Use of Superficial Temporal Fascia Flap for Treatment of Postradiation Trismus: An Innovation

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Abstract: Post radiation trismus severely reduces the quality of life. Radiation causes fibrosis of muscles of mastication resulting in severe restriction of mouth opening. Treatment options are limited as most of the local flaps are in the radiation zone. The present case is the first case in existing literature where, following the release of fibrosis secondary to radiation, superficial temporal fascia (STF) was used to cover the defect with excellent results and no recurrence after a year of follow up.

Key Words: Radiation, superficial temporalfascia flap, trismus

The ever-increasing incidence of oral cancer in India is apparent in the literature. Use of tobacco and its products can cause devastating effects on health. Treatment of cancer in the form of surgery and radiation for complete cure has resulted in a vast number of functional problems. Post radiation fibrosis of muscles of mastication resulting in trismus is often a late complication.[1] The prevalence reported for trismus after head and neck cancer treatment is in the range of 5% to 38%.[2] Literature supports physiotherapy and medical modalities for treatment of radiation-induced fibrosis but in severe patients surgery remains the only treatment option. Trismus is unavoidable in patients with cancer of the base of tongue wherein surgical and radiation treatment is often mandatory. The surgical treatment options for trismus include various procedures such as simple release of fibrous bands with or without reconstruction using various flaps, for example, skin graft,[3] buccal pad fat,[4] nasolabial flap,[5] greater palatine pedicled flap,[6] tongue flap[7] and radial artery forearm flap.[8] Coronoidectomy is a known adjunct to all these surgical procedures.[9] The technique described here was first used for treatment of oral submucous fibrosis in 2005.[10] To the best of the knowledge of all the authors, the present case is the first case in the existing literature wherein following the release of fibrosis secondary to radiation, STF was used to cover the defect with excellent results and no recurrence after a year of follow-up.

CLINICAL REPORT

A 46-year-old male reported to our center with a chief complaint of inability to open mouth since 1 year. History of present illness revealed that the individual had undergone hemiglossectomy, comprehensive neck dissection on right side, and selective neck dissection on the left side without reconstruction for carcinoma oral cavity (primary: anterolateral tongue; stage: T2 N2b, Mo). Only primary closure was carried out to close the defect. The mouth opening after surgery was limited to 2 finger breadth. Following surgery, chemo and radiotherapy was used to address the adverse features noticed during histopathological examination of the excised specimen. During radiotherapy mouth opening further reduced and progressed to the present state. On examination interincisal mouth opening was 11 mm (Fig. 1). There was severe fibrosis of the entire oral cavity with restriction of the tongue movements. Keeping in view the clinical findings, history and medical documents produced by the patient—a diagnosis of postradiation trismus in an operated patient of carcinoma oral cavity was made. Patient was counseled regarding available surgical modalities and the poor prognosis of the condition. Routine preanaesthetic investigations were carried out and surgery was planned under general anesthesia (fibre-optic intubation). Incision from the preauricular region was extended to the temporal region and dissection was performed in the subfollicular plane to develop STF to its maximum limit (Fig. 2A). Similar incision and dissection was carried out on the opposite side (Fig. 2B). After subperiosteal dissection over the zygomatic arch, origin of the masseter muscle was completely released till zygomatic process of the maxillary bone. This allowed partial release of the fibrosis. Intraorally, bilateral incisions were made to release the mucosa, buccinator muscle, and pterygomandibular raphe. Through the same approach bilateral coronoidectomy along with temporalis myotomy was carried out. This procedure created a large mucomuscular defect. Mouth opening achieved at this stage was 40 mm. STF flap was elevated from the pericranium and the deep temporal fascia (Fig. 2C-D). The flap was pedicled on the superficial temporal vessels and rotated over the zygomatic arch and brought intraorally to fill in the defect. The interrupted and mattress sutures were placed by using No. 3-0 Vicryl (Ethicon, Somerville, NJ) to secure the graft (Fig. 3A-B). STF covered the entire defect, eliminating the possibility of secondary epithelialization. Postoperatively, prophylactic antibiotics and nasogastric feed was given for 1 week. Surgical suction drains were removed from the temporal region after 72 hours. Mouth-opening exercise was started within 48 hours. This intensive exercise was carried out daily for 3 months and with reduced frequency for next 1 year. The patient was monitored for postoperative mouth opening (interincisal distance in millimeters) and epithelialization of STF. Excellent take up and epithelialization of STF was noticed in 4 weeks (Fig. 4). Mouth opening 1 year postoperatively is about 35 mm (Fig. 5).

DISCUSSION

When the radiation field involves the muscles of mastication postradiation, fibrosis leading to trismus often takes place. Ischemia and fibrosis is thought to be due to endarteritis obliterans. Postradiation trismus often leads to poor quality of life. It compromises the dental hygiene and results in poor calorie intake.[1] The aim of this procedure was to release the postradiation fibrosis and provide long-term adequate mouth opening.

Conservative treatment options are not recommended in the advanced stage as surgery is the only effective treatment modality. The release of fibrous bands and use of skin grafts often result in

FIGURE 1. Reduced preoperative mouth opening.

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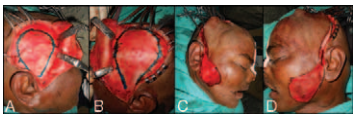

FIGURE 2. A, STF developed through preauricular approach on right side. B, STF developed through preauricular approach on right side. C, STF raised on right side. D, STF raised on left side.

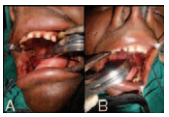

FIGURE 3. A, STF secured intraorally on the right side. B, STF secured intraorally on the left side.

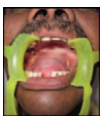

FIGURE 4. Take up and epithelialization of STF.

FIGURE 5. Adequate mouth opening postoperatively.

recurrences due to graft contraction and scarring. Only release of fibrous bands and coronoidectomy will not provide adequate mouth opening as some form of interpositional barrier is required so as to achieve and maintain adequate mouth opening. Buccinator and masseter muscle flaps could not be used due to extensive fibrosis. Buccal pad fat is generally the first choice in oral submucous fibrosis. This option was not available as it gets fibrosed following radiotherapy. Nasolabial flaps were not used because of impaired blood supply as the facial artery is ligated at level I B during neck dissections. Moreover, it is inadequate to cover large mucomuscular defect. Greater palatine pedicled flap requires extraction of a molar to rotate the flap and is insufficient to cover the defect. Moreover in radiation trismus even the palate gets fibrosed. Hemiglossectomy makes tongue flap impossible in this patient. Radial artery free forearm flap is bulky, hair bearing, time consuming, and requires microvascular expertise.[4] The only viable option left in this patient was STF. The STF flap is an extension of the galea aponeurosis in the temporal region and superficial musculoaponeurotic sheet system in the facial region which can be rotated to cover the surgical defects. The fascia can be further extended to include the temporoparietal fascia and galea, if required. It has been used extensively in head and neck surgery, not only as a graft to reconstruct intraoral and extraoral defects, but also as interpositioning material following the release of temporomandibular joint ankylosis, oral submucous fibrosis, and superficial parotidectomy.[11] The flap can be raised rapidly and easily without any specific treatment. It is reliable and allows a long pedicle. In the present patient, none of the local flaps was available to cover the large mucomuscular defect secondary to the release of fibrosis. The only option left was a distant flap not affected by the post-radiation trismus. STF unlike temporalis flap does not cause hollowness in the temporal region. This is one of the most common flaps used in head and neck surgeries and most of the surgeons are well versed with the harvesting and utility of the flap. There is absolutely no donor site morbidity with this flap. The scar gets covered by the hair bearing area. Facial nerve is underneath STF, so there are minimal chances of damage to the temporal branch. Looking at the poor prognosis of radiation trismus, the authors have combined transection of the fibrous bands, temporalis myotomy, cornoidectomy, and interpositioning with STF as an innovative technique and found it to be safe and effective.

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Versatile Clinical Application of the Spike Screw: Direct Anchorage Versus Indirect Anchorage

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Objectives/Introduction: This article represents clinical application of spike screw, novel design of miniscrew, for direct anchorage and indirect anchorage in orthodontic treatment. Accompanied by easy placement and removal, the spike screw provides good stability for the orthodontic anchorage.

Materials and Methods: The spike screw consists of 6 spikes attached to a washer with laser welded stainless-steel hook that is placed by self-drilling fixation miniscrew. The spike screws were applied to correct malocclusions in patients as follows: traction of

impacted canines and protraction of posterior teeth as a direct anchorage and correction of midline discrepancy as an indirect anchorage. For orthodontic traction of impacted canines, spike screws were placed in the mandibular labial mucosal area to create extrusive forces. Afterward, it was utilized for the protraction of posterior teeth. In the second case of the indirect anchorage, spike screw was applied on the midpalatal area to correct midline discrepancy that occurred during orthodontic treatment. The extended hook of a washer was prebended along the curvature of the palate and then secured with a mini screw. The extended hook was bonded to maxillary left first molar.

Results: In the first case, the spike screw provided adequate anchorage for the vertical traction of horizontally impacted canine. Since the spike screws were placed in the mandibular anterior lesion, the vertical traction force was applied simply with orthodontic elastics. Also, enough distance was achieved for up-down elastics to work by placing the spike screw in the opposite arch. The force of vertical traction was adjusted with selection of size and force of up-down elastics. Later, it was used to provide anchorage for protraction of mandibular molars without changing orientation of the spike screws. In the second case, the spike screw placed in the midpalatal area was attached to the left first molar and worked as an indirect anchorage. The midline discrepancy was resolved by consolidating the spaces to the left with securing the left first molar location.

Conclusion: The novel design of the spike screw permits clinicians to have minimum invasive and easy placement and removal of the appliance while maintaining a good control over tooth movement with improved stability in various clinical cases.

Key Words: Biocreative strategy, miniplate, miniscrew, orthodontics, spike screw

In every action of tooth movement, an equal and opposite reactive force is generated according to Newton's third law of motion. Orthodontic anchorage is defined as the resistance to unwanted tooth movement to reduce the negative consequences, which manifests clinically as anchorage loss.[1] During tooth movement, achieving absolute anchorage with traditional appliance can be a biomechanical challenge.[2] There are many different sources of orthodontic anchorage, such as the segments of teeth, headgear, face mask, and intermaxillary elastics. The clinical outcomes of these appliances are dependent on the patient's compliances. Since the introduction of miniscrews in orthodontic treatment, miniscrews not only unrestrained clinicians from anchorage-demanding cases, but they also enabled clinicians to have assured control over tooth movement in three dimensions with minimized discomfort to patients.[3] Orthodontic miniscrews represent the form of provisional anchorage and appear to provide a variety of benefits.

Despite these advantages, many clinicians have reported miniscrews failure rate of 10–20%.[4,5] Several factors associated with the failure of miniscrews were reported.[4–9] One critical factor that influences the stability of miniscrews is the loading force. Crupi et al[6] reported that the overloading resulted in accumulation of damage that displayed loosening of miniscrews and peripheral bone absorption. To overcome these problems, miniscrews are combined with additional structure called a washer to improve the stability by modifying the force system in our previous studies.[9,10] Due to the unique design, ''spike screw'' increases stability by reducing the high peak stress and obtains good stability like mini-plate system with noninvasive and easy placement. This article will illustrate the versatility of ''spike screw'' as a direct anchorage and an indirect anchorage in the correction of malocclusion.

METHODS

The spike screw (Jin-Biomed Co., Bucheon, Korea) consists of the modified washer with laser welded stainless-steel hook and self-drilling fixation miniscrew (Fig. 1).[9,10] A washer, which is a disk-shaped thin plate with a central hole, is used to relieve the load of a threaded fastener—such as a screw—and reinforce the anchorage. The washer used in this study was modified with addition of spikes. Six spikes were attached to the bottom side of the washer to render the washer effective in soft tissue (Fig. 1A). The hook is fabricated in 0.9 mm stainless steel that is firm enough to withstand orthodontic force application without distortion, but moldable enough to bend for intraoral adaptation. The hook length can be easily adjusted with cutting, too. When the fixation miniscrew is placed into the washer hole, the screw head fits tight and flat to the washer (Fig. 1B–D). The spike screw can be placed with minor surgical incision for the tight adaptation of the screws on the washer, and it can be done with local anesthesia.

The spike screws were applied to tract impacted canines and protraction of posterior teeth as a direct anchorage and to resolve midline discrepancy as an indirect anchorage. By placing in the mandibular labial mucosal area, it can give simple force direction and enough gaining of distance for force generation by up-down elastics. Once the impacted canines were guided into the lateral incisor extraction spaces, the spike screws served to protract mandibular molars. In the second case as an indirect anchorage, spike screw was applied on the midpalatal area to correct midline discrepancy that occurred during orthodontic treatment. The extended hook of a washer was prebended along the curvature of the palate and then secured with a mini screw, and then it was bonded to maxillary left first molar to reinforce anchorage of the first molar.

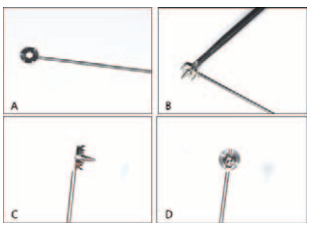

FIGURE 1. The spike screw design: the "spike screw" (Jin-Biomed Co., Bucheon, Korea) consists of the modified washer with laser welded stainless-steel hook and self-drilling fixation miniscrew (Jin-Biomed Co., Bucheon, Korea). The 6 spikes assist in anchorage of the unit along with a miniscrew.

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CLINICAL CASES

Spike screws were applied to correct malocclusions in cases as follows: traction of impacted canines and protraction of posteriors as a direct anchorage and indirect anchorage for midline correction.

In the first case, the patient was a 12-year-old girl with the chief complaint of impacted canines. The panoramic radiograph showed impacted maxillary canines and severe root resorption of maxillary incisors due to horizontal impacted canines (Fig. 2). The treatment sequence was made to extract lateral incisors, to expose impacted canines surgically, and then to tract canines to lateral incisors' position by spike screws and elastics as target teeth movement using biocreative strategy. For orthodontic traction of impacted canines, spike screws were placed in the mandibular labial mucosal area under local anesthesia to create the extrusive forces. Incision was needed for the placement of the spike screws in the labial mucosal area, but minimally about less than 3 mm. After positioning the washers in the point of interest, the self-drill miniscrews of 4 mm were inserted through the washer hole to securely place them (Fig. 3). The long hooks were prebended to serve for the traction of impacted canines. After insertion of spike screws, we checked the clearance between the spike screws and adjacent tooth roots using dental CT image (Fig. 3E). The 4 mm self-drill miniscrew is long enough to penetrate the cortical bone, but short enough to be safely placed without distressing about penetrating root surface. The miniscrews with spikes afford sufficient fixation to withstand orthodontic force application. Successful eruption with minimal additional root resorption was found in progress panoramic radiograph (Fig. 4). After traction of canines, spike screws were used as direct anchorage for protraction of mandibular posterior teeth. Mandibular first premolars were extracted for the correction of molar relationship and anterior occlusion. Protraction of mandibular posteriors was applied from the hooks of the spike screw directly via brackets with elongated hooks attached to mandibular first molars (Fig. 4C-D).

In the second case, spike screw was used for indirect anchorage for midline correction. The patient was a 16-year-old female with the chief complaint of anterior protrusion. Extraction of 4 first premolars was chosen as treatment method to retract anterior segments to resolve lip protrusion. To correct midline discrepancy,

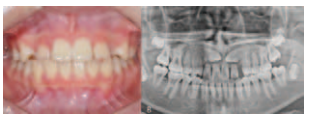

FIGURE 2. The intraoral photo and panoramic radiograph of case 1. A, The intraoral photograph shows that all teeth are erupted except both impacted canines. Notice the limitation of the eruption spaces on both sides. B, The panoramic radiograph shows severe root resorption of maxillary incisors due to horizontally impacted canines.

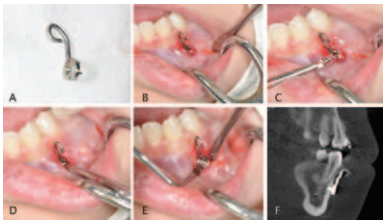

FIGURE 3. The spike screw used as a direct anchorage in case 1. A, The prebended spike screw with reduced length of extended hook. B, Minimum incision required for the positioning the spike screw washer hole to adapt the spikes directly to the cortical bone surface. C, Preparing a self-drilling fixation miniscrew into the washer hole. D, Placing a self-drilling fixation miniscrew into the washer hole. E, Checking the placement. F, Checking the root proximity of the screw through dental CT image. CT, computed tomography.

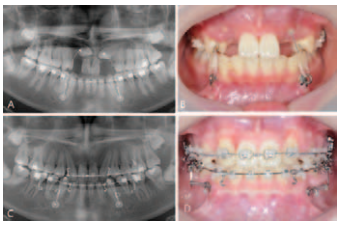

FIGURE 4. The panoramic radiographs and intraoral pictures during treatment in 3 months (A and B) and 36 months (C and D).

which occurred during the treatment, spike screw was applied on the midpalatal area (Fig. 5A-C). The extended hook of a washer was prebended along the curvature of the palate and secured with mini screw in midpalatal area under local anesthesia and it was bonded to maxillary left first molar. The bend was particularly created to compensate reactive force of the orthodontic forces. The retraction of the maxillary anterior teeth and maxillary midline correction were done using the single spike screw placed on midpalatal area as an indirect anchorage. After 4 months, midline discrepancy was alleviated (Fig. 5D-F). After complete closure of extraction spaces by consolidating to the left side, the midline discrepancy was corrected. Orthodontic fixed appliances were debonded and fixed retainers were delivered (Fig. 5G-I). The removal of the spike screw was quite simple since the fixation miniscrew was exposed without any mucosal covering. The spike screw was removed by unscrewing the miniscrew and little pulling of the washer under local anesthesia to reduce any patient discomfort (Fig. 6).

DISCUSSION

Since the introduction of miniscrews for orthodontic treatment, different types of miniscrews and methods of application have been investigated. The novel design of the spike screws was applied for

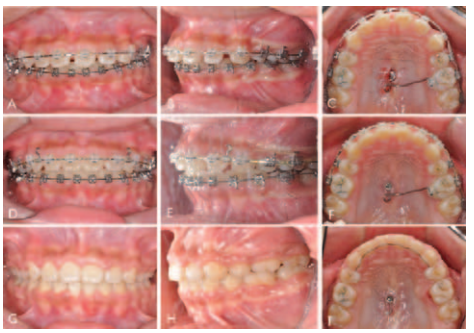

FIGURE 5. A-C, The spike screw placed in midpalatal area to correct midline discrepancy occurred during orthodontic treatment. It served as indirect anchorage by bonding the extension hook to the lingual surface of left first molar. D-F, The 4-month progress intraoral photographs showing improved midline discrepancy. G-I, Posttreatment intraoral photograph illustrating corrected midline discrepancy.

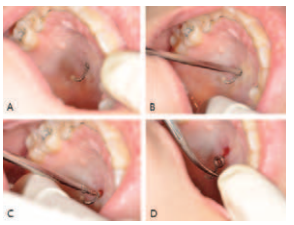

FIGURE 6. Spike screw removal process in sequence. Removal of the mini-screw with a driver and little pulling of the washer removes the spike screw unit.

correction of malocclusions; direct anchorage for vertical traction of impacted canine and protraction of posteriors with single placement and indirect anchorage for midline correction.

Direct anchorage is typically achieved from a miniscrew inserted in a buccal site, through attached mucosa, and between canine and the first premolar roots. However, spike screws were placed in the mandibular labial area to create the extrusive forces required to erupt canines. Due to traction by spike screw and up-down elastics, no reactive forces such as extrusion force occurred in the mandibular dentition.[11] Moreover, simple mechanics can be applied. In this case, spike screws were inserted in mucosal area. Because of great distance from impacted canines and spike screws, adjusting the size and force of elastics can produce large range of extrusive force. Canine traction is performed immediately following the surgical placement, without leveling and alignment with brackets. This saves treatment duration.

The spike screw was placed in the midpalatal area as indirect anchorage for midline correction. Interdental miniscrews can act as a mechanical interference that limits adjacent tooth movement. Therefore, removal and replantation of miniscrews are required in certain cases such as midline correction and total distalization of dentition. However, the midpalatal area has no dental roots, and the limitation of tooth movement is not consideration.[12] By bending the extension hook welded on washer, spike screw on the midpalatal area could serve as indirect anchorage for correction of deviated midline.

CONCLUSION

The novel design of the spike screw permits clinicians to have good control over tooth movement with improved stability in various clinical cases. The orthodontic force application could become an easy task since the extended hook can be bended to the need of clinician to achieve desired biomechanical forces. The advantages of spike screw were verified in this study, but further studies are needed before it can be applied widely.

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The Radiological and Stereological Analysis of the Effect of Low-Level Laser Therapy on the Mandibular Midline Distraction Osteogenesis

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Objective: The aim of this study was to evaluate the effect of low level laser therapy (LLLT) on bone mineral density by using high-resolution computerized tomography (HR-CT) and stereology in patients subjected to mandibular midline distraction.

Methods: Nine patients between the ages of 13 and 16 years with mandibular transverse deficiency (>5 mm) were evaluated. Mandibular midline distraction osteogenesis was performed for all the patients. The patients were divided into 2 groups: the control group (n = 4) and the laser group (n = 5). GaAlAs, 830 nm wavelength, power of 40 mW, energy of 8.4 J/cm^2 dose per spot, was directly applied from 2 points on the mandibular midline. The laser was applied in 8 treatment sessions at 48-hour intervals. Bone mineral density and volume of the newly formed bone were analyzed using HR-CT and stereological methods.

Results: A higher bone mineral density rate was found in the laser group ($P < 0.05$). A higher newly formed immature bone rate was found in the control group ($P < 0.001$). These findings suggest that more mature bone may also have a greater mineral organization than that of immature newly formed bone, which is shown by HR-CT and stereological results.

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Conclusions: The retention period can be shortened and mineralization may be increased by using LLLT in mandibular distraction osteogenesis.

Key Words: Distraction osteogenesis, bone healing, low-level laser therapy

Mandibular transverse deficiency (MTD) is a common clinical problem associated with narrow basal and dentoalveolar bones. MTD is reflected in wide lateral vestibules, severe anterior crowding, and tipping and impaction of anterior teeth.[1] In correcting transverse mandibular deficiencies, orthodontists have limited options such as tooth extraction, dentoalveolar expansion, and interproximal enamel reduction. Patients with MTD in a mixed dentition stage are commonly treated with orthodontic expansion using a lip bumper, Schwarz's device, or functional devices. These therapies lead to relatively stable results for younger patients. However, orthodontic expansion of the anterior mandibular arch is at high risk of relapse and generally unstable.[2–4]

Mandibular distraction osteogenesis (MDO) has been used as an efficacious surgical technique for the treatment of congenital retrognathia, micrognathia, and hypoplasia. Mandibular midline distraction (MMD) was offered as a treatment option for correcting mandibular transverse deficiency.[5–7] Distraction osteogenesis (DO) requires device manipulation during lengthening and a subsequent consolidation period that is proportional to the amount of bone lengthening. This period ranges from 2 to 6 months depending on the desired length and anatomic location of the distracted area. Despite the technological advancements, the length of time required for bone consolidation continues to be a significant limitation of this procedure.[6,7] Additionally, there are some complications that can occur in the distraction process such as infection, malunion, ununion, or lack of patient cooperation. There are some experimental studies to reduce or prevent these complications by shortening the treatment period and increasing osteogenesis. Various factors play a role in the success of DO, especially increased blood flow and vascularization are vital components of the formation of a healthy union in DO.[8,9]

In recent studies, low-level laser therapy (LLLT) demonstrated an increase in mitoses, tissue repair, peripheral blood circulation, osteoblastic activity, and bone regeneration, with favorable effects on the healing of both solid and soft tissues. LLLT accelerates bone healing, shortens treatment duration, and decreases morbidity rates.[10–12] There are a few experimental studies about LLLT effects on distraction healing; however, clinical studies on the evaluation of the LLLT effect on MMD were not found in the published literature. The aim of this study was to evaluate the effect of LLLT on bone mineral density by using high-resolution computerized tomography (HR-CT) and stereology in patients subjected to MMD (Tables 1-2).

TABLE 1. The Bone Densitometry Values of the Distracted Area Obtained From CT Images at Postoperative 12 Weeks

	Laser Group	Control Group
Bone densitometry values (HU)	562	43
	430	643
	702	350
	214	245
	488	
Mean+SD	479 ± 179	320 ± 250
P	0.3	

CT, computerized tomography; SD, standard deviation.

TABLE 2. The Results of the Steorological Anlysis of the Distracted Area at Postoperative 12 Weeks

	Laser Group	Control Group
Newly formed immature bone volume (mm^3)	850	1000
	450	1100
	400	1300
	500	1175
	475	
Mean+SD	535 ± 179.9	1143.7 ± 109.5
P	0.00	

SD, standard deviation.

METHODS

This study was approved by the research and ethics committee of the Ondokuzmayis University Faculty of Medicine with the project number PYO.DIS.1901-12/012. Written informed consent was obtained from the patients. Nine patients referred to Ondokuz Mayis University's Dental Faculty were included in this study. The patients undergoing a permanent dentition process with a transverse mandibular deficiency of more than 5 mm as demonstrated by orthodontic examination where routine orthodontic treatment failed were included in the study. The patients with any systemic health problems or congenital deformity were excluded from the study. The sample was randomized and divided into 2 groups: the control group (CG) comprised 4 patients (3 men and 1 woman) with a mean age of 15 years old, without irradiation, and the laser group (LG) comprised 5 patients (3 men and 2 women) with mean age of 14.8 years old, treated with laser irradiation. Before the operation, a custom-made, tooth-borne hyrax expander device (Lewa Dental, Remchingen, Germany) was placed lingually in the mandibular midline and fixed to the bands of the first premolars and first molars (Fig. 1).

Surgical Technique

For the comfort of the patient, the surgery is performed under general anesthesia (nasotracheal intubation). The patient is draped in a standard manner and the oral cavity is disinfected and rinsed (2% chlorhexidine digluconate solution). Local anesthetic is injected in the anterior mandibular region (lidocaine 10 mg/mL + adrenaline 1/ 200,000). A short horizontal incision is made through the buccal sulcus between the canine teeth, inferior to the muco-gingival junction. After the reflection of mucoperiosteal flap, the mandibular midline osteotomy is performed with a 0.3-mm oscillating saw, starting at the mandibular border and continuing upward interdentally as high as possible. The osteotomy is then finalized with a 4-mm chisel. The mobility of the mandibular halves is checked and the distractor is then activated by about 2 mm to make sure that there are no bony interferences (Fig. 2). The distractor is then deactivated. The wound is closed in layers. Postoperative procedures and medication consisting of painkillers, an antiseptic mouthwash, and an antibiotic are prescribed for the first 5–7 postoperative days. Thereafter, with a latency period of 5 days, the appliance was activated. The rate and rhythm of distraction was

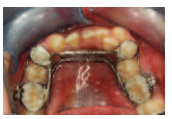

FIGURE 1. Occlusal view of the custom-made tooth-borne lingually placed distractor device.

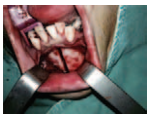

FIGURE 2. Intraoperative view of the midline osteotomy.

2×0.5 mm/day). When the planned expansion was completely achieved, the screw device was fixed and retained for 3 months.

LLLT Applications

In group 1, LLLT equipment (Fotona XD-2, Ljubljana, Slovenia), gallium–aluminum–arsenide laser (GaAlAs; 830 nm wavelength, power of 40 mW, energy of 8.4 J/cm^2) was applied. Two points on the mandibular midline were determined (Fig. 3). The first irradiated point (A) was at the region of the alveolar bone between the roots of the central incisor teeth. The second point (B) was located in the buccal sulcus depth on the midline, approximately 5 mm below point A. Two laser applications were performed at each treatment session (1 dose per point). The first was administered 24 hours after surgery and the subsequent sessions at regular 48-hour intervals. Each patient had 8 laser treatment sessions.

Radiologic Examination

In both groups, following a consolidation period lasting an average of 6–8 weeks, CT images were taken from all patients at 3 months postoperative. All patients were positioned with the occlusal plane perpendicular to the horizontal plane for CT scans. Images were taken by HR-CT (Aquilion 16 system, Toshiba Medical System Corporation, Tochigi-ken, Japan) according to a standard protocol. Axial slices were obtained from the superior border of the mandible to the low border of the corpus mandible, including the distraction area at the midline at 1 mm intervals. Density measurements using Hounsfield Units (HU) were made from the marked area between the distracted bone segments. Mean HU values as a unit of bone density were obtained, making 5 measurements for each patient (Fig. 4). Bone density values were measured twice by the same examiner.

Stereological Analysis

Volume Estimation Using the Cavalieri Principle

Volume density of regularly shaped objects such as a prism or cube can be estimated by the following formula: $V = t \times a$, where (t) is the height and (a) is the base area of the object. Similarly, using the Cavalieri principle, an unbiased volume estimation of an irregularly shaped object may be obtained efficiently and with precision by superimposing a point grid on the sectional profiles and counting all the points hitting the related area. Each point in the grid symbolizes a unit area. When this section area is multiplied with the section thickness, an unbiased estimation of structure volume is found.[13] In the present study, volumetric data were reconstructed and sectioned into 1 mm in the axial plane, and sections of thickness with 1 mm and 3 mm intervals were obtained. The volume of each defect was estimated using the Cavalieri principle (Fig. 5). The surface area of each section was measured by means of the point grid. Each measurement was repeated 3 times by 1 observer. The average score was used for estimation. Total area calculation was made using the above formula. Total area and section thickness of consecutive sections were replaced in this formula.

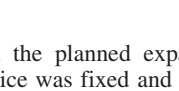

FIGURE 3. Laser application points.

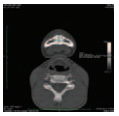

FIGURE 4. The presentation of the bone densitometry measurements of the distracted area on the axial computerized tomography images (O).

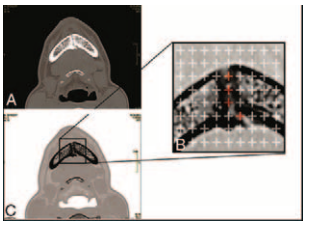

FIGURE 5. Schematic illustration of the Cavalieri method application. Axial computerized tomography images of the mandible (A) inverted first (B). Point counting grid was applied to the region of interest so that estimation would perform on it (C). Then volume of the distracted area was estimated using this grid (red plus) at the end of the 90 days.

Statistical Analysis

The results were evaluated using the SPSS 15.0 software for Windows (SPSS Inc, Chicago, IL). The Kolmogrov–Smirnov test was used to assess whether the groups demonstrated normal distribution curves. The parametric one-way analysis of variance test was used. The results were expressed as mean ± standard deviation (SD), and $P < 0.05$ was accepted as significant.

RESULTS

There were no complications in the postoperative healing period. However, subjective symptoms such as postoperative swelling and pain were lower in the laser group and patient comfort was better than in the control group.

Bone healing of the distraction gap was observed in all the patients. The bone density values of the LG (479 ± 179 HU) increased when comparing CG (320 ± 250 HU) (Fig. 6). Significant differences existed between the 2 groups in the bone density values ($P = 0.002$) (Table 1).

The results of the stereological analysis revealed increased immature bone volume in CG (1143.7 ± 109.5 mm^3) when comparing LG (535 ± 179.9 mm^3) (Fig. 7). The comparison of immature

FIGURE 6. The graphic showing bone density values of the control and laser groups.

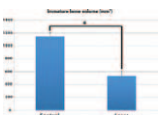

FIGURE 7. The graphic showing immature bone volume values of the control and laser groups.

bone volume of the laser and control groups revealed a statistically significant difference between the groups ($P = 0.00$) (Table 2).

DISCUSSION

MTD is frequently seen in patients needing orthodontic treatment. The deficiencies are commonly treated by orthodontic methods such as dental compensation, extraction, and arch expansion. However, it is difficult to achieve mandibular expansion after the pubertal growth period with these methods. Many orthodontists report a high risk of dental relapse, periodontal complications, and loss of alveolar bone. Therefore, the treatment of choice is mandibular midline distraction after the pubertal growth period.[14,15]

Increases in mandibular width by symphyseal DO have been shown to be an acceptable and stable treatment method option for MTD and anterior crowding with low complication rates.[14–17] Different types of symphyseal distractors have been used for MTD. Due to significant patient discomfort, frequent device breakdown, soft tissue irritation, and gingivitis, bone-borne devices are no longer used in our clinic. In this study, we used custom-made, tooth-borne lingual distraction devices.

The postoperative retention period is important to achieve bone regeneration and minimize relapses. Many therapeutic alternatives are being studied to promote cell biostimulation and improve regenerative capacity, including the transplantation of progenitor cells, administration of growth factors, hormones, and the application of demineralized bone matrix, calcium sulfate, and electrophysiological tools has been extensively investigated. Laser therapy has gained popularity in regenerative medicine due to its positive effect on healing periods of both soft and hard tissues. In our study, it was clearly seen that LLLT application with GaAlAs significantly promoted the distracted bone healing in all analyses.[17–20]

Although some other investigators such as Kan et al[18] reported that because the optimal doses, intensities, treatment intervals, and wavelengths for various indications remain unclear and the distraction protocol (latency period, rate, rhythm, and strain) can alter the process of bone formation, it is obvious that other experimental models should be designed to determine the optimal distraction protocol and laser exposure protocol for best results in this field. Vedovello Filho et al[19] and Angeletti et al[10] reported that the use of LLLT after surgically assisted rapid palatal expansion. Angeletti et al[10] used a GaAlAs laser (830 nm wave length, power of 100 mW, 0.06 cm^2 tip diameter). They applied 1 session of laser application every 48 hours on 3 points near the midpalatal anterior sutur for a total of 8 sessions. Laser protocol and laser parameters used in this study are similar to those reported by Angeletti et al.[10]

Some investigators, including Pretelli et al[20] and Satio et al[21], claim that low-level lasers can be useful in the early stages of bone formation, but are not effective in later stages. Cerqueira et al[22] investigated the effects of LLLT in different stages of DO on sheep mandibles. They reported that lasers positively affect bone healing during the early stages due to the cellular component being more prominent and more likely to be affected by laser therapy. Similarly, we applied LLLT in the early stages of distraction periods. Our results are in agreement with those of Satio et al, Pretelli et al, and Cerqueira et al.[20–22]

GaAlAs laser application is reported to be useful for the process of new bone formation by affecting the calcium transport.[23] Khadra et al[24] in their studies both 14 and 28 days postoperative LLLT application (830 nm, 75 mw output) showed a significant increase in the deposition of calcium, phosphorus, and insoluble protein. The amount of calcium and phosphorus in the postoperative experimental group from day 14 to day 28 was higher than that of the CG. These findings suggest that LLLT accelerates the maturation of new bone tissue and increases the mineralization. Hübler et al[12] investigated the chemical compositions of bone with X-ray fluorescence spectroscopy and X-ray diffraction and reported greater mineralization and crystallinity ratios in the LLLT group compared with the control group. Our results are in line with the literature; bone-mineral density values obtained in the LLLT group were significantly higher than that of the CG.

Quantitative information related to osteogenesis can be beneficial for better comprehension of distraction mechanisms and regulation of bone formation for clinical applications. There are some experimental studies about LLLT's effects on distraction healing by using histomorphometry, microtomography, and plain radiography.[12,19–21] There are no clinical studies in the literature examining the effects of LLLT on mandibular midline distraction via HR-CT and stereology. Among the methods that evaluate bone structure and quality, CT is distinguished by its capacity to evaluate three-dimensional volumetric mineral density and it permits an isolated evaluation of cortical and trabecular bone densities. Therefore, we used HR-CT for bone density analysis. HR-CT evaluation of distracted bone demonstrated significantly greater bone mineral density in the laser group (523 HU) when compared with that in the control group (322 HU), as in agreement with the literature that reported LLLT accelerates bone regeneration and increases mineralization.

The volume of biologic structures can be estimated by combining the sectional radiologic imaging techniques with the Cavalieri principle of stereologic volume estimation as described in the previous studies.[25,26] Volume measurements using CT scans have already been reported in the literature. Bayram et al compared the mandibular condyle volume measurements attained using the Cavalieri principle on cone beam CT (CBCT) images. They concluded that the Cavalieri principle is a valid tool for volume estimation of the mandibular condyle.[27] There are also reports showing the use of CBCT in estimating the volume of teeth, pulp chamber, mandibular condyle, and upper airway volume.[28–30] In studies analyzing the effect of section thickness on volume estimations of organs or cavities by using CT images, the authors reported underestimations of the volumes that were caused by increases in slice thickness.[19,20] Sezgin et al[30] stated that volume assessments can be performed on CBCT images safely by using the Cavalieri principle and a slice thickness up to 1 mm can be chosen for volume estimation of intraosseal defects.

In the present study, newly formed bone volume was measured by combining the CT images with 1-mm slice thickness with the Cavalieri principle. We observed an excellent agreement between stereologic measurements and bone density measurements performed on CT scans. Our results revealed that bone mineral density values (HU) were higher in the LG (523 HU/ 322 HU), and these findings indicate that the lasers increased maturation of newly formed bone. Stereologic results showed that immature newly formed bone volume was higher in the CG (1143 mm^3) than the LG (535 mm^3). This contrast was attributed depending on the increase of mineralization in the LG bone density measurements, while the volume of newly formed bone was higher in the CG because there is no mineralization increase. Increased mineralization of the samples in this study indicates a better quality of newly formed bone in the laser group. Our findings suggest that more mature bone may also have a greater mineral organization than that of immature newly formed bone, which is shown by HR-CT and stereologic results.

In conclusion, no other clinical studies using HR-CT and stereologic analysis of the effects of LLLT on the mandibular DO were found in the literature. The degree of osseous density is crucial for the success of distraction. This is a pilot study; therefore, in the future, we plan to study a larger patient population and longer follow-up periods. Additionally, further studies should

be conducted to evaluate the effects of the different laser parameters at different time points. It can be concluded that the retention period can be shortened and stability may be increased by using LLLT in the mandibular midline DO.

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Outcomes of Vacuum-Assisted Therapy in the Treatment of Head and Neck Wounds

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Introduction: Head and neck wounds can present a reconstructive challenge for the plastic surgeon. Whether from skin cancer, trauma, or burns, there are many different treatment modalities used to dress and manage complex head and neck wounds. Vacuum-assisted closure (VAC) therapy has been used on wounds of nearly every aspect of the body but not routinely in the head and neck area. This study was conducted to demonstrate our results using the VAC in the treatment of complex head and neck wounds.

Methods: This is an IRB-approved, retrospective review of 69 patients with 73 head and neck wounds that were managed using the VAC between 1999 and 2008. The wound mechanism, location, and

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size, length of VAC therapy, patient comorbidities, use of radiation, complications, and ultimate outcome were assessed. In this patient population, the VAC was utilized because the standard reconstructive ladder was not a good option or had previously failed.

Results: Sixty-nine patients with complex head and neck wounds were treated with the wound VAC. The mean age of the patients was 66 years, with a range of 5–96 years. Males outnumbered females in this study nearly 2:1. Eighty-six percent of patients had wounds secondary to cancer, 8% secondary to trauma, 3% secondary to infection, and 3% secondary to burns. The VAC was used as a dressing over skin grafts in 50%, over Integra in 21%, and over open debrided wounds in 29%. Wounds healed without complication in 44% of the skin grafts, 67% of Integra-covered wounds, and 71% of debrided wounds. Minor complications included failure of complete graft take, failure of granulation tissue formation in open debrided wounds, infection, and hematoma formation under skin grafts. Major complications included positive cancer margins requiring reexcision and death secondary to pulmonary embolism, sepsis, and metastatic cancer. Most complications resolved with dressing changes, repeat grafting, or the administration of antibiotics.

Conclusions: Our results demonstrate that the wound VAC provides a reliable, effective, and durable dressing for a multitude of complex head and neck wounds. Additionally, it is a valuable tool when traditional surgical procedures are not a viable option.

Key Words: Head and neck reconstruction, head and neck wounds, negative pressure wound therapy, subatmospheric pressure therapy, vacuum-assisted closure

Head and neck wounds can present a reconstructive challenge for the plastic surgeon. The challenge arises from the irregular surface contours and thickness of the native tissue. There are many different treatment modalities used to dress and manage complex wounds in this anatomic region. The standard reconstructive ladder employed by plastic surgeons in the treatment of acute and chronic wounds includes primary closure, healing by secondary intention, local tissue transfer, grafts, and flaps.

The Vacuum-Assisted Closure (VAC) device (KCI Inc, San Antonio, TX) was developed by Argenta and Morykwas in 1997 as an adjunct to the plastic surgeon's standard armamentarium for wound therapy. It works by applying continuous, subatmospheric pressure to a wound through an open-cell polyurethrane sponge secured with an adherent drape.[1] The VAC has been shown to promote wound healing through increasing blood flow and granulation tissue formation, improving oxygenation, decreasing tissue edema, and reducing bacterial load.[2] Its utility in improving the take of split-thickness skin grafts, as measured by decreased area of graft loss, decreased need for repeat grafting, and improved graft appearance compared with traditional bolster techniques, has been well documented.[2–5] This improvement has been hypothesized to be related to the superior stabilization of the graft to the contours of the wound bed, decreased opportunity for hematoma or seroma formation and direct facilitation of the plasmatic imbibition and vascularization processes which the VAC provides.[2,6,7] It has also been demonstrated as a tool for assisting with the preparation of wound beds for subsequent skin grafting[8,9] and for accelerating the incorporation of Integra (Ethicon Inc, Somerville, NJ).[1]

VAC therapy has been used on wounds of nearly every aspect of the body, but not routinely on the head and neck. This may be due to the irregular contour of many of these wounds or the involvement of hair-bearing areas. This study was conducted to review our results using the VAC in the treatment of complex head and neck wounds to bring light to its utility in this challenging region of the body.

METHODS

This is an IRB-approved, retrospective review of 69 patients with 73 complex head and neck wounds managed using the VAC between 1999 and 2008 at Wake Forest University Baptist Medical Center. The VAC was maintained at continuous subatmospheric pressure at 125 mm Hg and served to dress skin grafts, Integra, and open, debrided wounds. Standard management included VAC changes 3 times per week on open wounds, whereas the VAC was left in place for 5–7 days over skin grafts and 7–14 days over Integra. Both hospital VAC devices and portable home VAC devices were utilized in this study.

Wound mechanism, location, and size, length of VAC therapy, patient comorbidities, use of radiation and chemotherapy, complications, and ultimate outcome were assessed in chart review. In this patient population, the VAC was used where traditional head and neck reconstructive techniques were not a good option or had previously failed.

RESULTS

Sixty-nine patients with 73 complex head and neck wounds were treated with the wound VAC during the reviewed time frame. The mean age of the patients was 66 years of age, with a range of 5–96 years. Males outnumbered females in this study nearly 2:1 with 44 males and 25 females. Comorbidities of patients included the following: hypertension (51%), coronary artery disease (48%), diabetes mellitus (17%), and peripheral vascular disease (12%). Fourteen patients (20.6%) were current smokers. An additional 16 patients (23%) had a remote smoking history. Thirty-six percent of patients had a history of radiation therapy to the head and neck, and 36% had received chemotherapy.

The average wound size was 107 cm^2, with a range of 4–605 cm^2. Eighty-seven percent of patients had wounds secondary to cancer, 7% secondary to trauma, 3% secondary to infection, and 3% secondary to burns. The VAC was initially used as a dressing over split-thickness skin grafts in 52%, over Integra in 19%, and over open, debrided wounds in 29%. Skin grafting was eventually performed on all of the wounds that were initially open or covered with Integra, all with the use of the VAC. Average length of follow-up was 503 days.

Overall, a healed wound was ultimately achieved 89% of the time. Half of the remaining wounds which were not healed at the time of last follow-up were in patients who died of their underlying condition before a healed wound could be achieved. Seventy-nine percent of the 38 wounds that initially received VAC therapy over a skin graft had a 90% or greater take of the graft. Of the 8 wounds with less than 90% skin graft take, 4 went on to heal with only local wound care, 2 required additional skin grafting, and 2 were in patients who died of their underlying condition. Examples of successfully healed wounds are shown in Figs. 1-3.

Thirteen patients had a local recurrence of their previously excised cancer. Other minor complications included infection requiring antibiotics (2) and hematoma (5) or seroma (1) formation under skin grafts. Most of these resolved with local wound care, repeat grafting, or with the administration of antibiotics.

DISCUSSION

Since its introduction, the wound VAC has been repeatedly reported to be of great utility in the treatment of complex wounds across all

surgical specialties and in a variety of anatomic locations, including the chest, abdomen, perineum, and extremities.[10–16] Many of these studies demonstrate a benefit in the speed of wound healing, a decrease in the associated complications, or, in the case of open abdominal and sternal wounds, a decrease in patient mortality or hospitalization length with the use of the VAC compared with alternative, more traditional dressings.[9–11,15-17]

In addition to its usefulness in a variety of locations, subatmospheric pressure therapy use has also been described in a variety of different types of wounds. These include wounds related to trauma, burns, oncologic resection, wound dehiscence, radiation, and vascular insufficiency.[8,9,12–14,18,19] As previously described, its efficacy in improving the take of split-thickness skin grafts has also been documented at length.[2–5] This diverse range of usages make the wound VAC a powerful tool in the repertoire of a plastic surgeon.

Despite the gamut of its wound care applications repeatedly presented in the literature, there is a relative paucity of reports regarding use of the VAC for wounds on the head and neck. As this anatomic region is frequently affected by wounds due to trauma, burns, radiation, and oncologic resection, it follows that the same wound-healing benefits seen with use of the VAC in other locations would likely apply to wounds in this region. This study does, in fact, serve as a demonstration that the wound VAC provides a reliable, effective, and durable dressing for a multitude of complex head and neck wounds with very challenging features. Regardless of the etiology of the wound or the presence of a host of significant comorbidities—diabetes, hypertension, and tobacco use, a stable healed wound was achieved without complication in the vast majority of patients.

Given that many patients in this study ultimately underwent split-thickness skin grafting of their wounds with good result, the previously reported improvement of graft take with the use of the VAC in other parts of the body was felt to be applicable to the head and neck. The irregular contour of this area, especially with regards to adequate skin graft contact for initiation of the steps of graft incorporation, may be a reason that subatmospheric pressure therapy has not been traditionally used to this anatomic region.

We, however, found that the use of the VAC as a dressing over skin grafts was actually advantageous in its ability to maintain the graft in an evenly distributed manner on the often irregular wound bed. With minimal experience, the VAC dressing could be adequately applied to a variety of shapes, sizes, and locations of wound with excellent graft take. Of the 38 wounds grafted during the initial procedure, 79% had greater than a 90% graft take. Only 2 required subsequent repeat grafting.

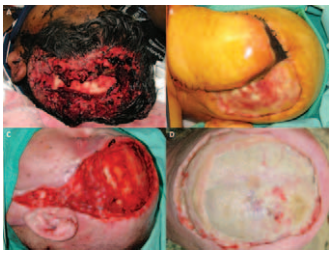

FIGURE 1. Difficult wounds in which VAC use facilitated reconstruction. A, Traumatic wound reconstruction—traumatic left parietal and occipital scalp avulsion injury in which the VAC was used both to prepare the wound bed for rotational flap and split thickness skin grafting and also to facilitate skin graft take; B, VAC use following distal flap loss in oncologic reconstruction— left occipital scalp wound following excision of a postradiation Marjolin's ulcer in which the VAC was used to prepare the wound bed for a latissiumus-free tissue transfer after the loss of the distal half of a left trapezius myocutaneous flap; C, VAC use to assist with Integra and skin graft take in oncologic reconstruction—large right head and neck defect following resection of a right postauricular squamous cell carcinoma and failed right deltopectoral and pectoralis myofascial flap reconstruction for which the VAC was utilized to facilitate Integra and split thickness skin graft take after burring the outer table of exposed skull; D, VAC use on open dural wound in oncologic reconstruction—occipital scalp and skull defect with a 20 × 18 cm area of exposed dura following occipital squamous cell carcinoma resection complicated by radiation-induced osteonecrosis in which serial VAC changes were performed for several weeks until patient was medically stable enough for reconstruction with a latissimus-free flap.

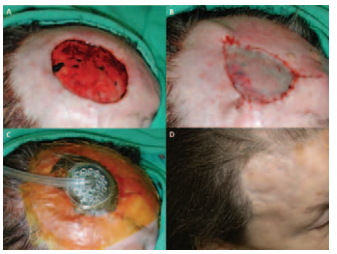

FIGURE 2. VAC use to facilitate skin graft take in Mohs oncologic reconstruction. A, A 70-year-old female underwent Mohs excision of a right anterior scalp and forehead basal cell carcinoma resulting in a 6.5 × 7 cm wound with exposed bone at the base of the wound. B, The outer table of the skull was burred down to a bleeding wound bed which was then covered with a split-thickness skin graft. C, A VAC dressing was utilized as a bolster to facilitate skin graft take. D, At 5 months postoperatively, the patient had excellent wound healing with only a slight contour irregularity.

Similarly, the established application of subatmospheric pressure therapy to achieve superior Integra and subsequent skin graft take was found to hold true with use on head and neck wounds in this study. Skin grafts were applied at an average of 8 days from initial Integra placement with excellent results. This time period was significantly shorter than manufacturer recommendation of a minimum of 2 weeks.[1] This shortened interval could potentially correlate to decreased length of hospitalization and health-care costs. Following Integra take, skin grafts showed good adherence after an average of 4 days of topical subatmospheric pressure.

As a retrospective review with no alternative dressings assessed as a control, this study is limited in its ability to definitively demonstrate superiority of the VAC dressing. That being said, in our experience it was consistently an effective wound management tool recommending its installment as a staple in treatment of head and neck wounds.

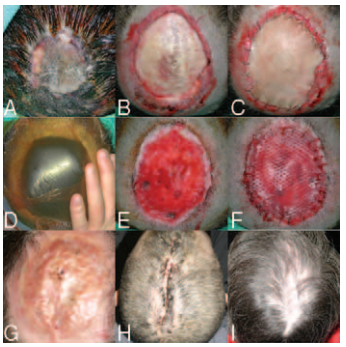

FIGURE 3. VAC use to facilitate Integra and skin graft coverage of an electrical injury burn. A, A 43-year-old male sustained a 4 × 4 cm scalp burn in an electrical injury at work. B, The wound was tangentially excised which resulted in a 10 × 7 wound with exposed skull in the base of the wound. C, The wound was treated with serial debridements and allograft placement. D, VAC coverage was used between debridements to assist with granulation formation. E, All exposed skull was covered with healthy granulation tissue following Integra placement with the use of the VAC. F, A meshed split thickness skin graft was then applied to the wound, using the VAC as a bolster. G, There was complete take of the skin graft at 1 month. H, Following tissue expansion, the skin grafted area was excised 3 months postoperatively. I, No easily visible scar remained 19 months following excision of the grafted area.

CONCLUSIONS

Whether dressing skin grafts, Integra, or open wounds we found the wound VAC to be an efficient and dependable tool in the management of head and neck wounds resulting from trauma, burns, or oncologic resection. As such, the VAC should be routinely utilized by the plastic surgeon in the treatment of complex head and neck wounds as a means of achieving successful wound healing, particularly where the standard reconstructive ladder was not a good option or had previously failed.

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Accessory Nostril: A Rare Congenital Nasal Anomaly

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Abstract: Accessory nostril is a very rare congenital anomaly with an unknown etiology also known as supernumerary nostril. A few accessory nostrils have been reported up to the present time, and extremely rare cases located on columella. A newborn infant with respiratory distress was referred to our hospital. The authors observed that accessory nasal nostril is not related to normal nasal cavity on the median line of columella. In this article, the authors reported accessory nostril case in newborn and review the literature.

Key Words: Accessory nostril, congenital anomaly, nose, supernumerary nostril

Accessory nostril is a rare congenital anomaly and it can be with or without accessory cartilage, unilateral or bilateral, communicated within the normal nostrils. It is usually associated with other congenital anomalies.[1] Accessory nostril was first published in 1906 and to this time, few cases were reported in the literature. It is also known as supernumerary nostril. Columellar localization of accessory nostril is extemely rare and only 2 cases of localized columella have been published.[2,3] We describe accessory nostril in newborn, which is settled on columella and ends with a blind pouch and review the literature.

CLINICAL PRESENTATION

A male term neonate was born to a 34-year-old woman (gravida 3, para 2). As the baby had 3 nostrils, he was brought to our hospital for physical examination and evaluation. Prenatal and antenatal history was uneventful and there was no history of consanguity. On physical examination, weight 3090 g (25–50%), height 46 cm (10–25%), and head circumference 35 cm (75–90%) in normally percentile. There was third nostril on the columella and the baby had respiratory distress (Fig. 1A). The nasal dorsum was broad. A nasogastric tube was placed in accessory nostril but it would not advance. Plenty of mucoid secretion was observed from 2 normal nostrils and 1 accessory nostril. Because the nostrils are often obstructed with secretion, an orofaringeal airway cannula was placed. After orofaringeal cannula replacement, the respiratory distress symptoms receded. Hematologic, biochemical, and thyroid function tests were within normal range. Echocardiologic examination revealed patent foramen ovale. Minimal pelvicaliceal dilatation was viewed by the abdominal ultrasound. The maxillofacial tomography revealed thick nasal septum and a cleft on the anterior nasal septum. This cleft is opening to the skin from anteriorinferior

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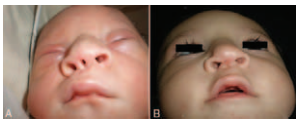

FIGURE 1. A, Broad nasal dorsum and accessory nostril on the columella. B, Postoperative view on sixth month.

nasal area. A transfontanel ultrasonography was performed for possible additional anomaly and corpus collosum dysgenesis; dilatation of lateral ventricules occipital horns was determined. Magnetic resonance imaging (MRI) was recorded to the same as pathology. After antibiotherapy, nasal secretions were decreased and orofaringeal canulla was removed. On day 30, surgical repair was performed on the third nostril under general anesthesia. The fistulectomy of the accessory nasal tract was performed surgically and primary closure with partial skin trimming of the columella. The baby's health has clinically improved and has been discharged (Fig. 1B).

DISCUSSION

During the nasal development of embryological period, at the end of the fourth week, maxillary prominences can be distinguished lateral to the stomodeum, and mandibular prominences can be distinguished caudal to it. During the fifth week, the nasal placodes invaginate to form nasal pits and they create a ridge of tissue that surrounds each pit and thus forms the nasal prominences. Those prominences on the outer edge of the pits are the lateral nasal prominences; those on the inner edge are the medial nasal prominences. Subsequently, the cleft between the medial nasal prominence and the maxillary prominence is lost, and they fuse together.[1,4] Any developmental distress during this period can be as a consequence of nostril anomalies.

Accessory or supernumerary nostril is a very rare congenital anomaly, which is still unclear in etiology. Up to this time, 37 accessory nostril cases have been reported. The first case was recorded in 1906 by Lindsay, a patient with bilateral accessory nostril.[2] In that case, the external openings of the accessory nostrils were settled above the normal nostrils and accessory nasal cavities were communicated within the ipsilateral normal nasal cavities. The second case was reported in 1920 by Tawse, a patient with a unilateral accessory nostril, which is communicated within the normal nasal cavity.[5] A further case was reported by Reddy and Rao.[6] In 2009, an accessory nostril case with esophagial atresia, anal atresia, and patent ductus arteriosus (PDA) was reported.[7]

Duplication anomalies of the nose include polyhinia (double nose) and accessory nostril (supernumerary nosrtil). Both are rare congenital nasal deformities resulting from abnormal embryological development. There are differential diagnoses, which include nasal glioma, encephalocele, nasal dermoid, nasolacrimal channel duplication, meningocele, myelomeningocele, and mid-facial cleft anomalies.[8]

Accessory nostrils present with normal pair nostrils. These abnormal accessory nostrils are developed from the fissuring of the lateral nasal process. Other congenital anomalies with accessory nostril include hypoplastic heminose, cleft palate and lip, nasoocular cleft, congenital auricular hypoplasia, congenital cataract, microcornea, esophagial atresia, anal atresia, and PDA.[9–12] In the literature, in 40% of the cases, the third nostril sided on the left normal nostril, 33.3% of cases sided on right of the normal nostril, and only 2 cases sided on columella. In our patient, the accessory nostril was sided on columella. Of these cases, approximately 50% patients were having isolated supernumerary nostrils, and other half associated with additional anomalies. Only 1 patient had 3 additional anomalies (esophagus atresia, anal atresia, and patent ductus arteriosus). Our patient had corpus collosum dysgenesis and lateral ventricular dilatation.

The reported cases till now are inadequate. To determinate the embryological implications, anatomic presentations and possible additional anomalies with accessory nose cases need to be further investigated. We aimed to share this rare congenital anomaly within medical field. In this rare anomaly, surgery should be performed at an early age to avoid severe impact on the nasal cartilages because of the fistula, deformation of adjacent structures, and the psychologic effects. It is important to resect the entire fistular tract and to preserve the normal nostril.

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Association of Titanium Mesh and Bovine Pericardium Membrane in the Treatment of Severe Enophthalmos

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Abstract: The blowout fractures may be classified as pure or impure depending on the associated structures. There are 2 main theories attempting to describe the mechanism of injury, the hydraulic, and blocking mechanism. The complications of this type of fracture may involve diplopia, enophthalmos, and ocular movement restriction. Several materials are available for the

reconstruction of orbital floor, including the titanium mesh, which present great properties, such as easy modeling and stabilization, small thickness, and shape maintenance. There, however, are disadvantages such as the possibility of adherence formation. The aim of this report is to describe the case of a patient with an 8-month blowout fracture sequel, presenting extensive enophthalmos and treated by affixing a titanium mesh associated with bovine pericardium membrane in the orbital floor. Therefore, based on a 2-year follow-up, it was possible to observe how effective the association between these 2 materials in solving the case was.

Key Words: Enophthalmos, ocular motility disorders, orbital fractures

The orbital floor fractures may be classified as pure blowout in which only the orbital floor is involved, and impure, where bones in adjacent regions are also involved.[1] The aim of blowout fracture treatment is restoring the continuity of orbital floor, providing support for orbital contents and preventing soft-tissue fibrosis.[2]

Different materials are available for the reconstruction of orbital walls, but there is no consensus about which is the best; however, the ideal material should be strong enough to support the orbital contents, inexpensive, affordable, easy to work around, resorbable, and biocompatible.[3]

Rinna et al[2], reported that from 379 patients evaluated in their study, 268 were properly treated with bovine pericardial membrane.[2] For extensive fractures measuring more than 1 cm in diameter, titanium mesh, however, is indicated because of its easy modeling and large biocompatibility.[2]

The most frequent ophthalmic complications in midface reconstruction are diplopia, enophthalmos, and in some rare situations, the blindness.[4] The binocular diplopia is the most common complication of orbital trauma and may be temporary or permanent if not treated.[4]

The aim of this report is to describe the case of a patient with blowout fracture sequel presenting extensive enophthalmos, where the reconstruction of orbital floor was performed with a titanium mesh associated with bovine pericardium membrane.

CLINICAL REPORT

A 50-year-old female leukoderma patient, a victim of cycling accident 8 months ago, attended the maxillofacial surgery service complaining that her eye was deep. On physical examination, the patient presented an extensive enophthalmos in the left eye, with the limitation of supraversion movement. The patient also reported binocular diplopia. Computed tomography (CT) showed fracture of the orbital floor with more than 50% of commitment, without reaching the infraorbital ridge or the superior and lateral walls of the orbit (Fig. 1).

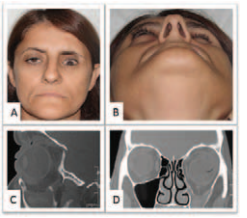

FIGURE 1. Patient in frontal view in A. Caudal-cranial view, showing extensive enophthalmos in B. Computed tomography sections in C and D.

Thus, the patient was submitted to surgical treatment under general anesthesia and orotracheal intubation. A subtarsal access was performed with divulsion of periorbital tissues. There was a gap in the orbital floor causing a critical defect. For this, a titanium mesh was installed in the orbital floor, being attached to the infraorbital margin with 1.5 system screws (MDImplants, Fortaleza, Ceará, Brazil), and a bovine pericardium membrane (Hpbio, Fortaleza, Ceará, Brazil) was affixed on the mesh, restoring a more appropriate orbital volume and solving enophthalmos (Fig. 2). During the postoperative period, normalization of diplopia and ocular movement was observed. Currently, the patient has shown no functional or aesthetic complaints after the 2-year follow-up period (Fig. 3).

DISCUSSION

The mechanisms of blowout fractures are not clear; however, there are 2 main theories, hydraulic and blocking mechanisms.[5] In the first, the effects of trauma kinetic energy are transferred via orbital soft tissue to the orbital floor, and in the second, fracture is produced as a result of force transmission through the orbital ridge to the orbital floor.[5]

Park et al[6] analyzed 354 patients who experienced pure blowout fractures. The most frequent fracture observed was an isolated fracture of orbit medial wall, followed by orbital floor fracture and a combination of both. Furthermore, men were more often affected, with 295 cases in comparison with 59 women.[6] In the case reported, the patient was a female and the fracture was limited to the orbital floor.

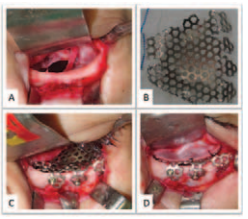

FIGURE 2. Aspect of orbital floor defect in A. Titanium mesh modeled in B. Fixed mesh in C. Bovine pericardium membrane apposition in D.

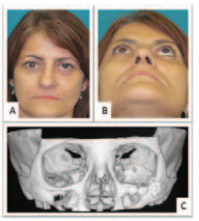

FIGURE 3. Patient at 2 years postoperatively in A and B. Computed tomography tridimensional reconstruction showing titanium mesh adapted to orbital floor in C.

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According to Bartoli et al[7], the best results in the treatment of blowout fracture are associated with the time elapsed between trauma and surgery, and the delay in floor reconstruction can bring a great impact on the final result.[7]

Regarding eye complications, in a study conducted by Shin et al[8], with 952 patients diagnosed with pure blowout fracture, the diplopia was present in 27.6% of patients, followed by 12.8% with extraocular movement restriction, and 3.4% presenting enophthalmos. Higashino et al[9], in a study with 106 patients presenting pure blowout fracture, observed that the severity of enophthalmos and diplopia were related to the defect width and to the protrusion degree of inferior rectus muscle toward the maxillary sinus.[9] In the current case, the patient had diplopia associated with severe enophthalmos, resulting from an extensive defect in orbital floor, and in addition, it was an 8-month evolution sequel.

Several materials are available for reconstruction of orbital floor.[3] Among them, the titanium mesh presents properties, such as easy modeling and stabilization, small thickness, shape maintenance, and unique ability to compensate the volume when appropriately adapted without resorption potential.[4]

Kersey et al[10], reported a study with 10 patients who presented adherences in titanium mesh after orbital reconstructions, requiring the material removal.[10] Liu et al[11], evaluated the apposition of bovine pericardial membrane in rat orbital floor, and observed calcified tissue formation.[11] Bartoli et al[7], conducted a study involving 301 patients with orbital floor fracture, of which 180 were properly treated with bovine pericardium apposition.[7] Because of the orbital floor defect extent and the period between the injury and surgery, a bovine pericardium membrane was affixed on titanium mesh, minimizing the possibility of adherences in mesh holes.

Based on the information above, it was observed that the use of titanium mesh associated with bovine pericardium membrane was effective in the patients' treatment; however, further studies are required to determine the degree of effectiveness of the association between the 2 reconstructive materials.

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Optimal Osteosynthesis in Zygomatic Complex Fractures

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Key Words: Fixation, fractures, road traffic accidents

The zygoma articulates with the frontal, sphenoid, temporal, and maxillary bones. It may be separated from its 4 articulations during fracture. This is called a zygomatic complex fracture. The terms trimalar or tripod fracture are therefore inaccurate. These terms reflect an inability to easily identify the orbital (zygomaticosphenoid) portion of the injury before the advent of computed tomography (CT). The zygomatic arch may be fractured independently or as part of a zygomatic complex fracture. The fracture displacement decides the type of treatment required to achieve optimal results.[1]

MATERIALS AND METHODS

The brief clinical report was planned of total 860 patients who underwent craniofacial trauma related surgeries during a span of 15 years by the corresponding author. Of these 860, 262 patients were clinically diagnosed and radiologically confirmed patients of isolated zygomatic complex fractures. All these patients underwent closed reduction and open reduction and internal fixation under general anesthesia within 2-weeks post injury as per the protocol given by Ellis and Kittidumkerng[2] in 1996. Total 50 patients, however, required an additional fixation over the standard 2 point fixation through subciliary approach. All these patients were analyzed for the incidence, etiology, pattern, type of treatment, and outcome of the treatment rendered.

RESULTS

The incidence of isolated zygomatic complex was 30%. The average age at the time of injury was 36 years (14–68 years). There were 242 men and 20 women. The highest incidence of fractures was seen in the third decade of life (167 patients, 64%) followed by second decade of life (62 patients, 24%). The right side of the face was involved in 72.5% patients, whereas left side of the face involved 27.5% patients The most common etiology was road traffic accidents (226 patients, 86%) followed by accidental falls (16 patients, 6%), organized sports related (13 patients, 5%), and domestic violence (7 patients, 3%). Most common seen pattern was laterally displaced on vertical axis (189, 72%) followed by medially displaced on vertical axis (50, 19%) and undisplaced (23, 9%). One hundred sixty patients were treated by 2 point fixation, 50 patients by 3 point fixation, and 25 patients by single point fixation. Total 25 patients were managed by closed reduction only. On objective evaluation after 1 year skeletal deformities for example asymmetry of face, depression/flattening of the malar eminence, flattening, hollowing, or broadening over the zygomatic arch, palpable steps/gap deformities of infra/lateral orbital margins were present in 13 patients (5%). Ocular/ophthalmic symptoms, such as increased

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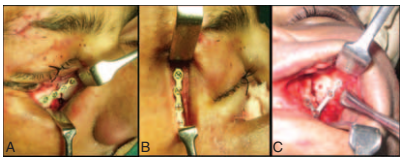

FIGURE 1. A, Infraorbital region fixation. B, Frontozygomatic region fixation. C, Zygomatic buttress region fixation.

scleral show, antimongoloid slant, ectropion, hypoglobus, enophthalmos, exophthalmos, and vertical dystopia were present in 8 patients (3%). Sensory deficit of infraorbital/zygomaticotemporal/zygomaticofacial nerve were present in 23 patients. And 3 patients had restricted mouth opening. Satisfactory results were obtained in 215 patients (86 %). Maximum complications were found in patients where 2 point fixation was carried out (Fig. 1).

DISCUSSION

There has been a paradigm shift in the management of zygomatic complex fractures from conservative to surgical in the last few decades. The decision on the number of plates and screws is based on the fracture features, such as displacement, communition, and stability after reduction. Considering the anatomy of the zygoma and the areas of fracture involving the 4 suture lines, a minimum of 2 point fixation was found to give stability in terms of restoration of shape without the danger of displacement. The 2 common points of fixation were the zygomatic buttress and the frontozygomatic suture regions. An ideal surgical approach to treat, reduce, and rigidly fix zygomatic complex fractures should provide maximum exposure of the fractured segments, minimize potential for further injury to facial structures, and ensure good cosmetic results. Local incisions in 2 point fixation have been the intraoral vestibular approach to the buttress and the lateral eye brow incision to access the frontozygomatic region. These are ideal incisions in terms of access and aesthetics.[3,4] The algorithm proposed by Ellis and Kittidumkerng in 1996 is only suitable for midenergy fractures and for high-energy fractures an extra plate at the infraorbital region provides higher number of stability and accurate reduction. In our study, the most optimum method of treatment was a 2 point fixation at the frontozygomatic region and the zygomatic buttress region providing adequate stability to the fractures. Though most of the sub optimal results were present in the cases where 2 point fixation was done. Every zygomatic complex fracture is different and thus requires a careful assessment before reduction and choosing open reduction and internal fixation as a treatment modality. Latest studies have shown the importance of addressing sphenozygomatic suture region through the lateral brow approach, whereas fixing the lateral orbital wall region in case of intraoperative CT is not available. Authors were not aware till last year about this algorithm and the principle behind it because of service constraints.[5]

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Bisphosphonate-Related Osteonecrosis of the Jaw After Tooth Extraction

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Abstract: Bisphosphonates are widely used for treatment or prevention of bone diseases characterized by high osteoclastic activity. Among the oral medicines used to treat osteoporosis, alendronate has been often used. Despite of the low rate of complications on its use, cases of osteonecrosis of the jaw have been reported on literature after tooth extractions. The main symptoms include pain, tooth mobility, swelling, erythema, and ulceration. The risk factors related to osteonecrosis of the jaw associated with bisphosphonate are exposition time to the medicine, routes of administration, and oral surgical procedures performed. The aim of this work is to report a case of a patient showing osteonecrosis of the jaw associated with the use of oral bisphosphonates after tooth extractions. The patient was treated through the suspension of the alendronate with the removal of the necrotic tissue and the foci of infection. After a year's follow-up, the patient showed no recurrence signs. From the foregoing, the interruption of the alendronate use and the surgical treatment associated to antibiotic therapy showed effective on the patient's treatment.

Key Words: Bisphosphonate-associated osteonecrosis of the jaw, osteoporosis, tooth extraction

Bisphosphonates are synthetic analogs of pyrophosphate widely used on treatment and/or prevention of metabolic bone diseases characterized by high osteoclastic activity.[1] Despite the benefits related to the application of these medicines, the osteonecrosis of the jaw has been recognized as the main complication associated with intravenous or oral therapy with bisphosphonates. There are several reported cases in the scientific literature since 2003.[1,2]

In spite of the incidence of this disease being unknown to the general population, it seems to be relatively low in patients who received oral bisphosphonates through the osteoporosis treatment.[3] Risk factors related to the osteonecrosis of the jaw include exposition time to the medicine, sort of medicine used, routes of administration, and oral surgical procedures.[3,4]

Although this disease can occur from any oral surgical intervention, the tooth extraction is considered as the main intervention

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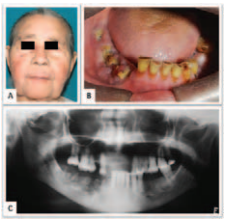

FIGURE 1. A, Patient in the front view. B, Intraoral exposition of the necrotic bone. C, Preoperative panoramic radiography.

responsible in the majority of patients.[5] The clinical signs and symptoms mostly present include pain, tooth mobility, swelling, erythema, and ulceration.[4,5]

The treatment of patient with established diagnosis of medication-related osteonecrosis of the jaw (MRONJ) consists of the elimination of pain, control of hard- and soft-tissue infections, and minimization of occurrence of the disease or its progression.[4] The surgical management is advised only to the patients on advanced stages of this disease and to those in which conservative treatment has failed.[6,7]

The goal of this work is to report a case of a 75-year-old woman undergoing treatment for osteoporosis with sodium alendronate for more than 5 years, with complaints of dysphagia, pain, and intraoral bone exposition after carrying out tooth extractions 4 months ago.

CLINICAL REPORT

A 75-year-old woman showed complaints of dysphagia, pain, and bone exposition in posterior region of the mandible on the right side started 4 months after tooth extractions. The patient revealed having hypertension, and making use of sodium alendronate of 10 mg once a day orally for the osteoporosis treatment; however, it had been suspended 3 months ago. The patient reported use of antibiotics and antiinflammatory medicines with no improvement of the clinical situation.

Intraoral examination revealed a large area of necrotic bone exposition on the right side of the mandible alveolar region, anterior inferior tooth mobility, erythematous mucosal tissue surrounding, and pus. The panoramic radiography showed areas of diffuse bone sclerosis related to osteolytic areas and small bone kidnappings in alveolar region of the posterior right side of mandible (Fig. 1).

The performed treatment was the surgical removal of whole necrotic bone, extraction of all compromised tooth, antibiotic therapy with 300 mg of clindamycin (Dalacin®C, Guarulhos, São Paulo, Brazil) 4 times a day orally for 15 days, mouthwash with chlorhexidine gluconate 0.12% (Periogard-Colgate-Palmolive Brazilian industry, São Bernardo do Campo, São Paulo, Brazil) 3 times a day, and 500 mg dipyrone sodium 4 times a day orally, for relief of pain (Fig. 2).

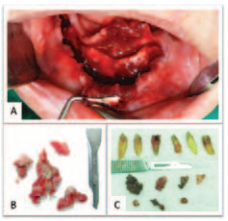

FIGURE 2. A, Intraoral aspect after removal of necrotic bone and foci of infection. B, Removed necrotic bone. C, Removed teeth.

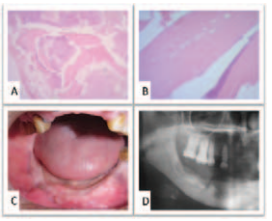

FIGURE 3. A, Intraoral aspect after a year follow-up. B, Postoperative panoramic radiography.

The removed material was forwarded to histopathologic examination revealing compact bone fragment with necrosis characteristics and basophilic amorphous areas compatible with bacterial colonies, it agrees with diagnosis of osteonecrosis of jaw. The patient recovered fairly well and, at this moment, a yearly follow-up showed no recurrence or functional and aesthetic complaints (Fig. 3).

DISCUSSION

In 2014, the American Association of Oral and Maxillofacial Surgeons recommended changing the nomenclature of bisphosphonate-related osteonecrosis of the jaw (BRONJ) in favor to the term medication-related osteonecrosis of the jaw (MRONJ, owing to the growing number of osteonecrosis patients involving the jaw associated with other antiresorptive (denosumab) and antiangiogenic therapies.[3]

The confirmation of MRONJ is defined as an area of bone exposition in maxillofacial region that does not heal within 8 weeks, in a patient who was or is being exposed to antiresorptive or antiangiogenic agents and has no history of radiotherapy on head and neck region or obvious metastatic disease to the jaws.[3] The patient of the reported case belongs to this category because the lesion had been identified 4 months ago by her dentist, with no radiotherapy history of head and neck region.

From the work of Lin et al,[8] 2014, with carrier patients of osteoporosis using alendronate orally, it could be observed that incidence of MRONJ was extremely low, and the risk of development of these lesions was not elevated in the first 4 years after starting the treatment.[8] Despite of the findings of the literature, the patient of the presented case used alendronate orally for more than 5 years and developed MRONJ after tooth extractions.

A study carried out by Mavrokokki et al,[9] 2007, revealed that 158 patients of MRONJ associated with the use of bisphosphonates were identified mainly in sick people with bone malignancies (72%), and the main factor was the tooth extraction (73%).[9] Other factors were untreated periodontal disease, mucosal trauma, or badly adapted prosthesis.[9] As observed in the presented case, the patients had undergone tooth extractions, resulting in necrotic lesions on the spot of the extractions.

According to Ruggiero et al,[4] 2009, the risk of MRONJ in patients using intravenous bisphosphonates is significantly larger than on those who receive orally; however, because of the big number of patient using this medicine to the osteoporosis treatment, it is important to determine the incidence of MRONJ in this group to assess the related risk to the long use of this medicine.[4] On the reported case, the patient presented MRONJ after long use of alendronate, being important more studies for the best treatment of patients like this.

In the multicenter study assessing 347 patients with MRONJ who underwent surgical treatment, it was demonstrated that almost

70% of them had the regression of the lesions.[10] With the attempt to decrease the risks of MRONJ manifestation, elective surgical procedures must be avoided in patients using intravenous bisphosphonates if possible.[3] Patients using bisphosphonates orally for more than 4 years, in case of surgical intervention, should stop the use of the medicine 2 months earlier and return to use 3 months after the intervention, if the systemic conditions permit.[3] On the reported case, the patient had suspended the medicine 3 months before the surgical procedure of bone kidnappings removal and foci of infection.

The dental treatment of patients with MRONJ must be done with the most atraumatic way, avoiding tooth extractions.[11] The odontogenic infections must be treated more severely with antibiotic therapy.[11] The interruption of the bisphosphonate for 6 to 8 months can be adopted with the medical evaluation, once the interruption of treatment with the medicine has demonstrated improvement on clinical situation.[11] The surgical treatment of the patient with the suspension of the bisphosphonate use and the antibiotic therapy show themselves effective on the treatment of the MRONJ, agreeing with the literature.

A detailed understanding about the frequency of the complications with MRONJ is important to enable the health care professionals to advise properly their patients about the bisphosphonate use. The remarkable aspect to be considered is the condition of oral health of the patient before the beginning of therapy with bisphosphonates. The dentists must be aware about the bisphosphonate use and the necessity of their patients, specially for those that need tooth extractions and are using bisphosphonates.

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Comparing Viability of Periodontal Ligament Stem Cells Isolated From Erupted and Impacted Tooth Root

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Purpose: The aim of the study was to compare the viability of periodontal ligament-derived stem/progenitor cells (PDLSCs) from 2 different sources.

Materials and Methods: Periodontal ligament (PDL) tissue was obtained from 20 surgically extracted human third molars and 20 healthy premolars extracted for orthodontic reasons. Periodontal ligament-derived stem/progenitor cells were isolated from 2 different PDL tissue sources and characterized by colony forming unit assay, cell surface marker characterizations, and their osteogenic differentiation potential. To determine cell viability within 2 groups, the colorimetric 3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyl tetrazolium bromide (MTT) metabolic activity assay was used. Data were statistically analyzed using independent *t*-test by SPSS 16 software (SPSS Inc, Chicago, IL).

Results: According to the MTT assay, the mean viability rate $\pm$ standard deviation of PDLSCs in the impacted third molar sample cells was 0.355 ± 0.411 and for erupted premolar sample cells was 0.331 ± 0.556. Based on One-Sample Kolmogorov-Smirnov test, *P* value for impacted and erupted teeth was 0.954 and 0.863, respectively. No statistical difference was seen between 2 groups. (P value > 0.05)

Conclusions: Our results demonstrated that if surgical aseptic technique is a method employed to maintain asepsis, PDLSCs obtained from impacted and erupted tooth root would have the same viability rate.

Key Words: Periodontal ligament, stem cell, viability

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The PDL is a soft connective tissue embedded between the cementum and the inner wall of the alveolar bone socket, to sustain and help constrain teeth within the jawbone. Periodontal ligament not only has an important role in supporting teeth, but also contributes to tooth nutrition, homoeostasis, and repair of damaged tissue.[1–3] Periodontal ligament contains heterogeneous cell populations that can differentiate into either cementum-forming cells (cementoblasts), periodontal ligament-forming cells (fibroblasts) or bone-forming cells (osteoblasts).[4–9]

Recent findings suggest that PDL cells have many osteoblast-like properties, including the capacity to form mineralized nodules in vitro, expression of the bone-associated markers alkaline phosphatase and bone sialoprotein, and response to bone-inductive factors, such as parathyroid hormone, insulin-like growth factor 1, bone morphogenetic protein 2, and transforming growth factor 1.[2,4,10–14] The presence of multiple cell types within PDL has led to speculation that this tissue might contain progenitor cells that maintain tissue homoeostasis and regeneration of periodontal tissue.[6,15–17]

Periodontal diseases are the main cause of tooth loss and are a substantial public health burden worldwide.[18,19]The reconstruction of healthy periodontium destroyed by periodontal diseases is a major goal of periodontal therapy. Periodontal regeneration, however, is especially challenging, as it requires predictable regeneration of three quite diverse and unique tissues (eg, cementum, PDL, and bone) and a triphasic interface between these different tissues to guarantee the restoration of their complex structure.[20,21] Many new approaches have been developed for treating periodontal defects, including guided tissue regeneration, growth factors, and enamel matrix proteins,[22–26] but so far, none of these treatments has provided consistently predictable outcomes, especially in advanced periodontal defects.[27]

Recent insights into the reparative capability of the periodontium in conjunction with advances in stem cell biology and regenerative medicine enable the development of novel therapies using either endogenous regenerative technology[21] or cell-based therapeutics that are likely to achieve robust regeneration with higher efficacy and predictability.[28] The aim of this study was to isolate PDLSCs from PDL tissue of both impacted and erupted tooth and compare by 3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyl tetrazolium bromide (MTT) assay the viability of PDLSCs that obtained from 2 different sources.

MATERIALS AND METHODS

Samples and Cell Culture

Normal full impacted third molars (N = 20) and normal full erupted first premolar (N = 20) were collected from 26 healthy individuals aged 18 to 30 years at the oral and maxillofacial department of the Hamadan dental school, Iran, following approved guidelines set by the regional ethical review board of Hamadan university of medical science.

The teeth were immediately immersed into Hank's buffered salt solution (HBSS; Invitrogen, MA) that contained 100 U/mL penicillin/streptomycin (Sigma-Aldrich, St. Louis, MO) and transferred to the laboratory. The PDL tissues in the middle third of the root surface were separated by sterile blade and washed several times with phosphate buffered saline (PBS; Invitrogen, MA). The tissues were then digested with 2 mL of α-minimum essential medium (α-MEM, Invitrogen) containing 3 mg/mL collagenase (type I) and 4 mg/mL dispase (both from Sigma-Aldrich) for 15 minutes at 37°C in a humidified atmosphere of 5% CO_2.

To isolate PDLSCs, the digested PDL tissues were then transferred into 2 six-well plates (Nunc, Thermo, Denmark), and cultured in α-MEM supplemented with 10% fetal bovine serum (FBS), 0.292 mg/mL glutamine (both from Invitrogen), 100 U/mL penicillin/streptomycin at 37°C until the cells successfully grew out from the 2 different PDL tissue sources.

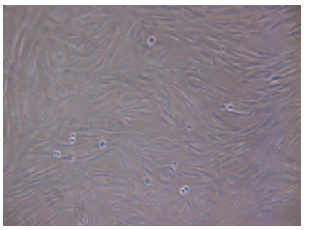

FIGURE 1. PDLSCs were derived from human periodontal tissue after third passage. PDLSC, periodontal ligament-derived stem/progenitor cells.

Colony Forming Assay

The third passage human PDLSCs (Fig. 1) were plated into 90-mm dishes (2 dishes for each cell line) at a density of 1×10^3 cells/well and cultured in complete medium for 12 days for the colony-forming unit fibroblast (CFU-F) assays. The aggregates containing more than 50 cells were scored as colonies.

Flow Cytometric Analysis of Cell Surface Markers

Periodontal ligament-derived stem/progenitor cells s (third passage) were adjusted to a concentration of 1×10^6 cells/mL after being digested with 0.25% trypsogen (Hyclone) and washed with PBS for three times. Then 100 mL from each cell suspension was added to a microtube and 6 tubes were prepared for the identification of different cell markers. Subsequently, the following antibodies were added to the microtubes according to the manufacturer's instructions: CD31, CD34, CD45, CD90, CD105, and CD146. The analysis was done by using a flow cytometry cell Sorter (Becton & Dickinson, Mountain View, CA) and the obtained data were analyzed using the Win-MD 2.8 cell cycle analysis program (Becton & Dickinson).

Osteogenic Differentiation of PDLSCs

The human PDLSCs (third passage) were cultured and induced to assess their mineral nodules in vitro. The osteogenic medium was a-MEM containing 10% FBS, 50 mg/mL ascorbic acid (Sigma-Aldrich), 10 nM dexamethasone, and 10 mM b-glycerophosphate and refreshed at 3-day intervals for osteogenic induction. After 4 weeks of osteogenic induction, the mineral nodules were observed using a phase-contrast microscope (IX70, Olympus, Tokyo, Japan), and the images were captured (600D, Canon, Tokyo, Japan) (Fig. 2).

Cell Viability Assay

The 3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyl tetrazolium bromide (MTT) colorimetric assay was used to evaluate cell viability.

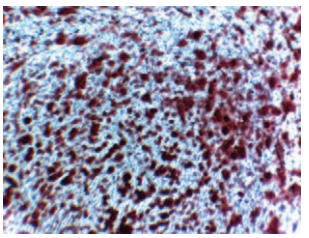

FIGURE 2. Osteogenic differentiation of PDLSCs; Alizarian red staining showed mineral nodule after 4 weeks of osteogenic induction.

For assay the cells were digested and suspended in 3 mL of a MEM-containing 10% FBS. Cell suspensions from each group were added into two 96-multiwell plates (Nunc) and incubated for 24 hour at 37°C. Thereafter, 100 μl MTT solution (0.2 mg/ml, Sigma) diluted in a MEM was added into each well until formazane crystal formation occurred. Then 100 μl DMSO (99.5%, dimethyl-sulfoxid) was added into wells to dissolve formazan crystals. The absorbances of the wells were detected at 540 nm using a microplate reader. The recorded optical density (OD) values of 2 wells were taken and used to determine the final average reading. The results from different groups were statistically compared.

Statistical Analysis

Data analysis was performed with SPSS version 16 software (SPSS, Inc., Chicago, IL) and One-Sample Kolmogorov-Smirnov test was used to analyze the significance between the 2 groups. *P* values less than 0.05 were judged to be statistically significant.

RESULTS

Isolation and Identification of PDLSCs

Cells successfully grew out from all of the PDL tissues derived from donors after 2 to 5 days of culture. Periodontal ligament-derived stem cells were obtained, and their mesenchymal stem cell (MSC) properties were characterized by colony-forming unit assay, cell surface marker characterization, and their osteogenic differentiation potential.

It was found that the cells demonstrated a spindle-shaped morphology and single colonies formed 12 days after being plated at a low density, which confirmed the capacity of the PDLSCs to form CFUs. The detection of surface molecule expression revealed that the PDLSCs were negative for hematopoietic markers, such as CD34 and CD45, but positive for mesenchymal-associated markers, such as CD31, which is considered to be an early marker for MSCs (Fig. 3).

A capacity for multiple-directional differentiation is also 1 of the key properties of any MSC line. Hence, the PDLSCs (third passage) were induced into osteogenic media to evaluate their differentiation potentials. After 4 weeks of osteogenic induction, mineral deposits could be observed by alizarin red staining, which indicated the PDLSCs' osteogenic potential. These results suggest that PDLSCs were successfully obtained from the human PDL tissues.

Cell Vitality

According to the MTT assay, the mean viability rate ± standard deviation of PDLSCs derived from impacted third molars was 0.355 ± 0.411 (OD) and from erupted premolars was 0.331 ± 0.556 (OD) (Fig. 4). Based on One-Sample Kolmogorov-Smirnov test, *P* value of impacted and erupted teeth derived PDLSCs were 0.954 and 0.863, respectively. No statistical difference was seen between 2 groups. (*P* value> 0.05)

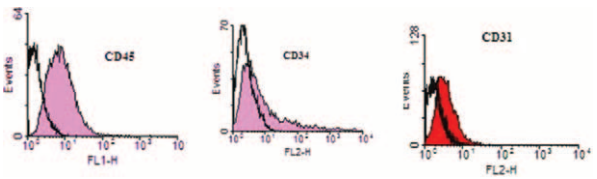

FIGURE 3. The detection of surface molecule expression revealed that the PDLSCs were negative for CD34 and CD45 but positive for CD31, which is considered to be an early marker for MSCs. MSC, mesenchymal stem cell.

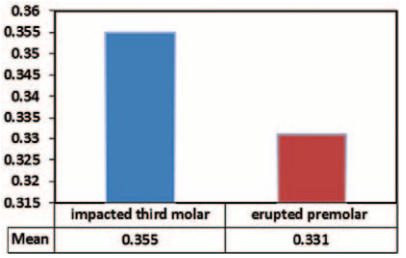

FIGURE 4. Mean viability rate of PDLSCs in 2 groups, impacted third molar and erupted premolar sample cells.

DISCUSSION

Mesenchymal stemcells are among the most promising adult stem cells for clinical applications and they were originally found in the bone marrow.[29–31] The bone marrow continues to be the best characterized source and is used as a benchmark for comparison with other sources of MSCs.[32,33] Cell isolation and expansion from the bone marrow, however, is technically difficult and implies an invasive procedure sustaining pain and morbidity to the patient; moreover, MSC functional parameters seem to be highly influenced by interindividual characteristics.[14] Indeed, alternative sources of harvesting, with potential clinical application, have received increased attention owing to the improved appeal of translational scenarios.[34] Amniotic fluid, adipose tissue, and, more recently, oral tissues have been used to isolate, process, and expand MSCs with similar phenotypic profile, with significance for regenerative purposes.[34]

Dental tissues have been considered as a potential source for the isolation of MSC-like populations.[35] Until recently, 5 different populations have been isolated and characterized in postnatal dental tissues, and classified according to the tissue of origin: dental pulp stem cells (DPSCs), stem cells from exfoliated deciduous teeth (SHEDs), stem cells from apical papilla (SCAPs), periodontal ligament stem cells (PDLSCs), and dental follicle precursor cells (DFPCs).[35]

Periodontal ligament-derived stem/progenitor cells are a heterogeneous population with stem cell characteristics, as they express MSC-associated markers, originating from the periodontal ligament.[36] This cell population exists in the human periodontal ligament of healthy and periodontitis-affected teeth, in the coronal, apical, and furcation locations of the root surfaces.[37] Similar to other dental stem cells, PDLSCs are capable of differentiating, under defined in vitro conditions, into cells resembling cementoblasts, osteoblasts, adipocytes, chondrocytes, and fibroblasts.[38,39] This population, as reported for other dental tissue derived stem cells,[40] seems to have a faster cell growth rate and higher clonogenic capability than BMMSCs.[38]

In 2006, the International Society for Cellular Therapy (ISCT) proposed minimal criteria to define human multipotent MSCs regardless of the tissue from which they are isolated.[41] According to the ISCT criteria, MSCs must be adherent to tissue culture-treated plastic when maintained in standard culture conditions. In addition, MSCs must express CD105, CD73, and CD90 and lack the expression of CD45, CD34, CD14 or CD11b, CD79a or CD19, and HLA-DR surface molecules. Finally, MSCs must be able to differentiate to osteoblasts, adipocytes and chondroblasts in vitro.[42]

Our findings suggest that PDLSCs represent a novel population of multipotent stem cells, as shown by their capacity to create colony-forming units, 12 days after being plated at a low density, and their osteogenic differentiation potential after induction into appropriate media. In the current study, we found that the PDLSCs

are similar to other mesenchymal stem cells with respect to their expression of CD31, and lack of expression of CD34/CD45.[43]

The osteogenic potential of PDLSCs has been assessed previously with several cell-culture methods, and the ability of such cultures to form a mineralized matrix has been noted.[4,11] Our data showed the potential of PDLSCs to form calcified deposits in vitro, as previously shown with other mesenchymal stem cell populations, such as BMSSCs and DPSCs. Periodontal ligament-derived stem/progenitor cells, however, formed sparse calcified nodules compared with their bone marrow and pulp tissue counterparts.

Among viability assays that depend on the conversion of substrate to chromogenic product by live cells, the MTT assay developed by Mosmann[44] is still among one of the most versatile and popular assays. The MTT assay involves the conversion of the water-soluble yellow dye MTT [3-(4, 5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide] to an insoluble purple formazan by the action of mitochondrial reductase. Formazan is then solubilized and the concentration determined by optical density at 570 nm. As with the Alamar Blue assay, small changes in metabolic activity can generate large changes in MTT, allowing one to detect cell stress upon exposure to a toxic agent in the absence of direct cell death. According to the MTT viability assay, we found no statistical difference in the mean viability rate of PDLSCs between impacted third molar and erupted premolar sample cells.

There are several clinical and educational values to this study that can benefit the dental field. It must be mentioned that periodontal diseases are the main cause of tooth loss and are a substantial public health burden worldwide. The development of more advanced therapeutic interventions for periodontal disease is an urgent clinical necessity. The direct delivery of stem cells into periodontal defect sites is an easy approach in conjunction with well-established surgical procedures. Stem cells will mediate tissue regeneration and re-establish a healthy microenvironment at the post-treatment stage, which ensures a long-term favorable therapeutic effect.[45] So the availability of high-quality periodontal stem cells from impacted and erupted tooth, makes stem cell-based periodontal therapy more accessible and a feasible reality.

CONCLUSIONS

The results of this study showed that human PDL contains a population of multipotent postnatal stem cells that can be isolated and cultured in vitro, providing a unique reservoir of stem cells from an accessible tissue source. We found that if aseptic technique be employed during cell harvesting, isolation, and culture, both impacted and erupted tooth root can be suitable sources for PDLSCs. Consequently, PDLSCs have potential for use in periodontal tissue regeneration. In future studies, the therapeutic capacity of these cells to repair large periodontal defects induced by periodontal disease should be assessed in animal models.

ACKNOWLEDGMENTS

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Gorlin-Goltz Syndrome: An Uncommon Cause of Facial Pain and Asymmetry

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Abstract: Gorlin-Goltz syndrome is an underdiagnosed autosomal dominant disorder with variable expressivity that is characterized by an increased predisposition to tumorigenesis of multiple types. The major clinical features include multiple basal cell carcinomas (BCCs) appearing in early childhood, palmar and plantar pits, odontogenic keratocysts of the oral cavity, skeletal defects, craniofacial dysmorphism, and ectopic intracranial calcification. The authors present the clinical course of a 12-year-old girl presenting with facial asymmetry and pain because of previously undiagnosed Gorlin-Goltz syndrome. Early diagnosis and attentive management by a multidisciplinary team are paramount to improving outcomes in patients with this disorder, and this report serves as a paradigm for maintaining a high clinical suspicion, which must be accompanied by an appropriate radiologic workup.

Key Words: Ectopic calcification, Gorlin-Goltz syndrome, nevoid basal cell carcinoma syndrome, odontogenic keratocyst

Gorlin-Goltz syndrome, also called nevoid basal cell carcinoma syndrome (NBCCS) or basal cell nevus syndrome, was first reported by Gorlin and Goltz[1] in 1960.[2] It is an uncommon autosomal dominant multisystem disorder with high penetrance and variable expressivity, arising as a de novo mutation in approximately 40% of cases.[3] The estimated prevalence ranges from 1/57,000 to 1/256,000 and varies depending on geographic location.[4] No sexual predilection has been reported.[4] The major clinical features include multiple basal cell carcinomas (BCCs) appearing in early childhood, palmar and plantar pits, odontogenic keratocysts of the oral cavity, skeletal defects (eg, bifid ribs), craniofacial dysmorphism (eg, macrocephaly, frontal bossing, and coarse facial features), and ectopic intracranial calcification (eg, falx cerebri).[4,5] In addition, these patients are also at an increased risk of various neoplasms, including medulloblastoma, meningiomas, and ovarian and cardiac fibromas.[2,4,6]

Odontogenic keratocysts (jaw cysts) are seen in up to 90% of patients and are most common in the mandible.[7] The cysts are most often asymptomatic but may cause dental pain and swelling upon eroding through bone; moreover, they carry malignant potential and have been reported to transform into ameloblastomas and squamous cell carcinomas.[4,8–10] Keratocysts appear as unilocular lytic lesions on radiograph or computed tomography (CT) imaging and are usually the earliest clinical features of the syndrome in the first and second decades of life.[4]

Here, we report an interesting case of facial asymmetry and jaw pain caused by previously undiagnosed Gorlin-Goltz syndrome in a pediatric patient.

CLINICAL PRESENTATION

The patient is a 12-year-old girl with no past medical history who was referred to Texas Children's Hospital (TCH) from an outside facility after progressive swelling and asymmetry was noted in her face, specifically her jaw and cheeks. The patient also reported right eye and right jaw pain, but denied any changes in her vision. Further inquiry revealed that the patient's mother and maternal grandmother both had histories of jaw swelling.

Physical examination demonstrated a cooperative patient with marked facial asymmetry in animation and repose. Her malar areas were notably increased in volume with no appreciable induration of

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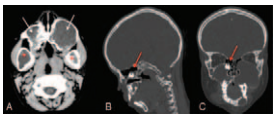

FIGURE 1. Computed tomography showing lytic lesions (A) (red asterisks) of the mandible bilaterally and an expansile mass within both maxillary sinuses (white arrows). Magnetic resonance imaging (B-C) revealing evidence of the expansile masses compressing bilateral orbital floors and abutting the ethmoid sinuses. A molar tooth (B-C) (red arrows) is visible on MRI sagittal and coronal sections. MRI, magnetic resonance imaging.

the skin. Her mandible also had increased volume bilaterally. There was no orbital dystopia and her extraocular muscles and associated cranial nerves were clinically normal. There, however, was reduced infraorbital nerve sensation bilaterally on examination. The frontal, zygomatic, buccal, and marginal mandibular and cervical branches of her facial nerve remained intact.

Intraoral examination revealed primary dentition and an anterior open bite. She did not endorse any change in sensation in her lower teeth or gingiva. Full body skin examination, including the palms and soles, did not reveal any irregular primary lesions.

RADIOLOGIC EVALUATION

Imaging performed at the referring hospital prompted concern that the patient's right adult canine tooth had been pushed upwards into the floor of her right orbit because of an expanding mass in her maxillary sinuses.

A repeat CT scan of her head (Figs. 1-2) at TCH revealed that the right mandibular ramus, angle, and body were expanded and replaced by a continuous soft tissue mass. Similarly, the left mandibular ramus, left parasymphyseal body, and both maxillary sinuses were also expanded and replaced by soft tissue masses.

The expansile masses were relatively well circumscribed with focal areas of ground-glass calcifications. The overlying osseous cortices were thinned, with some focal areas of cortical breakthrough. Several unerupted teeth were observed adjacent to the expansile masses.

The left maxillary sinus soft tissue was noted to elevate the left orbital floor and abut the left ethmoid air cells. The right maxillary soft tissue mass also elevated the right orbital floor. Both maxillary soft tissue masses were centered approximately over the premolars with slight malpositioning of the overlying maxillary dentition. Possible dehiscence of both inferior orbital nerves was noted. Aside from the aforementioned elevation of the orbital floors, the orbits were otherwise unremarkable.

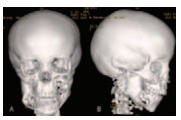

FIGURE 2. Preoperative computed tomography with three-dimensional reconstruction showing evidence of lytic jaw lesions (odontogenic keratocysts) bilaterally.

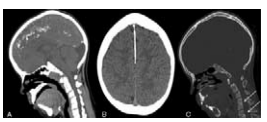

FIGURE 3. Below: ectopic calcifications (A-B) of the superior falx cerebri and tentorium cerebelli. Image C showing fusion of C4–C5 and C6–C7 vertebrae (white arrows).

Dural calcifications were noted throughout the falx cerebri and tentorium (Fig. 3A-B). In addition, there was partial posterior fusion of the C4–C5 and C6–C7 vertebral bodies (Fig. 3C), which has been previously reported in several cases of NBCCS.[4]

SURGICAL TREATMENT

The patient demonstrated little improvement with conservative treatment and ultimately required surgical enucleation of her odontogenic keratocysts.

The patient underwent excision of 7 odontogenic cysts and extraction of 8 ectopic teeth. Upon incision into the target areas, bone was found to be significantly thinned and easily perforated. There were large amounts of keratinous fluid inside each cyst and maxillary sinus. After suctioning, these areas were cleaned and using copious antibiotic irrigation, the ectopic teeth were removed without difficulties.

The patient underwent an uneventful postoperative hospital course and was discharged on day 2 on a full liquid diet. On her first follow-up visit 1 week later, her facial and trigeminal nerve branches were clinically intact and the patient was healing well with minimal drainage from her incisions.

DISCUSSION

Gorlin-Goltz syndrome has a wide range of clinical manifestations that may go unrecognized because of its variable expressivity. Over 65 mutations have been described in the literature to date.[11] The gene most commonly affected is the patched 1 tumor suppressor gene, *PTCH1*, which encodes a transmembrane protein that acts as a receptor for the hedgehog protein in the sonic hedgehog (SHH) signaling pathway.[2,12–14] Inactivation of the *PTCH* gene results in overexpression of the SHH pathway and is implicated in the development of BCC and myriad other tumors in Gorlin-Goltz syndrome.[15–18] Linkage analysis has also associated the syndrome with a 9q22.3 microdeletion, which includes the segment of chromosome 9 that contains the *PTCH1* gene.[19,20] Loss of this gene underlies the signs and symptoms of Gorlin-Goltz syndrome in people with 9q22.3 microdeletions.[19,20]

With a reported incidence between 66% and 92% in Gorlin-Goltz patients, odontogenic keratocysts are multiple and most frequently appear in the mandible.[5,14,21] Patients can develop these cysts as early as 7 or 8 years of age to approximately 30 years of age, at which time the cysts tend to decrease in rate of development.[4,22,23] In several population studies of NBCCS, incidence of jaw cysts was 13% before age 10 and 51% to 82% by age 20.[5,14,21] The reported mean number of cysts during a lifetime is 2.7 to 6 in published series.[4,14,21] There are no imaging features that differentiate odontogenic keratocysts in patients with Gorlin-Goltz from other odontogenic cysts. As such, multiplicity of odontogenic keratocysts could indicate a syndrome and warrants further clinical and radiologic investigations.[21] Lesions are usually treated via enucleation and curettage. Occasionally, highly aggressive recurrent lesions require resection to eliminate the lesion, although recurrence rates are reportedly as high as 60%.[4,24]

Ectopic calcifications (Fig. 3) of dural structures and ligaments are a common finding on head CT in adults and are often strikingly apparent beginning late childhood.[4,21] The age of onset for physiological dural calcifications has not been well established. The most common site of calcification is the falx cerebri with an incidence of 65% to 92%.[14,21] Other sites of ectopic calcifications in patients with NBCCS include the tentorium cerebelli (20%–40%), petroclinoid ligament (20%), and diaphragma sellae (60%–80%).[4]

Basal cell carcinomas associated with Gorlin-Goltz syndrome can vary in number from one to hundreds and most often appear between puberty and 35 years of age, with a mean age of 25 years.[4,25–27] Histologically, they, however, are indistinguishable from sporadic cases of BCCs.[26] Reports from epidemiological studies have indicated that the risk of BCC in this population, similarly to sporadic cases, shows a strong positive correlation with exposure to ultraviolet (UV) radiation.[4] As such, these patients need to avoid excess sun exposure. Management of BCCs is very challenging in this condition, owing to their multiplicity, early onset, and recurrent nature. Both surgical and nonsurgical (eg, photodynamic therapy, cryosurgery, and topical chemotherapy) approaches should be considered for BCCs, as cosmetic results from multiple surgeries may be unacceptable by patients. No large-scale scientific studies, however, have been performed in the context of this syndrome, especially in children. Further clinical trials comparing the effectiveness and cosmetic outcome between different treatment modalities are required.

It is essential to make an early diagnosis because the severity of complications, such as malignant skin and brain tumors, can be reduced with attentive medical and surgical management, and maxillofacial deformities related to the jaw cysts can be avoided. Moreover, children with Gorlin-Goltz syndrome have a predisposition for secondary cancers after exposure to radiation, both UV and ionizing.[21,28] Because management of both medulloblastoma and odontogenic cysts frequently includes radiation exposure through radiotherapy and serial CT imaging studies, respectively, it is important to make a diagnosis of concomitant Gorlin-Goltz syndrome in these patients to avoid unnecessary exposure to ionizing radiation.[21]

The most important aspect in the management of this syndrome is frequent clinical examination, counseling about sun protection, and early treatment of small tumors by surgical and nonsurgical methods. Life expectancy in patients with Gorlin-Goltz syndrome does not significantly differ from the rest of the population.[29] The major problem is with the cosmetic effect of the treatment of multiple BCCs and, to a lesser extent, of jaw cysts.

CONCLUSIONS

Gorlin-Goltz syndrome represents a challenging diagnosis for the clinician given its variable expressivity and frequently asymptomatic lesions. A thorough history and clinical examination remain paramount to securing an early diagnosis, keeping in mind that this syndrome is most frequently detected through oral and maxillofacial examination. Children who present with odontogenic keratocysts or medulloblastoma should undergo appropriate radiologic and genetic workup to assess for a possible syndromic etiology. If diagnosed at a young age, the clinical course and sequelae for the patient can be dramatically altered through preventative treatment and genetic counseling. The importance of continuous, long-term follow-up with a multidisciplinary team cannot be overstated.

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Esthesioneuroblastoma With Poor Outcome Despite Extensive Treatment

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Abstract: Esthesioneuroblastoma is a rare malignant tumor of neuroectodermal origin. It usually presents with nonspecific symptoms, such as nasal obstruction, epistaxis, and pain, but has an aggressive course if the treatment is delayed. The authors report a case of esthesioneuroblastoma in a 47-year-old woman, treated with extensive surgical resection, radiotherapy, and chemotherapy. Despite intensive treatment, the patient developed a local recurrence with systemic metastasis and succumbed 4 months later.

Key Words: Esthesioneuroblastoma, orbital tumor

Olphactory neuroblastoma, also known as esthesioneuroblastoma (ENB), is a rare malignant tumor of the neuroectodermal origin. It accounts for the 6% of the nasal cavity and paranasal sinus neoplasms.[1] The ENB has a bimodal age distribution in the second and sixth decades of life without a sex predilection. The most common presenting symptoms include unilateral nasal obstruction (70%) and epistaxis (50%).[2] Because of the nonspecific nature of the initial presentation of the tumor, patients frequently have a long history before the diagnosis. Kadish et al[3] were the first to propose a staging system for ENB where the patients were classified into 3 stages: stage A, tumor confined to nasal cavity; stage B, tumor extends to one or more of the paranasal sinuses; and stage C, where the tumor extends beyond the nasal cavity and paranasal sinuses. Morita et al[4] modified the Kadish staging system by reclassifying patients with lymph node or distant metastases as stage D. Craniofacial resection and adjuvant radiotherapy (RT) is accepted as a gold standard therapy.[2] Endoscopic surgery, chemotherapy (CT) and Gamma knife therapy were reported as alternative treatment choices.[5,6]

We present a patient of Kadish stage 3 ENB treated with a modified combination therapy, craniofacial resection followed by a conventional RT and concurrent CT.

CLINICAL REPORT

A 47-year-old woman presented with progressive unilateral nasal obstruction and minimal proptosis in the right eye associated with facial pain and blurred vision since 2 months. She had a history of treatment of the recurrent sinusitis for the last 1 year. There were increased intraocular pressure to 33 mm Hg, proptosis and chemosis in the right eye. Best corrected visual acuity decreased to 1/10 in the right and was 10/10 in the left eye. Imaging (CT and MRI) revealed an extensive tumor in the medial extraconal orbital area involving the right nasal cavity and extending into the frontal, ethmoid, maxillary sinuses, and anterior skull base (Fig. 1A). An endoscopically guided biopsy revealed tumor cells. Positron emission tomography (PET) of the whole body showed fluorodeoxyglucose (FDG) uptake only by the tumor in the nasal cavity. The tumor was staged at Kadish C with no distant metastasis. The patient was discussed with the ear–nose–throat (ENT) and neurosurgery departments and a decision of extensive craniofacial resection was taken. The surgery consisted of total exenteration of the right eye, curettage of the tumor and mucosa of the frontal recess and maxillary sinus, total ethmoidectomy, resection of the right perichondrium of the nasal septum, upper and middle turbinate (Fig. 1B). The dura at the skull base was resected for approximately 3×4 cm and the defect was sealed with the artificial dura and tissue adhesive. All the resected material was referred to the pathology clinic for examination. Microscopic examination of the tumor showed lobules of neoplastic cells separated by fibrovascular stroma (Fig. 1C(a)). Small or medium-sized tumor cells had uniform round vesicular nuclei with fine "salt and pepper" chromatin, and scant cytoplasm (Fig. 1C(b)). There were extensive areas of necrosis and high mitotic count. Tumor cells infiltrated the conjunctiva and the lower lid. Bulbus oculi and the optic nerve were tumor free. Surgical margins of the resected tissue were positive for the tumor cells. An immunohistochemical panel consisting of antibodies of pan-cytokeratin, epithelial membrane antigen (EMA), CD45, synaptophysin, chromogranin A, CD56, CD99, vimentin, Fli-1, TTF-1, S-100, and neuron specific enolase (NSE) was applied to identify the nature of the tumor. There was diffuse vimentin and CD56 (Fig. 1C(c)), multifocal synaptophysin (Fig. 1C(d)) and scattered neuron-specific enolase (NSE) positivity whereas the other markers were all negative. A diagnosis of olfactory neuroblastoma was made according to the morphologic and immunohistochemical features. The patient was then referred to postoperative RT and CT. Adjuvant RT with concurrent epirubicin, doxorubicin, and cyclophosphamide weekly was prescribed. Five weeks after surgery while receiving RT and CT, a brain-orbita MRI showed recurrence of the tumor at the sphenoid bone. A control PET of the whole body was performed thereafter and the results revealed FDG uptake by the tumor in the right nasal cavity and orbita, retropharingeal and deep cervical lymph nodes, T11, L4 vertebra, pelvis, left rib, both humeri, and both lungs. Thorax CT showed multiple nodules suggesting metastases in both lungs. Neurologic deficits, such as incontinence, blur of consciousness started in a month after the conclusion of the RT and CT. Brain MRI showed extension of the tumor to the frontal lobe of the brain (Fig. 1D). No more RT or CT was planned because of the deteriorated state of the patient. Eventually the patient was lost.

DISCUSSION

Olfactory neuroblastoma is a rare malignant neoplasm of the nasal cavity and of the paranasal sinuses. A Danish study has reported an

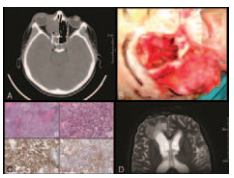

FIGURE 1. A, Tumor in the medial extraconal orbital area. B, Intraoperative view of the patient. C (a), Tumor with extensive areas of necrosis, lobules separated by fibrovascular stroma (HE ×4). C (b), Small or medium sized tumor cells with uniform round vesicular nuclei and scant cytoplasm (HE ×20). C (c-d), CD56 and synaptophysin positivity of tumor cells, respectively (×20, ×20). D, Brain extension of the recurrent tumor.

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incidence rate of 0.4/million inhabitants per year, with 48 patients being accumulated over a 13-year time frame.[7] Given this rarity, it is not surprising that many of these patients were treated for sinonasal disease for variable time frames, and thus presenting with moderately advanced disease at the time of diagnosis.[7,8] The Kadish staging system (and its modification, to allow a stage D to represent those patients with metastatic disease at presentation) is the widely accepted method of discriminating the extent of spread.[3] The mainstay of the treatment is surgery. The current accepted practice is open or endoscopic craniofacial surgical resection. Adjuvant RT is indicated for Kadish stage B and C, whereas Kadish A disease can be managed with surgery alone.[8,9] Retrospective data suggests that patients with high grade, Kadish stage C disease may benefit from adjuvant CT.[10,11] Diaz et al recommended using preoperative CT to reduce the extent of surgical resection if tumor reduction is achieved.[9] Kim et al reported on 6 patients who had concurrent CT and were locally controlled but died of metastatic disease.[12] The extent of disease is accepted as the strongest determinant of ultimate outcome.[13,14] In the Danish series, the disease-free survival was 67% at 5 years for stage B and 32% at 5 years for stage C.[7] Our patient who presented with locally advanced disease Kadish stage C was treated with craniofacial surgical resection. As negative surgical margins were not available, chemoradiotherapy was added. Despite the aggressive treatment approach, we observed distant metastases shortly after the surgery, and the patient died in a period of 4 months. It is clearly evident from our patient and from the literature that the management approach for olfactory neuroblastoma is a multidisciplinary concern and needs multimodal treatment.[15] Bottom line is the early diagnosis and urgent treatment of this highly aggressive tumor.

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Transection of Nasolacrimal Duct in Endoscopic Medial Maxillectomy: Implication on Epiphora

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Objective: Management of the nasolacrimal system is usually recommended during medial maxillectomy via external approach because of reported higher rates of postoperative epiphora. Association of the endoscopic medial maxillectomy (EMM) with epiphora, however, is not clearly stated. In this study, we attempted to evaluate whether patients develop epiphora after simple transection of the nasolacrimal duct during EMM.

Patients and Methods: Medical records of 26 patients who underwent endoscopic tumor resection for inverted papilloma (IP) were retrospectively reviewed. Patients who underwent EMM with nasolacrimal canal transection were included and recalled for lacrimal system evaluation. Twelve patients were eligible for inclusion and fluorescein dye disappearance test (FDDT) was performed for each patient. Patient demographics, tumor data, surgical procedures, and follow-up time were recorded.

Results: Of the 12 patients included in the study, 6 underwent canine fossa transantral approach concurrently with EMM. The mean duration of follow-up was 21.1 months (range, 6–84 months). Eight patients were graded as 0, whereas 4 patients were graded as 1 according to FDDT. All test results were interpreted as negative for epiphora. All patients were completely symptom free of epiphora.

Conclusions: Epiphora after EMM with nasolacrimal canal transection among patients with sinonasal tumors appears to be uncommon. Therefore, prophylactic concurrent management of nasolacrimal system including stenting, dacryocystorhinostomy (DCR), or postoperative lacrimal lavage are not mandatory for all patients.

Key Words: Endoscopic medial maxillectomy, epiphora, nasolacrimal canal

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With the development of endoscopic sinus surgery, the endoscopic resection has become the current surgical treatment of choice for majority of sinonasal tumors. The extent of sinonasal involvement by the tumor determines the extent of resection. Endoscopic medial maxillectomy (EMM) usually involves the resection of inferior turbinate and nasolacrimal duct.[1–3] Although EMM reduces the rate of complications those observed after external approach, various authors indicated the possibility of epiphora and dacryocystitis occurring because of transection of nasolacrimal duct.[4]

The management of nasolacrimal system at time of initial resection during external approaches varies with surgeon preference and previous experience. Medial maxillectomy via midfacial degloving or lateral rhinotomy may lead to troublesome postoperative epiphora and dacryocystitis. Reported rates of epiphora following maxillectomy or anterior craniofacial resection varies between 32% and 63%.[5] Therefore, to ensure that prolonged epiphora does not develop, concurrent management of nasolacrimal system such as routine concurrent dacryocystorhinostomy (DCR), and silicone tube stenting are the treatment of choices.[6] This, however, is based primarily on experience with external approach of medial maxillectomy.

Nasolacrimal duct is usually transected during EMM. It, however, is not clearly stated that whether the management of the nasolacrimal system is necessary, when EMM involves resection of the nasolacrimal duct. The aim of this study was to evaluate whether patients develop postoperative epiphora after simple transection of the nasolacrimal duct during EMM.

PATIENTS AND METHODS

Patients who had undergone EMM with resection of the nasolacrimal duct for sinonasal inverted papilloma (IP) between December 2006 and December 2014 at our tertiary institution were included in this study. Institutional review board approved this study. Medical records of 26 patients who underwent endoscopic sinonasal tumor resection were retrospectively reviewed. Eleven patients who underwent endoscopic sinonasal tumor resection with preservation of the nasolacrimal duct were excluded. Patients were recalled by telephone and invited for clinical evaluation and fluorescein dye disappearance test. Three patients whom we could not contact via telephone were assumed lost to follow-up. Finally, 12 patients were included in the study. Demographic and clinical characteristics including age, sex, stage of tumor, histopathology, surgical details, recurrence, and follow-up times were recorded. Fluorescein disappearance dye test was performed for each patient and informed consent was obtained concurrently. All tumors were staged using the IP staging system developed by Krouse.[7]

Surgical Details

All surgeries were performed using general anesthesia by the same surgical team. The patient was positioned in a reverse Trendelenburg's position (30°). Intranasal decongestion was achieved with cottonoids soaked in 2% oxymetazoline. Lidocaine (1%) with 1:100.000 adrenaline was injected at the attachment of the middle turbinate and around the sphenopalatine foramen intranasally. First, intranasal part of the tumor was debulked and origin of the tumor was attempted to be identified. If the tumor was originated from the maxillary sinus, a large middle-meatal antrostomy was performed to visualize the sinus. Sphenoethmoidectomy and/or frontal sinusotomy or middle turbinate resection before EMM were performed, if necessary. If the tumor originated from inferior, lateral, and anterior walls of the maxillary sinus, EMM was performed. Superior incision is carried out from the attachment of the middle turbinate on the lateral nasal wall across the lacrimal bone, anterior to the head of inferior turbinate. Anterior vertical incision is performed in front of the head of inferior turbinate using electrocautery. Inferior turbinate resection was carried out before inferior incision, which continued up to the posterior wall of the maxillary sinus along the junction with nasal floor. Osteotomies were carried out using chisel and surgical burr. Following the superior osteotomy nasolacrimal duct, as it descends from the lacrimal sac, is transected with endoscopic scissors and enclosed in the specimen (Fig. 1A-C). Medial wall of the maxillary sinus with inferior turbinate and nasolacrimal duct is completely removed (Fig. 1D). Bone at the origin of IP was drilled down with a diamond burr to ensure that no tumor remained.

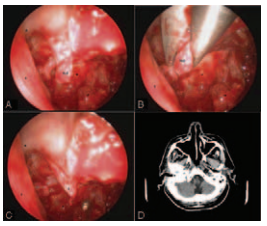

FIGURE 1. A, Medial wall of maxilla has been removed and nasolacrimal canal is exposed, B, Sharp transection of NLD by endoscopic scissor. C, Residual lacrimal aparat is shown. D, Axial CT image showing the complete removal of medial maxillary wall. A, axilla of middle turbinate; S, nasal septum; ∗, posterior wall of maxilla; L, lumen of the residual. CT, computed tomography; IP, inverted papilloma; NLD, nasolacrimal duct.

Lacrimal Duct Function/Fluorescein Dye Disapperance Test:

Fluorescein dye disappearance test was performed via instilling 2% drops into both conjunctival fornices. Normally little or no stained tear remains after 3 minutes. Prolonged retention usually indicates lacrimal drainage pathology. The amount of remained dyed tear was evaluated using cobalt light of an indirect ophthalmoscope in 5 minutes. Test result of FDDT was graded according to MacEwen and Young[8] as Grade 0 (no fluorescence in the conjunctival sac), Grade 1 (thin fluorescein marginal tear strips only), Grade 2 (between Grade 1 and 3), and Grade 3 (wide and bright fluorescein strip). Grade 0 and 1 were accepted as negative test result. Grade 2 and 3 were considered as positive test result.

RESULTS

Eight patients were men and 4 patients were women, with an average age of 51.4 (range, 20–73) years. The mean duration of follow-up was 21.1 months (range, 6–84 months). Of the 12 patients included in the study, 5 patients underwent EMM without combined procedure (Table 1). The remaining 7 patients underwent EMM with concurrent combined procedure such as canine fossa transantral approach and osteoplastic frontal sinus approach (Table 2). Two patients received postoperative radiotherapy. One patient (sixth case in Table 2) had previous lateral rhinotomy for IP. The FDDT test results were collected from all 12 patients included in the study. Eight patients were graded as 0, whereas 4 patients were graded as 1 according to FDDT. None of the patients graded over 1. All test results were interpreted as negative for epiphora. None of the patients had symptom of epiphora.

DISCUSSION

In this study, we sought to evaluate the patency of residual lacrimal pathway and postoperative epiphora using FDDT after nasolacrimal duct transection during EMM. The current study showed that, epiphora after EMM with nasolacrimal canal transection appears to be uncommon and residual lacrimal pathway remains to be functional.

Preserving the nasolacrimal duct during EMM limits the endoscopic visualization and access to the lateral and anterior maxillary

TABLE 1. Demographic and Clinical Characteristics of Patients Treated With EMM

Case	Age	Sex	Pathology	T Stage	Tumor Origin	Procedure	Fluorescein Dye Test	Recurrence	Follow-up (mo)
1	44	M	IP	2	M + AE	EMM	negative	No	14
2	70	M	IP	2	M	EMM	negative	No	8
3	64	F	IP	2	M	EMM	negative	Yes	48
4	42	F	IP	3	M	EMM	negative	No	6
5	50	F	IP	3	M + FR	EMM	negative	No	13

AE, anterior ethmoid; EMM, endoscopic medial maxillectomy; FR, frontal recess; IP, inverted papilloma; M, maxillary sinus.

TABLE 2. Demographic and Clinical Characteristics of Patients Treated With EMM and Combined Procedure

Case	Age	Sex	Pathology	T Stage	Tumor Origin	Procedure	Fluorescein Dye Test	Recurrence	Follow-up (mo)
1	70	M	IP + SCC	4	M	EMM + CL	negative	No	12
2	55	F	IP + SCC	4	M	EMM + CL	negative	No	13
3	44	M	IP	3	M	EMM + CL	negative	No	27
4	44	M	IP	3	M	EMM + CL	negative	No	19
5	73	M	IP	3	M	EMM + CL	negative	No	6
6	41	M	IP	3	M + Fr	EMM + OF	negative	No	84
7	20	M	IP	3	M	EMM + CL	negative	No	7

CL, Caldwell-Luc; EMM, endoscopic medial maxillectomy; Fr, frontal sinus; IP, inverted papilloma; M, maxillary sinus; OF, osteoplastic frontal sinus approach; SCC, squamous cell carcinoma.

sinus wall.[9] Extensive exposure of the maxillary sinus is necessary for complete resection of the tumor.[10] Resection of the entire medial wall of the maxillary sinus including the nasolacrimal duct and inferior turbinate is required for proper endoscopic access.[11] As the nasolacrimal duct and canal is resected during EMM, postoperative epiphora may be of concern.[4] Therefore, various authors have developed some modifications for EMM such as preservation of nasolacrimal duct or preservation of both nasolacrimal duct and inferior turbinate.[4,12]

Management of the nasolacrimal system during EMM varies between authors. Tomenzoli et al[13] only performed monthly lavage of the residual lacrimal pathways until healed and patent rhinostomy observed in patients requiring nasolacrimal duct resection. In the current study, we did not perform lacrimal lavage in any patient and we believed that functional lacrimal pump system can provide patency. Wormald et al[14] performed lacrimal sac marsupialization with the creation of anterior and posterior flaps. Sadeghi et al[15] performed endoscopic DCR and lacrimal stenting following transnasal EMM.

There is no consensus in the literature for the management of nasolacrimal system during EMM. To our knowledge, there is only 1 study which assesses the need of concurrent DCR during EMM. In that study, Sadeghi and Joshi[16] compared 5 patients who underwent concurrent DCR with 7 patients who did not undergo DCR and reported no epiphora in both groups. The author also proposed that there is no need to perform prophylactic DCR concurrently with EMM for all patients. Lombardi et al[17] retrospectively, however, reviewed 212 patients of sinonasal IP and reported 4 postsaccal lacrimal pathway obstruction in 48 of 212 patients who underwent EMM with nasolacrimal duct. The current study was in agreement with the previous study[16], which reported a low possibility of epiphora following EMM.

Schirmer test, visual analog score and FDDT were used for evaluation of epiphora in previous studies.[4,16] In the current study, we used FDDT which is a simple, rapid, reproducible, highly specific, and practical clinical test in diagnosis of primary acquired nasolacrimal duct obstruction.[18] Lacrimal clearance relies on several factors including gravity, capillary attraction forces, absorption by conjunctival surface, residual flow, and the lacrimal pump.[19] The lacrimal pump mechanism is considered to be the most important among all tear drainage-supporting mechanisms.[20,21] Reported higher rates of epiphora following anterior fossa craniofacial resection may due to as a result of disruption of this pump mechanism secondary to eyelid malpositioning and/or lacrimal outflow obstruction. In EMM, medial canthal anatomy and lacrimal fossa, however, are not disrupted as during external surgical approach. Most likely, continuing of tear flow in the residual lacrimal pathway with functional pump mechanism after sharp transection of the nasolacrimal duct may mainstay the patency. Hence, although the nasolacrimal duct is resected in EMM, residual lacrimal pathway remains to be functional.

The main limitations of the current study were the retrospective design and small number of cases included in a single institution. The data from the current study and findings from other studies, however,[13,16,17] suggest that postoperative epiphora secondary to EMM with nasolacrimal canal resection among patients with sinonasal tumors appears to be uncommon. Therefore, prophylactic concurrent management of nasolacrimal system, including stenting or DCR, or postoperative lacrimal lavage is not mandatory for all cases.

CONCLUSIONS

On the basis of our results, simple transection of the nasolacrimal duct during EMM does not lead to epiphora. Furthermore, prospective, randomized, clinical studies, however, designed to assess the effect of different interventions in the management of lacrimal system during EMM on postoperative epiphora are needed.

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A Life Threatening Pitfall in Ear Surgery: Extracranial Sigmoid Sinus

Osman Halit Çam, MD and Mehmet Karataş, MD†*

Aim: The aim of this article is to imply the significance of temporal bone computed tomography imaging before temporal surgeries.

Case: A 74-years-old patient was admitted to emergency department with dizziness and nausea. The neurologic examination showed a spontaneous nystagmus, whereas otologic examination revealed a left tympanic membrane perforation with mild discharge. A temporal bone computed tomography imaging was scheduled to exclude cholesteatoma and perilymphatic fistula. Computed tomography detected an anterior sigmoid sinus with middle fossa defect and subcutaneous course of the sinus in posterior–superior portion of the external ear canal skin with no cholesteatoma sign. Thus, Dix-Hallpike was performed on the patient and was positive on the right side. The patient was diagnosed as benign positional vertigo.

Conclusions: Sigmoid sinus is an important landmark in otologic surgeries and in some patients it may be problematic because of its dehiscence. To avoid any surgical complications it is highly important to evaluate a temporal bone computed tomography imaging before any transmastoid, retroauricular and edoaural surgeries.

Keywords Anomaly, extratemporal, otology, sigmoid sinus

The temporal region is a common surgical site in otorhinolaryngologic surgery, including cochlear implant, mastoidectomy, tympanoplasty, and transmastoid lateral skull base procedures. In these surgeries, sigmoid sinus and dural plate are used as notable landmarks.[1]

Some anatomic anomalies, such as sclerotic mastoid with poor pneumatization, anteriorly located sigmoid sinus, and inferiorly located dural plate, however, may complicate these procedures.[2]

These anomalies not only reduce the intraoperative maneuvering capability of the surgeon, but also limit the visualization of the surgical site and increase the complication risk. It is not possible to predict such defects without previous imaging studies. In this case report, we will discuss a patient with anomalous sigmoid sinus who presented to our Emergency Unit.

CLINICAL REPORT

A 74-year-old woman presented to the emergency unit because of severe dizziness, imbalance, and nausea. The history revealed diagnosis of positional vertigo with repeated attacks of dizziness, which had ceased since 1 year. The physical examination showed horizontal spontaneous nystagmus, whereas the neurologic examination exhibited ataxia. There was a large central perforation with serous discharge in the left ear. Fistula test was negative. The patient was observed to have cholesteatoma secondary to chronic otitis media and thin-section temporal computed tomography (CT) imaging was scheduled to rule out perilymphatic fistula. The temporal CT displayed communicating mastoid cells due to chronic otitis as well as defective appearance in the tegmen

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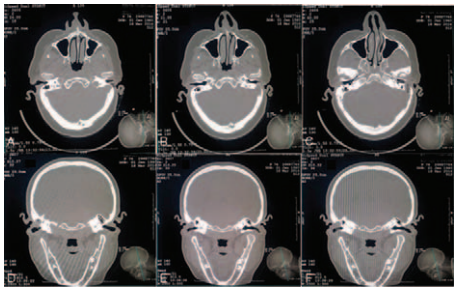

FIGURE 1. First row: axial CT scan series of the temporal bone from bottom to top. A, Very thin bone plate of temporal bone covering the sigmoid sinus on the left temporal bone (black open arrows). B, Absence of bony plate. Note that mastoid portion of the temporal bone is rudimentary (white open arrows). C, The sinus is in direct contact with the posterior–superior region of the external ear canal skin (white arrow: external ear canal, black arrow: sigmoid sinus hanging to external ear canal). Second row: coronal CT scan series of the temporal bone form posterior to anterior. D, Intratemporal course of the sigmoid sinus is clearly seen (black asterix: sigmoid sinus, white asterix: antrum surrounded by perianthral hair cells) E, Absence of bony plate just inferior to the sigmoid sinus (black asterix: sigmoid sinus, white asterix: antrum mastoideum). F, Hanging sigmoid sinus to the superior portion of the external ear canal (white open arrows). CT, computed tomography.

tympani, and soft tissues occasionally exhibiting high intensity and extending to the subcutaneous layer (Fig. 1).

The semicircular canals were patent. Because there was no history of an otologic intervention, the patient was evaluated via CT and scheduled for ear MRI. In the left temporal bone, sigmoid sinus was inducing a bone defect in the cranium, whereas extending to the subcutaneous layer following a superior–posterior contour through the external ear canal, indicating a risk of bleeding because of its subcutaneous nature and the absence of bone plate at this level.

Thus, the patient was subjected to Dix-Hallpike test, revealing a positive result. She was diagnosed with positional vertigo and she received Epley maneuver. She received positional recommendations for the following days. The patient was informed about her chronic otitis and the current vascular anomaly, and we highlighted the need for surgery. She declined undergoing an operation because of the possible risks and her age. Since then, the 6-month follow-up assessments of the patient, however, showed no recurrent attacks of dizziness.

DISCUSSION

The anteriorly located sigmoid sinus often narrows the mastoidectomy limits, precluding the surgeon from reaching the antrum by reducing the visualization.

In 2012, a study in Brazil compared the intraoperative data and computed tomography measures of 30 patients and concluded that the presence of a tomographic distance between the sigmoid sinus and the external ear canal lower than 9 mm complicated the procedure. The lowest distance was 4.7 mm.[3] Ekinci et al[4] measured the same distance as 13.2 mm.

In the current case, this value was zero and it was following a completely extracranial subcutaneous course in the anteroinferior plane. This may lead to fatal bleeding with sinus incision, just at the beginning of the retroauricular incision.

Shatz et al[5] found a significant relationship between mastoid pneumatization and anteriorly located sigmoid sinus.

Our patient, having no mastoid pneumatization, was consistent with this finding, as well. Despite the evidences indicating such a relationship, it, however, has not been definitively decided whether the sinus location reduces the mastoid pneumatization or the hypoplastic mastoid development causes the sinus to be located anteriorly.

In conclusion, before temporal surgeries, particularly in otologic interventions using transmastoid approach, temporal computed tomography should be applied and the images should be preoperatively evaluated with regard to anomalies and possible fatal bleedings.

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Zygoma Implant-Supported Prosthetic Rehabilitation of a Patient After Bilateral Maxillectomy

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Abstract: Maxillectomy defects may vary from localized to extensive soft and hard tissue loss. In addition to physical and psychologic damages, functional and aesthetic aspects must be restored. This clinical report describes the rehabilitation of a patient with a zygoma implant-supported obturator prosthesis caused by a subtotal bilateral maxillectomy due to a squamous oral cell carcinoma. Prosthetic rehabilitation of this patient was performed after zygoma implant surgery. A maxillary obturator prosthesis supported by 2 osseointegrated zygoma implants was fabricated. Despite limited mouth opening and anatomic deficiencies, the patient's aesthetic and functional demands were fulfilled.

Key Words: Maxillectomy, obturator prosthesis, zygoma implant

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Maxillectomy patients who undergo radical treatment of a maxillary tumor face with mastication, speaking, swallowing, and facial esthetic problems result in functional, emotional, and social impacts on these patients.[1–3] Several surgical reconstructive options exist, including prosthetic obturation, grafts and flaps.[4] Classification of maxillectomy defect affects prosthesis retention and the concentration of adverse forces on any remaining hard or soft tissues.[5] Various methods have been described for retention and support of a bilateral obturator prosthesis, such as zygomatic implants.[6] Zygoma implants, however, may be associated with several problems, including deficiency of hard and soft tissue, and overloading of the zygoma and implant.[1,5]

This article describes the prosthetic rehabilitation of a patient with a severe intraoral defect resulting from a maxillectomy resection, using 2 zygoma implants connected by computer-aided design/computer-aided manufacturing (CAD/CAM)-fabricated milled bar (infrastructure framework) and a maxillary obturator prosthesis.

MATERIALS AND METHODS

A 52-year-old man, who corresponded to prosthodontic diagnostic index (PDI) Class IV and Class X in the classification of maxillary defects by Brown et al,[7] patient that had a history of a bilateral maxillectomy for resection of a squamous oral cell carcinoma of the hard palate was referred to Department of Prosthodontics, Istanbul University for oral rehabilitation in 2012. Clinical examinations showed an oro-nasal communication due to subtotal bilateral maxillectomy and a maxillary prosthetic obturator was placed in 2012. The patient returned in November 2013 complaining about the former prosthesis that disturbed his perfections because of inadequate retention and stability. His presurgical medical evaluation revealed a radiotherapy treatment 10 years ago through head and neck region. After the appropriate medical consultation was obtained, cone-beam computed tomography (CBCT) was taken for further investigation. Presurgical evaluation included examination of zygoma anatomy, estimating implant's length and directions before the operation with the help of three-dimensional acrylonitrile butadiene styrene (ABS) plastic model (Z print150; Z Corporation, Rock Hill, SC) obtained from the CBCT (Fig. 1). As a result of three-dimensional determination of the patient's anatomy, surgical planning included only 2 zygomatic implants, each 1 on the different sites. According to the zygoma implant surgery protocol, surgery was carried out under general anesthesia. Local anesthetic was infiltrated with injections of articaine including epinephrine. The incision attempted to expose the area of the zygomatic crest and the subperiosteal dissection was advanced to the zygomatic buttress until the zygomatic notch could be reflected. The zygomatic implant osteotomy was completed with a 3.5 mm drill. The estimated lengths of the zygomatic implants were selected using a depth gauge. Afterwards, 2 30-mm zygomatic implants (Branemark System Zygoma TiUnite; Nobel Biocare, Zurich, Switzerland) were placed manually using an implant mount (Fig. 1). The operation sites were closed with interrupted absorbable sutures. After 2 months period, healing screws were adapted to the zygomatic implants. Multiunit abutments were connected to the implant body and a transfer impression (Impregum Penta; 3M ESPE, Seefeld, Germany) over the implants was made (Fig. 2). A free shape milled bar was designed without following a particular manufacturing shape and customized according to the denture tooth arrangement and the soft tissues (Fig. 3). Before the manufacturing of infrastructure framework, acrylate polymer blocks (Tizian Blank PMMA; Schütz Dental GmbH, Rosbach, Germany) were initially used for the fabrication of replica bar using CAD/CAM to control intraoral compatibility (Fig. 2). Wax occlusal rims formed on the acrylic base were used to make the interocclusal record to transfer the interarch relationship to the articulator (Artex CN; Amann Girrbach, Koblach, Austria) and to check occlusal vertical dimension. Maxillary obturator prosthesis and mandibular complete denture was completed and placed in the oral cavity in April 2014 (Fig. 4). Turkish version of the 14-item questionnaire[5] was given to the patient before (former obturator prosthesis) and after (zygoma implant-supported definitive obturator prosthesis) oral rehabilitation for self-completion to evaluate functional, esthetic, and psychologic satisfaction. Each item was scored by a number, with the final score (range: 0–29).

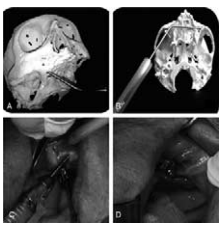

FIGURE 1. Presurgical examination of zygoma anatomy evaluated with three-dimensional plastic model (A-B). The zygomatic implant osteotomy was completed and zygomatic implants were placed (C-D).

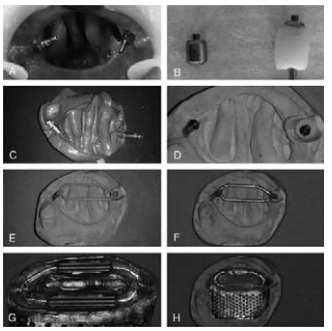

FIGURE 2. Transfer copings were placed and transfer impression was made (A-C). A custom gingiva former was produced using cold curing acrylic resin (B). Multiunit abutments were connected to the master cast (D). Replica bar was fabricated with acrylate polymer blocks and then infrastructure framework was fabricated (E-F). Superstructure framework was fabricated and checked on the master cast (G-H).

RESULTS

Following delivery of the prosthesis, the patient's response was favorable in relation to esthetics, speech, swallowing and mastication while the patient's oral and facial appearance improved. Postinsertion instructions were given with respect to insertion,

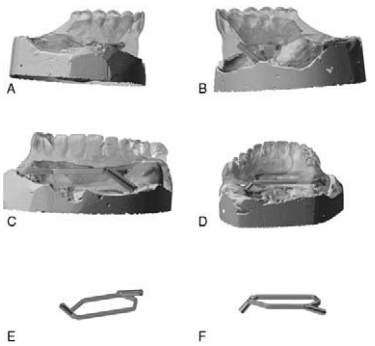

FIGURE 3. A free shape milled bar was designed and customized using computer-aided design system.

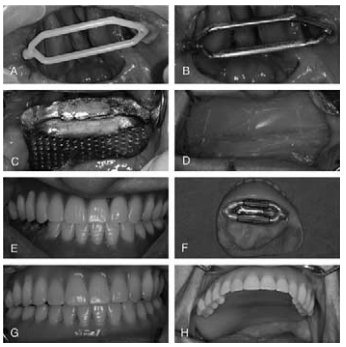

FIGURE 4. Replica bar was checked on patient's mouth before infrastructure and suprastructure frameworks were fabricated and applied on patient's mouth (A-C). Occlusal vertical dimension and denture teeth control was made (D-E) and prostheses in both jaws were placed in the oral cavity (F-H).

removal, and maintenance of the obturator, and intraoral hygiene. At the 6-month and 1-year follow-ups, the patient confirmed satisfaction with treatment and no significant complaints have been recorded. A significant decrease in the total questionnaire score between the former obturator prosthesis (score = 18) and the zygoma implant-supported definitive obturator prosthesis (score = 2), suggesting an improvement in the patient's quality of life and self-esteem.

DISCUSSION

Zygomatic implants are very useful in prosthetic rehabilitation of the severely resorbed maxilla, regardless of whether it is totally or partially edentulous individuals. A literature survey showed that good clinical outcome can be achieved.[7] This clinical case demonstrates zygoma implant-supported obturator prosthesis rehabilitation of a patient with subtotal bilateral maxillary defect.

Zygomatic implant surgery is an alternative treatment method which is less invasive and more predictable to bone grafts and maxillary sinus lift in patients with posterior atrophic maxilla.[8,9] Complications of soft tissues such as peri-implantitis and sinusitis may occur with this type of implants.[8]

Owing to the closeness with essential anatomical structures of the area, complications are often seen and complication risks can be reduced by three-dimenstional printed models.[10] Furthermore, infection or sinus complications should be treated with antibiotics or surgery. If infection is not resolved with the medication, the implant may require surgical removal.[8]

Success rates of zygomatic implants obtained by the many authors vary between 82% and 100%.[9] Keller et al[11] reported on the reconstruction of compromised maxillary arches 118 inlay grafts and 248 Branemark System implants. They reported an implant survival rate of 87% and a prosthetic survival rate of 95%.

This case confirms the view expressed in the literature that zygoma implant-supported obturator prosthesis have excellent retention and stability, and there is no displacement of the denture during speech and mastication.

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Double Free Flap Transfer Using a Vascularized Free Fibular Flap and a Rectus Abdominalis Musculocutaneous Flap for an Extensive Oromandibular Defect: Prevention of Sinking or Drooping of the Flap With an Anterior Rectus Sheath

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Abstract: The double free flap procedure is a preferred treatment for extensive composite defects of the oromandibular area. In this procedure, the choice and use of the flaps are both important. Flaps with adequate soft tissue are required to fill the extensive dead space

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for huge oromandibular defects. Such flaps, however, tend to sink and droop with time because of gravity, resulting in poor functional and aesthetic results. Here, the authors describe a procedure that avoids flap sinking and drooping, using a vascularized fibular osteocutaneous flap, which is well established for mandibular bone defects, and a rectus abdominalis musculocutaneous flap, which has a lot of soft tissue and a firm anterior rectus sheath. This method was used in 2 patients with extensive composite defects of the oromandibular area. In a patient with resection of the mobile tongue and oral floor, the anterior rectus sheath was fixed to the fibula and mandible to give a mylohyoid muscle-like structure, to prevent sinking of the reconstructed oral floor and tongue. Good swallowing function was maintained. In a patient with defects transversally from the submandibular region to the cheek, the sheath was fixed to the zygomatic arch to prevent cheek drooping. An acceptable aesthetic result was obtained.

Key Words: Appearance, double free flap, function, oromandibular defect, rectus abdominalis musculocutaneous flap, vascularized fibular osteocutaneous flap

Extensive composite defects of the oromandibular area that involve skin, mandible, oral mucosa, and soft tissues may be produced by surgical treatment and require complex reconstructive procedures. The double free flap procedure is one of the preferred methods for this type of defect.[1–4] In this procedure, both the flaps that are chosen and how the flaps are used are important. Flaps with adequate soft tissue are needed to fill the extensive dead space for huge oromandibular defects, but these kind of flaps also tend to sink and droop with time because of gravity, which gives poor functional and aesthetic results.[5] Thus, procedures are needed that avoid sinking or drooping of the flaps.

The use of a vascularized fibular osteocutaneous flap for a mandibular bone defect is well established,[6,7] whereas a rectus abdominalis musculocutaneous flap (RAM) is characterized by the presence of a lot of soft tissue and a firm aponeurosis (anterior rectus sheath).[5,8] Here, we report 2 patients, in which double free flap transfer of a vascularized free fibular flap and a RAM were used for treatment of extensive composite defects of the oromandibular area, with utilization of the firm anterior rectus sheath for prevention of drooping of the flaps.

PATIENT REPORTS

Patient 1

A 66-year-old man with squamous cell carcinoma of the oral floor underwent resection of the oral floor with all the mobile tongue, and bilaterally modified radical neck dissection with resection of the anterior mandibular continuity (Fig. 1A). The defect was reconstructed with a vascularized fibular flap and a RAM obtained with distal and proximal extension of the anterior rectus sheath. The mandibular continuity was reconstructed with the free fibular flap and 1 segmental osteotomy was performed to achieve the mandibular shape (Fig. 1B). The skin portion of the RAM was 18×10 cm, and the distal portion was de-epithelized and rolled to reconstruct the mental protuberance (Fig. 1C). The sheath was fixed anteriorly to fibular bone and posteriorly to mandible firmly (like a 'hung hammock') to form a mylohyoid muscle-like structure to prevent sinking of the flap with time (Fig. 1B-D). The sheath in the posterior area was prepared in a forked shape and sutured to the mandibular bilateral molar areas (Fig. 1D). The rectus abdominis muscle was reinnervated by anastomosis between the 10th intercostals nerve and the hypoglossal nerve to prevent fatty degeneration and muscle atrophy. Three years after the operation, swallowing function is preserved, the formed bulge of the oral floor is present, and there has been no sinking of the reconstructed oral floor. The continuity of the mandible formed by the vascularized fibular flap and mental protuberance with the rolled denuded skin region has resulted in a good aesthetic outcome (Fig. 2).

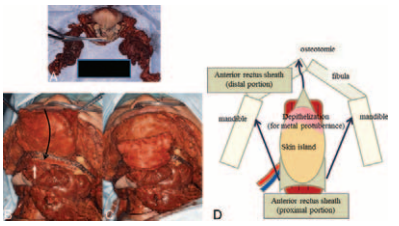

FIGURE 1. Patient 1: A, Excised specimen. The tumor of the oral floor was resected with the mobile tongue, bilaterally modified radical neck dissection, and resection of the anterior mandibular continuity. B, Vascularized free fibular flap and free rectus abdominalis musculocutaneous flap transfer. The rectus abdominalis musculocutaneous flap and vascularized fibular free flap were transferred to the mandible region. One segmental osteotomy was performed to achieve the mandibular shape (white arrow). The sheath was fixed anteriorly to fibular bone (black arrow) and posteriorly to the mandible firmly, like a 'hung hammock', to form a mylohyoid muscle-like structure. C, An 18×10 cm skin portion of the RAM was used. The distal portion was de-epithelized and rolled to make the mental protuberance. D, Schematic illustration of reconstruction (upper view). RAM, rectus abdominalis musculocutaneous.

Patient 2

A 53-year-old man with odontogenic carcinoma underwent tumor resection with total parotid gland resection and subtotal mandibulectomy, resulting in a through-and-through defect extending transversally from the submandibular region to the pterygomandibular space and infratemporal fossa (Fig. 3). A vascularized fibular osteocutaneous flap was used for reconstruction of the anterior mandible and left mandible body. The extensive through-and-through soft tissue defect was reconstructed with a RAM. The peroneal artery and vein were anastomosed to the left facial artery and vein. A deep epigastric inferior artery was anastomosed to the right superior thyroid artery, and a vein to the

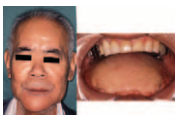

FIGURE 2. Patient 1: reconstructed oral floor, tongue and facial appearance at 3 years after the operation. The formed bulge of the oral floor was maintained without sinking. The continuity of the mandible formed by the vascularized fibular flap and mental protuberance with rolled denuded skin resulted in a good aesthetic result.

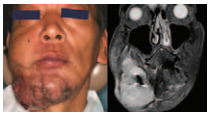

FIGURE 3. Patient 2: appearance of odontogenic carcinoma and T2WI MRI imaging. The tumor extended transversally from the submandibular region to the infratemporal fossa and pterygomandibular space. T2WI, T2-weighted image; MRI, magnetic resonance imaging.

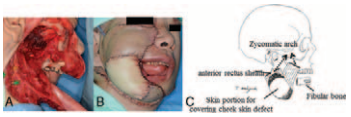

FIGURE 4. Patient 2: A, After tumor resection. A through-and-through defect was present that extended transversally from the submandibular region to the infratemporal fossa and pterygomandibular space. B, Immediate postoperative appearance. C, Schematic illustration of reconstruction. The distal and proximal extension of the anterior rectus sheath was fixed to the zygomatic arch (black dashed arrow) and hung like a hammock to prevent the RAM from drooping with time. RAM, rectus abdominalis musculocutaneous.

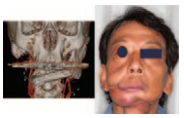

FIGURE 5. Patient 2: immediate postoperative three-dimensional-CT imaging and appearance 2 years after the operation. CT, computed tomography.

internal jugular vein. Two skin islands were used for coverage of the mucosa and skin defects. The muscle and fatty tissue of the RAM was used to fill the extensive dead space (Fig. 4A-B). The distal and proximal extension of the anterior rectus sheath were fixed to the zygomatic arch and hung like a hammock to prevent the RAM from drooping with time (Fig. 4C). Postoperative chemotherapy and 60 Gy radiotherapy were performed. Retouch surgery was performed for eyebrow drooping and ectropion of the lower eye lids because of facial nerve paralysis. Two years after the operation, the contour from the right cheek to the mandibular region has been maintained, despite slight soft tissue insufficiency of the left mandible (Fig. 5).

DISCUSSION

The choice of flaps and their manner of use are both important in double free flap transfer. A RAM is characterized by the presence of soft tissue and a firm anterior rectus sheath.[5,8] In patient 1 , the anterior rectus sheath of the RAM was fixed to the fibula and mandible to form a mylohyoid muscle-like structure to prevent sinking of the reconstructed oral floor and tongue, and good swallowing function was maintained. In patient 2, the distal and proximal extensions of the sheath were fixed to the zygomatic arch, and an acceptable aesthetic result was obtained.

After total resection of the mobile tongue or more extensive resection, the tongue and oral floor must be reconstructed with sufficient height and roundness to make the oropharyngeal space narrow enough to restore glossopalatal closing function and regenerate swallowing pressure[5,9,10]. The reconstructed oral floor and tongue cannot move and do not have sensation, and depression of the oral floor causes saliva and food residues to be trapped awkwardly. This makes smooth food transfer difficult, causing a time lag between glossopalatal closure and bolus transfer, as well as mistiming of swallowing as a whole, which results in mis-swallowing.[9] Thus, the bulge of the floor and tongue should be formed with a thick and bulky flap and need to be maintained for a long time.[5,9,10] In patient 1 in this report, the anterior rectus sheath was fixed to the bone to give a mylohyoid muscle-like structure and neural anastomosis, with the goal of preventing fatty degeneration and muscle atrophy. This maintained the bulge and prevented sinking of the reconstructed oral floor and tongue.

For a through-and-through defect extending transversally from the submandibular region to the infratemporal fossa and pterygomandibular space, as in patient 2, a flap with particularly extensive soft tissues is needed to fill the dead space. The more extensive the flap, the more it, however, tends to droop with time because of gravity. Consequently, the whole malar region is depressed and the aesthetic outcome is poor. We prevented depression of the bulky flap by fixing the distal and proximal extensions of the anterior rectus sheath to the zygomatic arch to hang the flap like a hammock. The procedure of muscular fixation to bone might be effective, but the muscle is softer and frailer than fascia and this may cause fatty degeneration and atrophy; thus, we believe that fixation of the anterior rectus sheath is likely to be more effective in the long term.

Use of a vascularized fibular osteocutaneous flap for segmental mandibulectomy is well established.[6,7] In reconstruction after resection of the mandibular continuity for an oral defect, a vascularized free fibular flap is the first choice at our institute unless vascularized bone reconstruction is not possible. A fibular flap is obtained as an osteocutaneous flap or osteomusculocutaneous flap to fill soft tissue defects. The soft tissue volume of these flaps, however, is too small for extensive mandibular defects. In such patients, the double free flap procedure with a RAM is effective.[1–4] A further advantage of using fibular flaps from the lower thigh in mandibular reconstruction with double free flaps is that resection of the tumor and elevation of the fibular flap and RAM can be performed simultaneously using a so-called 3-team approach.

In conclusion, we have reported 2 patients of reconstruction for extensive composite defects of the oromandibular area using a vascularized fibula osteocutaneous flap and a rectus abdominalis flap. The anterior rectus sheath of the RAM was fixed to the bone to prevent sinking of the reconstructed oral floor and tongue or malar ptosis because of gravity, and good functional and aesthetic results were obtained.

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