combination reduced pain in the first 24 hours and the following 7 days compared with saline injection in this study. The difference, however, was significant at the second, 12th, and 16th hours, and the second and third day between the groups ($P < 0.05$). Also, we did not find any significant difference in postoperative morbidity parameters, including otalgia, nausea, vomiting, fever, halitosis, and bleeding between the 2 groups. The total amount of analgesic consumption in the SG was significantly lower than in the CG on each day of the week after tonsillectomy.

One of the limitations of our study was the small number of subjects in each group. Another limitation may be the lack of a third group receiving levobupivacaine hydrochloride infiltration alone. To the best of our knowledge, the current study, however, is the first randomized, double-blind, and placebo-controlled study investigating the efficacy of peritonsillar infiltration of a levobupivacaine hydrochloride and dexamethasone combination in adult patients for a 1-week period of time.

CONCLUSIONS

Our results showed that a levobupivacaine hydrochloride and dexamethasone combination administered to the peritonsillar space can help pain control and decrease analgesic consumption in the postoperative period after adult tonsillectomy. The pain relieving effect of the drug combination can last to the third day after the operation. Further studies with a larger number of participants are required to support these results.

REFERENCES

1. Warnock FF, Lander J. Pain progression, intensity and outcomes following tonsillectomy. *Pain* 1998;75:37–45
2. Tas E, Hanci V, Ugur MB, et al. Does preincisional injection of levobupivacaine with epinephrine have any benefits for children

undergoing tonsillectomy? An intraindividual evaluation. *Int J Pediatr Otorhinolaryngol* 2010;74:1171–1175

3. Jebeles JA, Reilly JS, Gutierrez JF, et al. The effect of pre-incisional infiltration of tonsils with bupivacaine on the pain following tonsillectomy under general anesthesia. *Pain* 1991;47:305–308
4. Yilmaz S, Demiraran Y, Akkan N, et al. The effects of topical levobupivacaine on morbidity in pediatric tonsillectomy patients. *Int J Pediatr Otorhinolaryngol* 2009;73:1208–1210
5. McLeod GA, Burke D. Levobupivacaine. *Anaesthesia* 2001;56:331–341
6. Basuni AS, Ezz HA, Albirmawy OA. Preoperative peritonsillar infiltration of dexamethasone and levobupivacaine reduces pediatric post-tonsillectomy pain: a double-blind prospective randomized clinical trial. *J Anesth* 2013;27:844–849
7. Kaygusuz I, Susaman N. The effects of dexamethasone, bupivacaine and topical lidocaine spray on pain after tonsillectomy. *Int J Pediatr Otorhinolaryngol* 2003;67:737–742
8. Karaaslan K, Yilmaz F, Gulcu N, et al. The effects of levobupivacaine versus levobupivacaine plus magnesium infiltration on postoperative analgesia and laryngospasm in pediatric tonsillectomy patients. *Int J Pediatr Otorhinolaryngol* 2008;72:675–681
9. Diakos EA, Gallos ID, El-Shunnar S, et al. Dexamethasone reduces pain, vomiting and overall complications following tonsillectomy in adults: a systematic review and meta-analysis of randomised controlled trials. *Clin Otolaryngol* 2011;36:531–542
10. Kasapoglu F, Demir UL, Kaya FN, et al. The effects of levobupivacaine infiltration on post-tonsillectomy pain relief in adults: a single-blinded, randomized, and controlled clinical study. *Eur Arch Otorhinolaryngol* 2013;270:761–766
11. Tatar AO, Yoruk O, Akgun M. The effects of dexamethasone and levobupivacaine on postoperative pain in modified radiofrequency assisted uvulopalatoplasty (MRAUP) surgery. *Eur Arch Otorhinolaryngol* 2014;271:1803–1808
12. Bateman MC, Conejero JA, Mooney EK, et al. Short-stay cleft palate surgery with intraoperative dexamethasone and marcaine. *Ann Plast Surg* 2006;57:245–247
13. Steward DL, Grisel J, Meinen-Derr J. Steroids for improving recovery following tonsillectomy in children. *Cochrane Database Syst Rev* 2011;8:6–8
14. Aysenur D, Mine C, Ozgur Y, et al. Pre-emptive peritonsillar dexamethasone vs. levobupivacaine infiltration for relief of post-adenotonsillectomy pain in children: a controlled clinical study. *Int J Pediatr Otorhinolaryngol* 2014;78:1467–1471

Abducens Nerve Palsy and Ipsilateral Horner Syndrome in a Patient With Carotid–Cavernous Fistula

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Abstract: The combination of abducens nerve palsy and ipsilateral Horner syndrome was first described by Parkinson and considered as a localizing sign of posterior cavernous sinus lesions. The authors present a case with right abducens nerve palsy with ipsilateral Horner syndrome in a patient with carotid–cavernous fistula because of head trauma. The patient was referred to the ophthalmology clinic with diplopia complaint after suffering a head trauma during a motorcycle accident. Cerebral angiography showed low-flow carotid–cavernous fistula.

Key Words: Abducens palsy, anisocoria, carotid–cavernous fistula, cavernous sinus, Horner syndrome, ptosis

Traumatic abducens nerve palsy is a well-known complication of cranial trauma. The combination of abducens nerve palsy and ipsilateral Horner syndrome, on the contrary, was first described by Parkinson¹ as a separate syndrome localizing the lesion to posterior cavernous sinus. Ocular sympathetic nerve fibers enter the cavernous sinus with the internal carotid artery and then join the abducens nerve for a small distance in the posterior cavernous sinus. Thus, a postganglionic Horner syndrome and ipsilateral abducens palsy is an important indication for lesions in or effecting cavernous sinuses. We present a case with right abducens nerve palsy with ipsilateral Horner syndrome in a patient with carotid–cavernous fistula.

CLINICAL REPORT

A 22-year-old man was injured in motorcycle accident and was referred to our clinic for admission into intensive care unit. His computed tomographic scans showed basal skull fracture extending to carotid canal and pneumocephalus. Two days after his admission, he was referred to the ophthalmology department because of diplopia. Ocular examination showed right lateral rectus palsy and right partial ptosis (Fig. 1). His corrected visual acuity was 1.0 in each eye. Both light and near reflexes were prompt and there was no relative afferent pupillary defect. Biomicroscopic examination showed subconjunctival hemorrhage in his left eye and bruising of left eyelids. Funduscopic findings did not demonstrate any abnormalities. No proptosis was present with Hertel exophthalmometry, with both eyes at 14 mm. Palpebral fissure was 5 mm in the right eye and 7 mm in the left eye. Pupil diameter was 4 mm in the right eye and 6 mm in the left eye under darkened conditions (Fig. 2). As a result, Horner syndrome was suspected and to confirm the diagnosis 10% cocaine solution was inserted twice. Following the cocaine test, pupil diameter was 5 mm in the right eye and 7 mm in the left eye in dark. 1% hydroxyamphetamine test was not performed because of nonavailability. Instead, considering the involvement of both abducens nerve and sympathetic fibers; cerebral angiography was suggested. Cerebral angiography showed a low-flow direct carotid–cavernous fistula (Type A) (Figs. 3 and 4).

DISCUSSION

Abducens nerve is known to be vulnerable to trauma and inflammation, its impairment giving no clue to the damaged lesion site. Horner syndrome is caused by an interruption of the oculosympathetic pathway and can also be a diagnostic challenge. To determine Horner syndrome, 10% cocaine solution is used. The presynaptic uptake of norepinephrine is blocked by the cocaine in the papillary



FIGURE 1. Ocular examination depicting right lateral rectus palsy and right partial ptosis.



FIGURE 2. Anisocoria. Pupil diameter was 3 mm in the right eye and 5 mm in the left eye under darkened conditions.

dilator neuromuscular junction, causing dilation in normal pupil. Cocaine has been shown to be highly effective at separating Horner syndrome patients from controls, with a postcocaine anisocoria of >0.8 mm giving an odds ratio of 1050:1.²

Next step is 1% hydroxyamphetamine drops to determine the localization; but it is necessary to wait at least 24 to 48 hours before using it, if cocaine was used.³ When abducens palsy, however, is combined with ipsilateral blepharoptosis and pupillary miosis, they give an important clue about localization. Sympathetic innervation to the eye and ocular adnexae has a three-neuron pathway beginning in the central nervous system and concludes at the eye, and its third-order neurons form a plexus surrounding the internal carotid artery and enter the carotid canal into the cavernous sinus, leaving the fibers responsible for sweat and piloerection of the face to follow the external carotid artery. In posterior part of the cavernous sinus, the sympathetic fibers travel with the intracavernous sixth cranial nerve before joining the ophthalmic division of the trigeminal nerve on its course into the orbit. Since abducens nerve and sympathetic fibers cross pathways at the posterior part of the cavernous sinus, it was first predicted by Parkinson¹ that abducens nerve palsy and simultaneous ipsilateral Horner syndrome could be a symptom of cavernous sinus lesions. This combination of abducens nerve palsy and ipsilateral Horner syndrome with different pathologies have been reported in the literature, including intracavernous internal carotid artery aneurysm,^{4,5} petrous apex fracture,⁶ metastasis,^{5,7,8} and intracavernous carotid aneurysm.^{9,10} Our patient had a traumatic type A carotid–cavernous fistula following carotid canal involvement in basilar cranial fracture.

In conclusion, we emphasize that the combination of abducens nerve palsy and ipsilateral Horner syndrome is an important sign of posterior cavernous sinus injury, and should be remembered in management of head trauma patients.

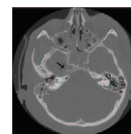


FIGURE 3. Computed tomography imaging showing the carotid canal involvement in basilar cranial fracture.

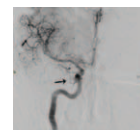


FIGURE 4. Cerebral angiography showing a direct carotid–cavernous fistula originating from the intracavernously located internal carotid artery.

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REFERENCES

1. Parkinson D, Bernard M. Horner syndrome and others? *Surg Neurol* 1979;11:221–223
2. Kardon RH, Denison CE, Brown CK, et al. Critical evaluation of the cocaine test in the diagnosis of Horner's syndrome. *Arch Ophthalmol* 1990;108:384–387
3. Davagnanam I, Fraser CL, Miskiel K, et al. Adult Horner's syndrome: a combined clinical, pharmacological, and imaging algorithm. *Eye (Lond)* 2013;27:291–298
4. Abad JM, Alvarez F, Blazquez MG. An unrecognized neurological syndrome: sixth-nerve palsy and Horner's syndrome due to traumatic intracavernous carotid aneurysm. *Surg Neurol* 1981;16:140–144
5. Striph GG, Burde RM. Abducens nerve palsy and Horner's syndrome revisited. *J Clin Neuroophthalmol* 1988;8:13–17
6. Ozveren MF, Uchida K, Erol FS, et al. Isolated abducens nerve paresis associated with incomplete Horner's syndrome caused by petrous apex fracture—case report and anatomical study. *Neurol Med Chir (Tokyo)* 2001;41:494–498
7. Tsuda H, Ishikawa H, Asayama K, et al. Abducens nerve palsy and Horner syndrome due to metastatic tumor in the cavernous sinus. *Intern Med* 2005;44:644–646
8. Gutman I, Levartovski S, Goldhammer Y, et al. Sixth nerve palsy and unilateral Horner's syndrome. *Ophthalmology* 1986;93:913–916
9. Fujisawa H, Marukawa K, Kida S, et al. Abducens nerve palsy and ipsilateral Horner syndrome: a predicting sign of intracranial carotid injury in a head trauma patient. *J Trauma* 2001;50:554–556
10. Vishnu VY, Petluri G, Gupta V, et al. Parkinson syndrome: a precise localization for abducens palsy. *J Neurol Sci* 2013;336:288–289