VOLUME 6 WINTER 2000 NUMBER 4

THE JOURNAL OF CRANIO-MAXILLOFACIAL TRAUMA

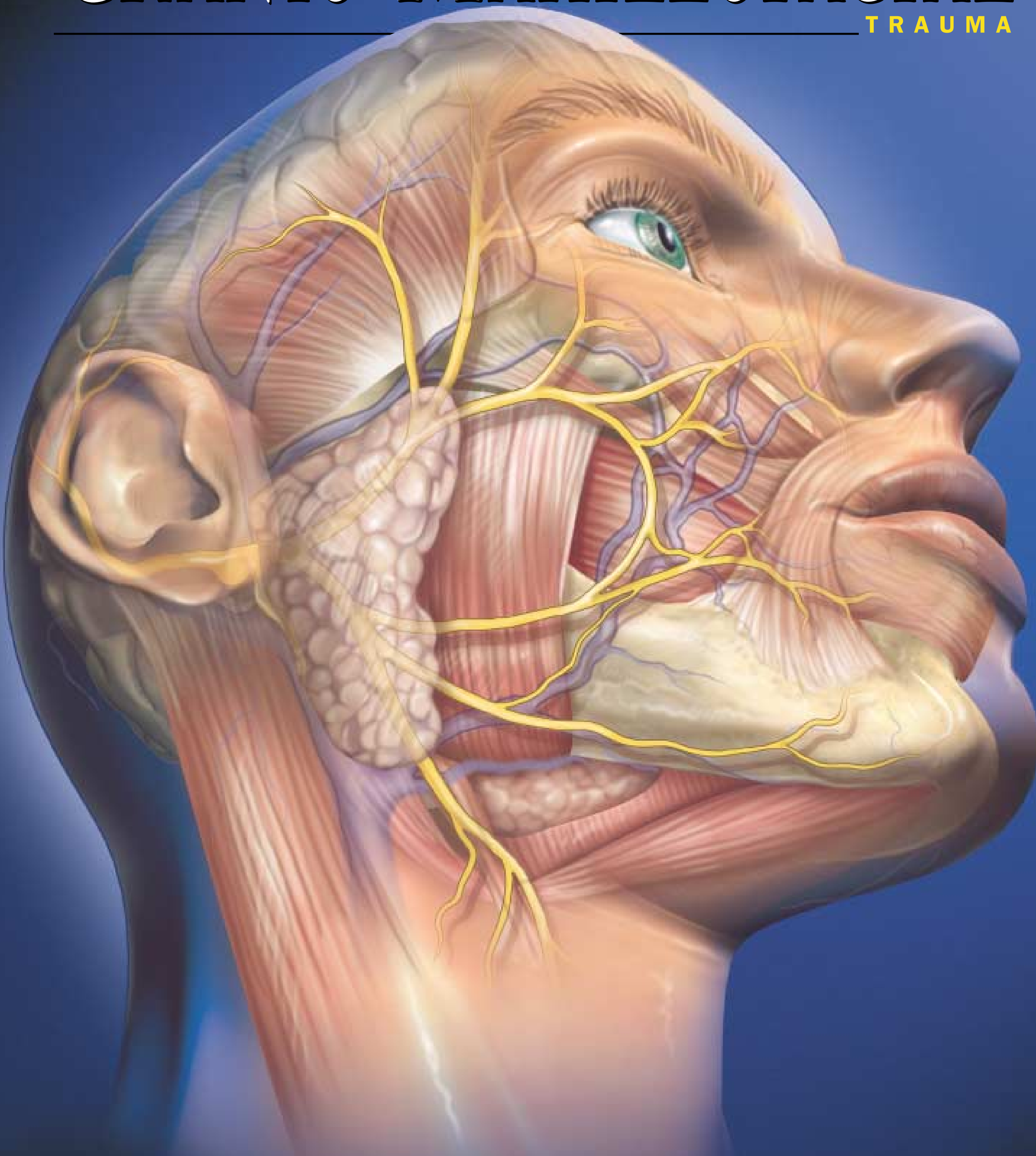

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TABLE OF CONTENTS

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Referral Patterns for the Treatment of Facial Trauma in Teaching Hospitals in the United States

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Abstract:

Background and Objectives. *The management of facial trauma is an integral part of the training of several specialties, including general plastic surgery, otolaryngology (ear/nose/throat — ENT), and oral and maxillofacial surgery (OMFS). Referral patterns of patients, however, vary at different institutions. The purpose of this article is to examine the referral patterns of facial trauma in the United States at teaching hospitals.*

Methods and Materials. *A questionnaire survey of physician-chiefs of emergency or trauma services at teaching hospitals was carried out. A variety of facial injury patterns were presented, and a hypothetical referral was requested. Additional questions of preferences and opinions regarding the various services were included.*

Results and/or Conclusions. *Most teaching hospitals had a formal protocol. With the exception of mandible fractures, referral patterns for patients with facial injuries were relatively even across the three specialties. Only 56% of respondents reported that they would seek referral for themselves or relatives in the same way as they would refer a patient. OMFS had statistically significant higher scores in timeliness, efficiency, and perceived competency in the handling of facial trauma than ENT and Plastic Surgery.*

Key Words: *Facial trauma, referral patterns.*

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The management of facial trauma is considered as an integral part of the training of several specialties, including general plastic surgery, otolaryngology (ear/nose/throat — ENT), and oral and maxillofacial surgery (OMFS). Referral patterns of patients who have suffered facial trauma to these various specialty services, however, vary at different institutions, according to physician preferences and protocols. Opinions also differ regarding the question as to which specialty is best suited for the management of facial trauma. Although specialty interests overlap in the treatment of maxillofacial injuries, previous studies have implied that general plastic surgical services handle a disproportionate number of facial traumas, that involvement is not equally distributed, and that the extent of care provided by some specialists may be at a higher level.[1,2] These studies — one of which consists of a review of a single institution's experience and the other of a survey of a single group of specialists — may be criticized for their bias and data accrual methods.[3,4] Other similar survey studies have been performed, but they have had either a limited focus or sites located only outside the United States.[5-8] We set out to examine the referral patterns of facial

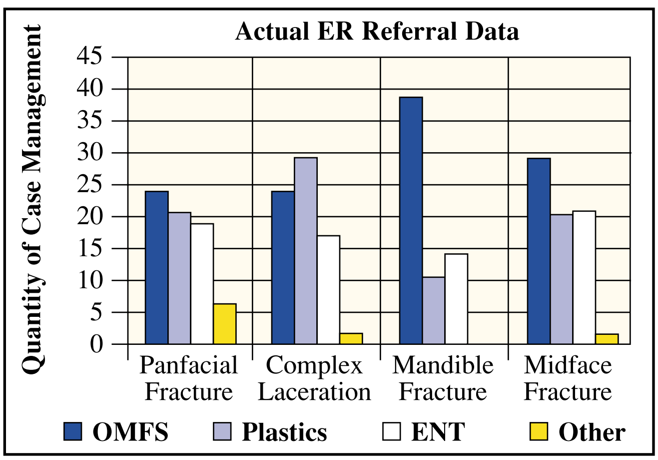

Figure 1. A bar graph of facial trauma referral trends (ie, indications of how the emergency room — ER — physicians typically refer facial trauma patients). Bar graph trend is displayed.

trauma in the United States at teaching hospitals in which all three specialties were represented. Additional information was gathered as to referral preferences and the perception among referral sources regarding the level of care provided by different specialties in the handling of facial trauma.

MATERIALS AND METHODS

One hundred questionnaires were faxed to physician-chiefs of emergency or trauma services at teaching hospitals in the United States.[9] Surveyed hospitals were limited to those in which oral and maxillofacial surgery, otolaryngology, and general plastic surgery were available for consultation. Teaching hospitals affiliated with the military services were excluded. The physician-chiefs of emergency or trauma services were chosen because of their familiarity with subspecialty involvement in trauma care at their institution. The respondents were blinded as to the specialty background of the investigators making the inquiries, and the questionnaire was designed to eliminate bias about specialty interest.[10]

The respondents were asked whether their hospital was a level I trauma center and whether there was a formal or informal protocol regarding the referral of facial trauma at their hospital. They were asked to triage and refer 4 hypothetical patients with various facial injuries representing different levels of complexity (panfacial injury, complex laceration, mandible fracture, and midface fracture). Inquiry was then made regarding the respondents' personal preference in case they themselves were to have sustained the facial injuries outlined in the 4 case scenarios. The respondents were also asked to rank their perception of the three services with regard to timeliness, efficiency, and competency in the handling of facial trauma.

RESULTS

A total of 46 responses were returned with complete data to the case-based scenarios and 35 with data regarding timeliness and perceived competency. Five responses had to be excluded, because it was not clear whether all three specialties were available for consultation, leaving 41 responses for analysis from the first portion and 35 from the second.

Protocol

With regard to protocol, 25 of the 41 (61%) respondents claimed that a protocol was in place at their institution for referral of patients with facial injuries. Of these, 21 (84%) stated that the protocol is formal and documented.

Referral Patterns Across the Three Specialties

The referral of patients with facial trauma, regardless of severity, was spread across all three specialties. Figure 1 demonstrates the actual referral pattern, with regard to which specialties typically manage panfacial injuries, complex lacerations, mandible fractures, and midface fractures. "Other" refers to either general surgery referral or transfer to another hospital. Interestingly, when asked to consider that the injured persons were either the referring doctors themselves or the doctors' relatives, there were differences when these responses were compared to the referral pattern for routine patients (Figure 2). Of the respondents, 44% would seek care for themselves or relatives in a different manner instead of conforming to the pattern in which the referrals were usually made at their institution. The trends between actual and preferred graphs appear similar, but the difference is apparent in the scatter analysis between the two sets of data. In other words, certain specialties were excluded by the referring emergency service physicians for the preferred referral categories.

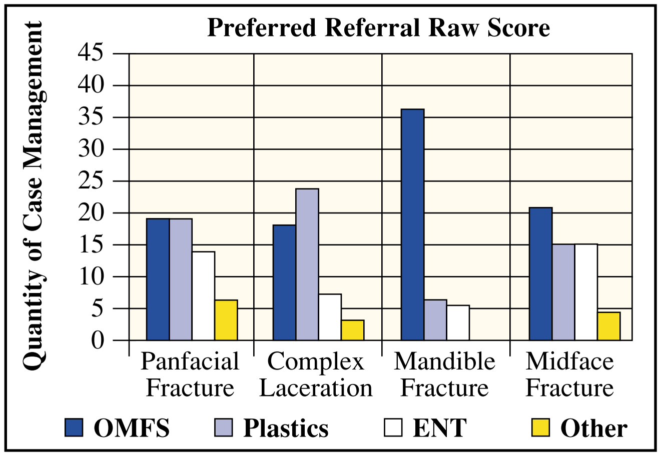

Figure 2. Facial trauma referral trends, as preferred by ER chiefs (physicians or their relative — the injured party). Bar graph trend is displayed.

The referral trends were relatively even for panfacial injuries, complex lacerations, and midface fractures among the three specialties. In order to determine whether an apparent preference for referrals was statistically sound, a chi-square test was performed (Table).

For patients with complex facial lacerations, a preference for plastic surgery is suggested. Statistically, however, the preference was not significant (p value = 0.02). A Bonferroni correction for this value reveals an overall p value of 0.15,

Table

Chi-Square Test Results, Showing the Statistical Significance of Mandibular Fracture Referral to the OMFS Service for Actual and Preferred Referrals.

Injury Type	Actual Referrals		Preferred Referrals	
	Chi-square	*P* value	Chi-square	*P* value
Panfacial	0.59	0.74	1.41	0.49
Complex	3.11	0.21	7.84	0.02
Mandible	**20.86**	**3.0E-05**	**37.24**	**82E-09**
Midface	2.09	0.35	1.41	0.49

E=exponent

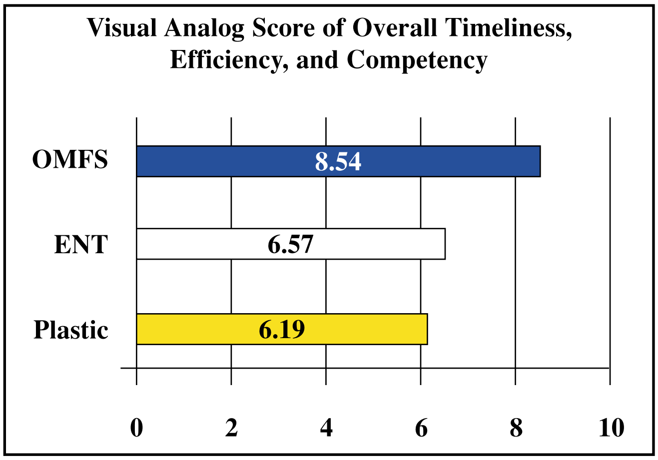

Figure 3. Bar graph trend of specialty rating for overall timeliness, efficiency, and competency is displayed. A rating from 1 through 10 was averaged; 1=poor, 10=excellent.

lending additional evidence that there is no marked preference for one specialty with regard to referring patients with complex soft tissue injuries. A similar trend was recognized for midface fractures and panfacial fractures in regard to increased referrals for OMFS. However, this was not a statistically valid observation.

Only the scenario involving an isolated mandibular fracture prompted a marked preference in the actual referrals ($p = .00003$) and the preferred referrals ($p = .0000000082$). Based on the chi-square test, the OMFS service outweighs ENT and general plastic surgery as the service requested by referral to handle mandible fractures.

Perceived Timeliness, Efficiency, and Competency

A visual analog scale (rating 1 through 10) was used to elicit information regarding perceived timeliness, efficiency, and competency in the care of facial injuries. A score of 1 is poor, 5 is average, and 10 is excellent. Altogether, 35 respondents completed these questions (Figure 3). The table includes the minimum, 1st quartile mean, median, 3rd quartile, maximum, total number, and standard deviation of the answers to the three parts of the question. The 1st quartile score for OMFS is 9, ie, higher than the 1st quartile score for ENT and plastic surgery. A disproportionate number of 10s were awarded to OMFS (and very few values less than 9), while the scores were more evenly distributed for ENT and general plastic surgery. This difference is statistically significant. A paired analysis between each of the scores was also performed. When comparing the paired differences for each of the three possible pairings against the null hypothesis that the mean difference is zero, ENT and plastic surgery were not distinguishable from one another. OMFS, however, had statistically higher scores than ENT and plastic surgery.

DISCUSSION

The data presented here confirm that the referral pattern of facial trauma to the surgical specialties varies among the teaching hospitals in the United States. The majority of the respondents reported having access to residents and staff in Plastic Surgery, Oral and Maxillofacial Surgery, and Otolaryngology. The majority of respondents stated that their hospital had a protocol or schedule for the referral of facial trauma; 39% did not have a protocol. In these cases, referrals were made based on traditional practice and physician preference. Of the hospitals with protocol, the majority was formal and documented.

The 4 case-based scenarios represent 4 patterns of facial injuries, and they were designed for simple categorization. It was felt that a straightforward clinical scenario would allow a more accurate characterization of what occurs in actual clinical circumstances. Certainly, we are aware that these 4 hypothetical case-based scenarios do not represent the numerous different patterns of facial injury that may occur in clinical practice. We believe, however, that by limiting the number of scenarios and, therefore, the length of the questionnaire, our response rate would improve. Although disappointed that all surveyed hospitals did not choose to respond, a response rate of 46% is consistent with other surveys of this nature. It is simply a reflection of the busy nature of the emergency departments and their coordinators.

Preferences in the referral of facial trauma were expected in our study. This bias is understandable and is based most likely on the experience of the referring physicians and their background in teamwork with various specialists. Certainly, a variety of factors influence choice of referral. With the exception of isolated mandible fractures, however, all three specialties appear to be involved in the treatment of all levels of facial injuries. Our data shows that the majority of physicians surveyed stated that they would refer an isolated mandible fracture to the oral and maxillofacial surgery service. A greater number stated a preference for treatment by oral and maxillofacial surgeons if they themselves or a relative were to sustain a mandible fracture. All other facial injuries — panfacial injuries, complex lacerations, and midface fractures — were referred in equal amounts to OMFS, ENT, and general Plastic Surgery. There was a trend towards referring complex soft tissue injuries to plastic surgery and midface fractures to OMFS; however, the trend was not statistically significant.

Overall, the data presented demonstrate that the management of facial trauma is distributed quite evenly among the specialties of oral and maxillofacial surgery, plastic surgery, and ENT. We found that oral and maxillofacial surgeons and otolaryngologists were actively involved in the repair of a variety of facial injuries — a finding that is quite different from the conclusions drawn by Sherick et al.[1] These authors suggested that, based on a retrospective review of treatment of pediatric facial fractures at one institution, plastic surgeons were more cost-effective and efficient in the repair of all categories of facial fractures, because the "competing" specialties (ENT and OMFS) were more limited in their scope of treatment. Our results seem to contradict these findings. A variety of reasons could explain this contradiction. The simplest explanation appears to be the fact that the experience of one institution with a particular population does not accurately reflect the referral patterns across the country.

This study highlights the need for objective criteria for assessment of quality of care for facial injuries. Our study did not allow assessment of long-term outcome, and it is possible that the views of physicians responsible for referring these patients are not consistent with the actual outcome. Indeed, surveys of referral practices simply illustrate what is happening from the standpoint of an emergency physician. Recommendations regarding quality of care and outcome can emanate only from properly conducted outcome analyses. These analyses are possible only after interdisciplinary barriers are removed and frank evaluations undertaken, without the fear of losing ground in the "turf war." An inference can be made from this study and the other limited literature on this subject that, within each specialty, there exists a subgroup of practitioners who share a sincere interest in maxillofacial trauma and who seek to advance their involvement with these cases. The management of these cases has long been considered neither particularly easy nor remunerative, and well-intended team approaches often fall victim to economic reality. A common academic ground should exist to allow motivated representatives of each of the three specialties to achieve the degree of cross-training necessary for a competent treatment of maxillofacial trauma.

CONCLUSION

This study confirms that the referral of facial trauma to various specialists in the United States varies at different teaching hospitals. All three specialties appear to be involved in the management of facial trauma, and it seems unlikely that any one specialty will be singled out as the sole provider of these services at all institutions. Consequently, a broad exposure of all trainees and dissemination of knowledge across specialty lines may ultimately lead to the highest level of care for the patient with facial trauma.

ACKNOWLEDGMENT

We wish to thank Dr. Louis Homer for his thorough and precise analysis of our data.

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Brett A. Ueeck, DMD ▪ Eric J. Dierks, DMD, MD

Discussion by Brian Alpert, DDS*

In the United States, craniomaxillofacial (CMF) trauma is managed more or less effectively by three different specialties — Plastic and Reconstructive Surgery, Oral and Maxillofacial Surgery, and Ear, Nose, and Throat Surgery. Although each one may identify with one or more areas of expertise within the field, this survey points out that in teaching hospitals none of the three training programs is exclusive — all apparently participate in the educational opportunities available.

However, there are numerous teaching institutions throughout the country where all three specialties are not well represented, and the management of traumatic facial injuries becomes exclusive. In these instances, the other healthcare specialties come to believe that the treatment of craniomaxillofacial trauma belongs to the only specialty that is performing the procedures in that particular institution. These erroneous perceptions are often carried out into practice. As a result, there are areas in the country where CMF trauma is the exclusive domain of one or perhaps two specialties. To further complicate the matter, referrals in some institutions are injury specific, ie, soft tissue injuries are referred to Plastic and Reconstructive Surgery, mandibular fractures to Oral and Maxillofacial Surgery, and frontal sinus injuries to Ear, Nose, and Throat Surgery.

All of us would like to believe that our specialty is better at managing these injuries than the "other guy" in the "other specialty," ie, the competition. However, exposure to individuals from other specialties at interdisciplinary forums and courses demonstrates that there are few, if any, discipline-specific areas of expertise. There are plastic and reconstructive surgeons and ear-nose-and-throat surgeons who are skilled in the management of mandibular fractures, as well as oral and maxillofacial surgeons who are proficient in NOE-frontal sinus injuries. Expertise is based on training and experience, not on board eligibility or certification in a particular specialty or preconceived or historical notions on who should be doing what. It is obvious from this survey that most of the responding teaching hospitals allow the three specialties access to training and experience in CMF trauma.

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Discussion by Steven R. Buchman, MD*

The stated purpose of the authors of this report was to "examine the referral patterns of facial trauma in the United States at teaching hospitals." They tried to accomplish their goal through the use of a questionnaire survey of physician-chiefs of emergency or trauma services at teaching hospitals. They attempted to infer the perception from these physicians as to their referral preferences for a hypothetical group of facial injuries.

Unfortunately, the laudable goals of such study are undermined by the faulty methods that were employed in this survey. As stated in their own discussion, the authors maintain that "analyses are possible only after interdisciplinary barriers are removed and frank evaluations undertaken." Indeed, only 21 of 46 (46%) of the respondents in this review had a formal and documented referral protocol for patients with facial injuries. Without such formal protocol, any individual bias based on any multitude of factors, such as staffing, personnel, professional and institutional relationships, as well as superficial stereotypical attitudes, would necessarily cloud the overall issues at play in this report. Utilizing such a faulty premise would expectantly produce any number of prescribed outcomes. In addition, bias as to the selection of programs included would also need to be reviewed. Including only those institutions that use a formal and documented referral protocol for patients with facial injuries would have significantly reduced such bias.

Furthermore, simply stating in the materials and methods section that "the questionnaire was designed to eliminate bias about specialty interest" does not make it so, and can no longer be considered as the scientific standard for the use of a questionnaire. This plainly cannot be judged without mention as to the validity of the instrument used. A valid questionnaire should be tested as to inter-rater and intra-rater reliability; only then can both the internal and external bias of the survey's design be judged impartial and balanced. Therefore, any statistical analysis derived from such a questionnaire is just as flawed as the unreliable data gleaned from the questions and the format.

In their attempt to better understand the differences in subspecialty care and referral patterns for facial injuries, the authors have attempted to analyze the perceptions of a group of referring physicians. Separating perception from reality, however, should be the goal of any scientific investigation in order to reduce bias and erroneous conclusions. Only the use of objective data can hope to get to the bottom of any scientific inquiry.

I can certainly understand the author's displeasure with the conclusions from one of our articles[1] analyzing the differences in subspecialty care of pediatric facial fractures at the University of Michigan; however, the conclusions were derived from objective data. The best way to further elucidate the subject would be to undergo a blinded prospective study looking at the pertinent questions or a similar retrospective study at a different institution to ensure that the conclusions are not based on some institutional bias.

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Tel: 743-763-8063, Fax: 743-936-7815.

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Complications of the Mandibular Fractures:
Principles and Management

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Bruce D. Fisher, DMD, MD†
David C. Stanton, DMD, MD‡

Abstract:

Background and Objectives. *Mandibular fracture complications occur due to several etiologic factors. Usually, these fractures are easily treated; however, at times they require advanced reconstructive efforts. Therefore, clinicians should be familiar with the various reconstructive methods and the use of resorbable materials to offer effective treatment to these patients. This article discusses the frequently seen complications of mandibular fractures and reviews treatment objectives and techniques.*

Method and Materials. *This article presents an illustrated case summary, describes the treatment of infection, as well as nonunion, and discusses the most frequent complications encountered. Reconstructive methods, including the use of a resorbable sheet to hold bone grafting material, are reviewed.*

Results and/or Conclusions. *Sophisticated reconstructive efforts may be required to restore the function and cosmetic appearance following a mandibular fracture. Infection, nonunion, and malunion are the most prevalent complications. They may require debridement, stabilization with rigid internal fixation, bone grafting, nerve grafting, and/or osteotomy. Materials such as polyglycolic and PLA mesh allow the surgeon to reinstate the form and contour.*

Key Words: *Mandibular fracture complications, infection, nonunion.*

Complications in the treatment of mandibular fractures are undesirable events, related to injury, patient noncompliance, or surgical intervention. They present unique challenges to even the most seasoned surgeons. The sequelae of these complications may be separated into two categories — functional disturbances and cosmetic deformity. The functional disturbances may include masticatory difficulty, airway compromise, speech difficulty, and sensory alteration, while the cosmetic deformities may include scarring, hemifacial hypoplasia, or facial convexity. Complication rates have improved since the early days of wire fixation, but even the most sound rigid fixation techniques may yield undesirable results. No other area of oral and maxillofacial surgery has been studied in more detail than the fracture of the

Figure 1. View of a fistula associated with a previous fracture and nonunion site.

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Figure 2. Panoramic tomogram of the fracture and nonunion site.

Figure 3. Intraoperative view of the nonunion site, debrided and irrigated prior to placement of the bone and nerve grafts.

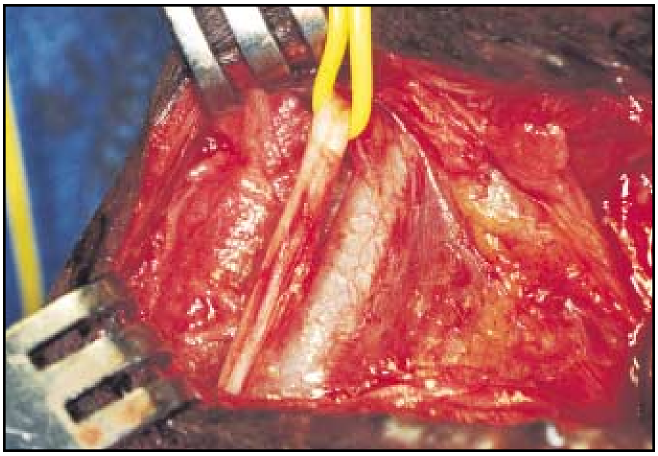

Figure 4. View of the great auricular nerve and its association with the external jugular vein.

Figure 5. Tibial bone graft site, marked for a limited incision.

mandible. Despite these efforts, little *prospective* evidence is available regarding the outcomes of the various treatment modalities. Retrospective studies offer some evidence that certain techniques have better long-term results than others, but more precise prospective studies are needed to further evaluate and compare these techniques of treatment. The purpose of this article is to present a case illustrating contemporary techniques of reconstruction utilizing new materials and to review the commonly seen complications of mandible fractures.

CASE REPORT

A 36-year-old male patient presented with the complaint of persistent facial drainage from the right lower jaw region (Figures 1 and 2). The patient disclosed a history of trauma that had taken place approximately 5 months prior to the presentation. Before the development of drainage from the right side of the face, the patient had not sought any treatment. Polysubstance abuse was a significant factor in the past medical history. The examination revealed a cutaneous fistula that was draining seropurulent material in the region overlying the right portion of the mandible. There was an obvious occlusal step-off with a right posterior open bite and absent sensitivity to light touch in the distribution of the right inferior alveolar nerve. Radiographic evaluation revealed a nonunion of the right mandibular body with findings suggestive of osteomyelitis. An additional nonunion of the left mandibular angle fracture was present.

The course of treatment included intravenous clindamycin, surgical debridement, pulsatile irrigation of the osteomyelitis, open reduction with internal fixation of the left mandibular angle fracture, and extraction of multiple nonrestorable teeth. The patient completed a 4-week course of antimicrobial therapy and returned to the operating room for reconstruction of the continuity defect and repair of the inferior alveolar nerve

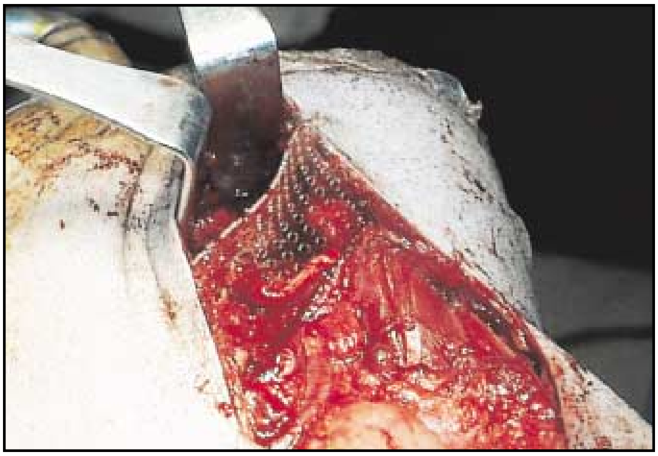

Figure 6. PLA mesh, conformed to the inferior and medial borders of the mandible prior to bone and nerve graft placement.

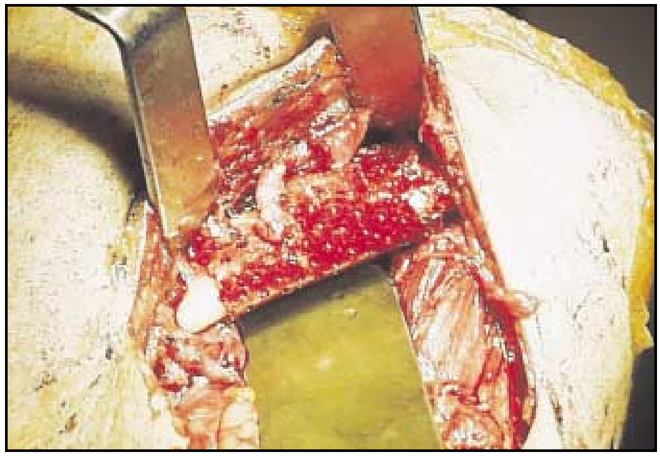

Figure 7. Conformation of the PLA mesh to the mandibular contour.

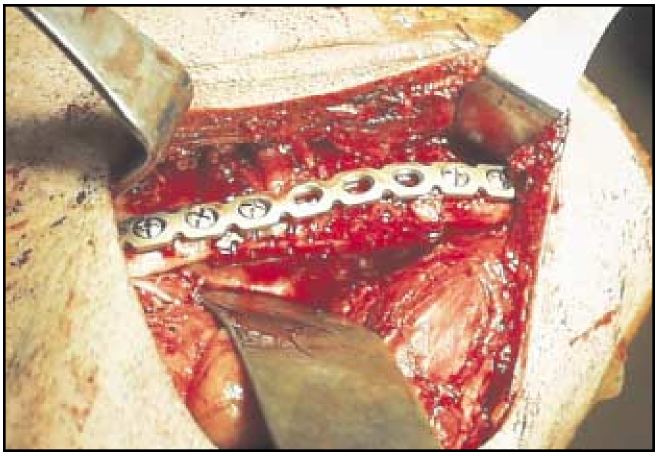

Figure 8. The final reconstruction, rigid internal fixation with PLA mesh, bone graft, and nerve graft in place.

Figure 9. Fistula formation, associated with osteomyelitis of the mandible and a pathologic fracture.

(Figure 3). The nerve was repaired using a free greater auricular nerve graft (Figure 4). The reconstruction was performed using cancellous bone, harvested from the tibia and placed into a resorbable 70:30 polylactate mesh "crib" that had been contoured to the inferior border of the mandible (Figures 5 and 6). The "crib" was secured to the inferior border of the mandible with multiple resorbable screws, bone graft was packed into the defect, and portals were made for passage of the inferior alveolar nerve (Figures 7 and 8). The "crib" was conformed to the lateral surface of the mandible and secured with additional resorbable screws. The plate was then fixed in the standard fashion, using a 2.4-mm mandibular reconstruction plate. The patient progressed well postoperatively and was discharged several days following surgery. There was no evidence of infection or wound breakdown. Sensory innervation in the distribution of the inferior alveolar nerve is returning slowly. Five months postsurgery, there are no other complications, the bone graft is incorporated, and the fracture site shows no signs of mobility.

DISCUSSION

Infection

Infection is the most common complication of surgical intervention, and its course was altered forever when Lister introduced the concept of asepsis prior to and during an operation. His concept of decreasing microbial numbers, allowing the host to overcome the virulence of the bacteria, dramatically improved complication rates. The current postoperative infection rates vary from less than 1% to 32% in a patient who undergoes repair of a mandible fracture.[1-5] These percentages are increased in substance abusers and noncompliant patients.[6] A significant delay in treatment has also been associated with an increase in infection rates.[7] Other notable factors include gross contamination of the site, poor host healing potential,

Figure 10. Computerized tomography (CT) scan of a nonunion site of an untreated mandibular fracture.

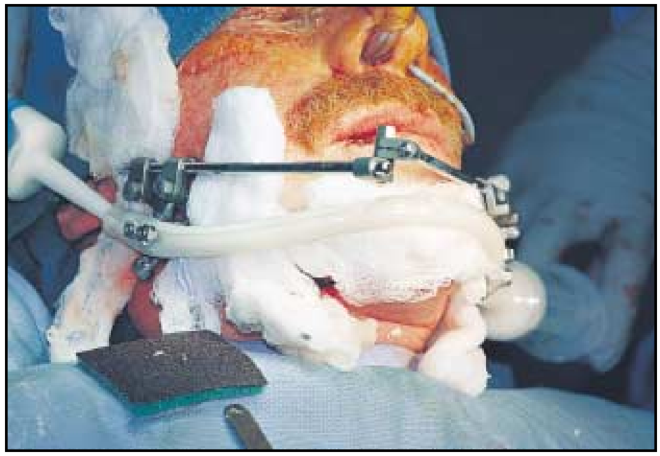

Figure 11. External fixation device, fabricated for the patient seen in figure 9.

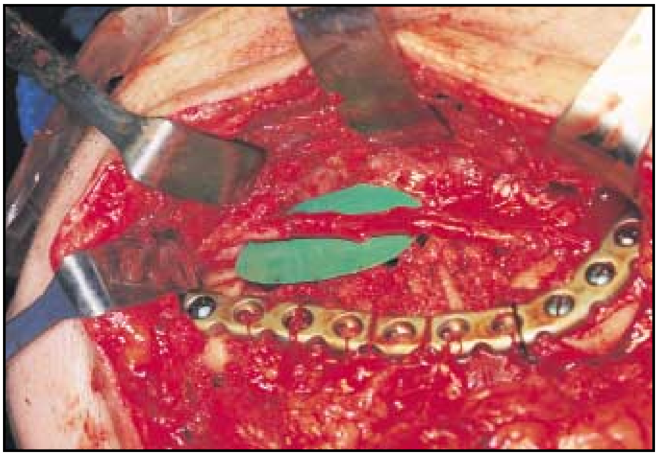

Figure 12. Reconstruction plate, corticocancellous bone graft, polyglycolic mesh, and greater auricular nerve graft utilized for the reconstruction of a mandibular nonunion.

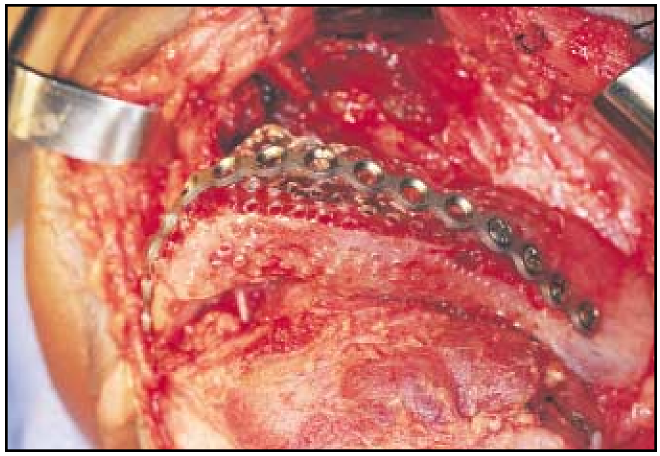

Figure 13. Reconstruction plate and PLA mesh, used for reconstruction of a pediatric continuity defect.

dentoalveolar disease, teeth present in the line of fracture, and atrophic architecture present in partially or totally edentulous mandibles. Of the facial bones, the mandible is the most frequently infected region following surgical intervention for traumatic injury. This vulnerability is thought to be due to instability of the segment from various muscular actions on the proximal and distal segments.

The manifestations of infected tissue include cellulitis, abscess, fistula, osteomyelitis, and necrotizing fasciitis (Figure 9); occurrence of the latter is rare. The diagnosis can be made using plain film, panoramic tomogram, and/or computerized tomography (CT) (Figure 10). Complete blood counts and cultures with sensitivity results are helpful in directing and evaluating therapies.

Since most infections of the oral cavity and the surrounding craniomaxillofacial region are polymicrobial, broad-spectrum antibiotics are utilized until adequate culture and sensitivity studies indicate a more specific therapy. Directed therapy is often more effective than the broadest antibiotic coverage. Reliable culture techniques are difficult to obtain from the contaminated environment of the oral cavity, but attempts should be made to ensure standardized culturing methods. Patients with prolonged stays in the intensive care unit setting often require special attention when selecting antibiotic therapy. Bacteria found in intensive care units are often multidrug resistant. If these microbes become the primary bacteria in an infection associated with rigid fixation or nonhealing fracture, they can be problematic. Culture-directed bacteriocidal therapy is often necessary to eradicate these types of infections, and the procedure may require the use of long-term intravenous antimicrobials.

The causative factors of the infection must be ultimately removed. Necrotic bone, dentoalveolar disease, foreign bodies, or fracture mobility must be eradicated to ensure success

Figure 14. Wire fixation, used unsuccessfully to reduce a mandibular angle fracture.

Figure 15. A tooth in the line of fracture, causing difficulty in anatomic reduction of the fracture segment, was removed prior to reduction.

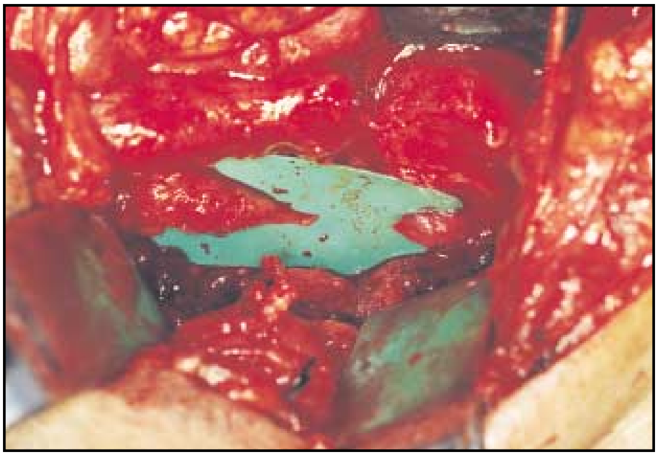

Figure 16. A scarred inferior alveolar nerve with a continuity defect. (Courtesy of Joseph Foote, DMD, MD.)

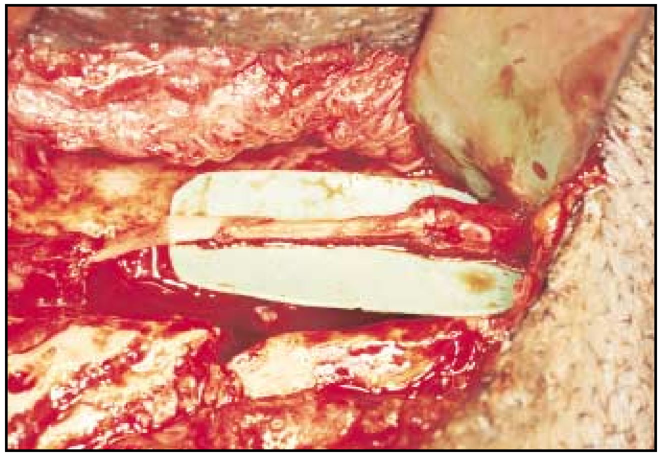

Figure 17. A reconstructed nerve segment with a free greater auricular nerve graft from the ipsilateral side. (Courtesy of Joseph Foote, DMD, MD.)

of the overall treatment. Incision and drainage are necessary when a collection of purulent material is present, and pulsatile irrigation is an effective method of decreasing bacterial concentration within the wound. Patients with nonunion fractures require debridement and definitive stabilization, using one of several methods available, ie, maxillomandibular fixation, open reduction with internal fixation, external fixation, and others (Figures 11 through 13).

The type of fixation has been shown to be a factor in the incidence of complications associated with mandibular fractures. When treated with closed methods, a fracture that does not perforate through mucosal tissue is considered a closed fracture. These fractures have little incidence of infection or nonunion. However, the incidence of malunion is higher because adequate reduction is not always achieved. This is especially true of condylar and subcondylar fractures in children. Passeri et al found that the incidence of infection in mandibular fractures, treated by closed reduction, was approximately 14%.[8] Numerous infections treated with closed reduction are associated with teeth within the line of fracture and teeth compromised by caries and/or periodontal disease.

Luhr examined mandibular fractures treated with closed reduction, dynamic compression plating, and wire fixation. He found a similar incidence of infection associated with closed reduction and open reduction with dynamic compression plating, but an increased incidence of infection when wire fixation was utilized.[9] This was hypothesized to be due to the mobility of the segments associated with wire fixation (Figure 14). Ellis and Sinn examined multiple types of fixation methods used to treat mandible fractures and observed a high rate of infection in patients who received two dynamic-compression plates.[4] Wire fixation was associated with an infection rate approaching 25%.[8] Champy originally reported an incidence of only 3.8% associated with his technique of using a 2.0-mm tension band plate, placed with an intraoral approach.[10] Based upon this data, the old dictums that suggest the use of large plates with maximum rigidity and stability may not necessarily be the best treatment for all clinical circumstances of mandibular fractures. Prospective trials comparing multiple modalities are required for adequate evaluation of these techniques.

When osteomyelitis compromises the bony healing of a mandibular fracture, it warrants special attention. Osteomyelitis is an inflammatory reaction in bone with evidence of sclerosis, altered blood supply, and dense scarring, inhibiting the local tissues from mounting an adequate healing response. Clinically, it is difficult to establish the difference between osteomyelitis and simple nonunion healing. Laboratory values, such as a complete blood count, erythrocyte sedimentation rate, and/or C-reactive protein levels, may be helpful in differentiating true osteomyelitis from simple infection and in following the effectiveness of therapy. Plain radiographs, CT scans, and magnetic resonance imaging (MRI) have been used to examine the site of infection and delineate the affected region of the mandible. Radionucleotide scans have been helpful, but they lack the specificity and advantage of visibility obtained by MRI. The treatment of osteomyelitis includes surgical debridement and pulsatile irrigation of the site after adequate cultures have been obtained. Following adequate debridement and sequestrectomy, the area should be immobilized and allowed to heal for several weeks prior to definitive attempts at reconstruction with bone grafts or other methods.

Nonunion and Nerve Injury

The mandible is associated with a relatively high incidence of malunion and nonunion fracture healing. Mathog reported an incidence of 2.4 % in 577 patients.[11] With recent advances in biomaterials we may be better able to avoid complications and correct these problems when they arise. Several specific risk factors are associated with mandibular fractures and their potential for nonunion or malunion. Infection is the major contributing risk factor; other considerations include inaccurate apposition of fracture segments, poor immobilization of segments, the presence of foreign bodies, muscle pull on the fracture segments, displacement of comminuted fracture segments (and the difficulty associated with adequately reducing them), aseptic necrosis of bony fragments, soft tissue interposition, malnutrition, and debilitation.

Inadequate apposition of fracture segments may result from a delay in (or an absence of) treatment, inadequate treatment, inability to align segments secondary to the presence of a foreign body, or loss of bone leading to a continuity defect. Redefining occlusal relationships is important in ensuring appropriate fracture segment reduction. Clinicians treating mandibular fractures should be familiar with dental anatomy and occlusion in order to balance the functional forces appropriately. Preoperative study models (with or without model surgery) and splint fabrication may aid in fracture reduction.

With the use of internal rigid fixation, the risk for poor immobilization of fracture segments should decrease. However, the use of internal rigid fixation is associated with its own set of complications. These include infection, nerve injury, dental injury, and foreign body reaction. These complications can be minimized with careful surgical technique and increased operator experience. The appropriate use of rigid internal fixation, applied in accordance with the standardized principles, decreases reliance on patient compliance and reduces or obviates the need for maxillomandibular fixation. Internal rigid fixation may be the treatment method of choice when coincidental medical illness renders maxillomandibular fixation unsafe or intolerable.

The application of the rigid fixation plates relies on proper technique of placement and anatomic positioning. The basic principles of rigid fixation include passive adaptation of the plate to the properly reduced fracture segments, appropriate positioning of screws in relation to adjacent anatomic structures, placement of screws in accordance with the principles of dynamic compression (where appropriate), placement of a tension band where necessary, and the use of plates and screws of adequate strength and durability. Recent data have questioned the original concepts of rigid fixation — specifically, the question of whether the larger dynamic compression plates are superior to smaller plates, placed with a limited dissection. Some of these data show a decreased incidence of infection in patients who underwent more limited dissection and had a less rigid plate placement.[12,13] An inadequate amount of prospective data exists at this time to comment on which technique is best suited for each area of the mandible.

In the treatment of mandibular fractures, the presence of teeth affords potential advantages and challenges. Teeth may present as obstacles to proper reduction; they may be a nidus for infection and may prevent ideal placement of rigid fixation (Figure 15). However, the ability to use the dentition and occlusion as a guide for fracture reduction offers a means of repair without open reduction that may be performed even under local anesthesia. Determination of fracture stability and segment displacement relates not only to the location of the fracture and the occlusion, but also to the various muscle attachments of the mandible. It is for this reason that fractures of the mandibular angle are especially prone to displacement secondary to muscle pull.

Comminuted fractures always merit special consideration, and the complication rate associated with comminuted fractures is higher in all types of fractures. Several reasons have been suggested: The increased force necessary to create this type of injury carries with it a higher degree of surrounding tissue injury; there is increased difficulty with reduction and stabilization of the fragments; and comminution places the patient at higher risk of ischemic compromise and avascular necrosis of fragments. Ischemic compromise is a relatively uncommon complication in the head and neck region of a healthy individual; however, certain fracture patterns do carry an increased risk for avascular necrosis. Comminution is one of these; the others relate to anatomic site of fracture. Fractures of the mandibular condyle and subcondylar region place a patient at increased risk for vascular compromise to the proximal fracture segment. The possibility of fragment necrosis and sequestration may result in nonunion healing or continuity defects.

Malnutrition and debilitation are additional risk factors for development of complications of mandibular fractures, especially in nonunion healing. Fractures in children and growing adolescents have their own associated potential sequela, including growth disturbances. Condylar and subcondylar fractures in young children often have poor outcomes, eg, ankylosis of the temporomandibular junction (TMJ). Fractures of the edentulous mandible also deserve special considerations, since there is clearly a relationship between mandibular atrophy and healing and the complications observed in mandibular fractures.

Treatment strategies may vary from patient to patient and the individual experience with different reconstructive techniques of any given surgeon. A team approach to the reconstruction may be helpful to benefit from the expertise of different clinicians, as some of these procedures can be technique sensitive. Options to consider for reconstruction of the mandibular nonunion site include:

- Maxillomandibular fixation.
- Rigid internal fixation with a large reconstruction plate.
- External fixation.
- Particulate bone grafting or cortical bone grafting to the defect.
- Polyglycolic or 70:30 polylactate mesh as a carrier for cancellous bone graft.
- Nerve grafting.
- Composite free-flap reconstruction.

As illustrated in the case report presented, we have utilized rigid fixation with a reconstruction plate and 70:30 polylactate (PLA) mesh as a carrier for bone grafting material. The working characteristics of this material make it ideal for use as a bone graft carrier, and it can be secured with resorbable screws. Using a heated water bath, heating element, or sponge with heated saline, the material is easily adapted to the exact contours of the mandible. Its pore diameter and configuration allows vascular ingrowth and prevents soft tissue ingrowth that may be associated with bone resorption and fibrous ingrowth into the graft. Since most nonunion sites of mandible fractures are accompanied by nerve scarring and/or obliteration, we also advocate nerve reconstruction, when possible, utilizing the greater auricular nerve from the ipsilateral side (Figures 16 and 17). It can be readily obtained from the same approach that is used to access the mandibular nonunion site.

CONCLUSION

Complications of mandibular fractures do occur and are associated with several specific risk factors. The treatment of these complications may require sophisticated reconstructive efforts to restore the function and cosmetic appearance. Infection is the most common complication and is easily treated with antibiotics that cover the polymicrobial milieu of the oral cavity. Nonunion healing of mandibular fractures often requires debridement, stabilization with rigid internal fixation, bone grafting, and nerve grafting. New materials, such as polyglycolic and PLA mesh, may assist the surgeon when incorporating bone graft materials in a defect. These materials allow to impart form and contour that facilitate further reconstructive efforts, such as osseointegrated implants or prosthetics.

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Correlation of Computerized Tomography and Flat Film Radiographic Findings With Clinical Examination in Patients Sustaining Periorbital Trauma

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Abstract:

Background and Objectives. *When patients arrive at an emergency center with periorbital trauma, flat film radiographs are taken routinely — they are less costly than computerized tomography (CT) scans. When flat film radiographs are combined with preoperative CT scans, a complete representation is obtained preoperatively, enabling the selection of optimal treatment. A retrospective review of the data in patient charts was performed in a large city hospital center in order to evaluate the results.*

Methods and Materials. *Charts of 164 patients who received trauma-related CT scans were evaluated, using the following procedures: ophthalmologic evaluation, examination of hard and soft tissues, examination of the cranial nerves, and neurologic examination.*

Results and/or Conclusions. *In the group in whom flat film had recorded negative findings, 21 of 32 patients had positive CT findings. Orbital fractures were the most commonly involved. The lamina papyracea and orbital floor fractures received the most benefit from the use of CT scans, followed by lateral sinuses and nasoethmoidal fractures. The authors concluded that patients with periorbital trauma benefit from preoperative CT scans.*

Key Words: *Periorbital trauma, computerized tomography.*

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Patients presenting to the emergency room with periorbital injuries undergo the initial plain film radiographs routinely. These patients may be divided into two groups. Patients in the first group are usually victims of trauma in which a low-velocity blow has been delivered to an area of the face. These patients often present with local soft tissue hematomas or abrasions, which draw attention to the injury. In these patients, a plain film radiograph of the face has been useful in establishing the presence of a bone injury. The second group comprises patients who have sustained substantial injuries due to a high-velocity force to one or more areas of the body. These patients frequently require emergency stabilization of the respiratory or the cardiovascular system prior to diagnostic imaging. Often the patients are in a coma or have multiple system injuries that render them unable to cooperate in the conventional radiographic examination. A reconstructed axial computerized tomography (CT) scan may be performed to obtain sagittal images of this group of patients. In the overall management of the trauma patient, plain film radiographs are substantially less costly than CT scans. However, the ability of a CT scan to diagnose the true extent of these injuries through preoperative imaging is of the utmost importance in

Table 1

Clinical Findings in Patients With Periorbital Injuries n=164

Injury	Number of Patients	Percentage
Periorbital edema/ecchymosis	149	90.8
Subconjunctival ecchymosis	79	48.2
Infraorbital paresthesia	21	12.8
Others	5	<3.0

understanding the incidence and treatment of acute and delayed sequelae to orbital trauma.

By having a complete representation of the fractures, obtained through CT, many of the preoperative decisions in terms of surgical access, fracture stabilization, type of bone, or the requirement of alloplastic grafting may be made prior to the surgery. The information gained aids consistently in arriving at more predictable results from the operative procedures. When orbital injuries are suspected, CT scans are beneficial in establishing the specifics of the injury. By combining the axial and coronal CT scans of the orbits, the full extent of the involvement may be readily assessed for the management of surgical repair.

METHODS AND MATERIALS

Data were collected from the charts for a retrospective evaluation of 164 patients who received trauma-related CT scans of the periorbital region at the emergency room at the Bellevue Hospital Center in New York City, NY, between September 1992 and July 1994. The results of the initial emergency room physical examinations of these patients were evaluated, using the following procedures:

Ophthalmologic Evaluation

Injuries were evaluated for positive or negative findings in the dysfunction of the extraocular muscles, diplopia, dystopia, enopthalmia, proptosis, subconjunctival ecchymosis, chemosis, direct and indirect light reflexes, visual acuity, and fundoscopic examination.

Neurologic and Cranial Nerve Examination

The patients were evaluated for positive or negative findings of trismus and/or paresthesia.

Hard and Soft Tissue Examination

The patients were evaluated for integrity of zygomaticofrontal suture and the superior, lateral, inferior, and medial orbital rims. Flat film examinations in this institution consist of obtaining views from the orbital, lateral skull, anterior/posterior skull, water's submental vertex, and the nasal bone. The CT scan examinations consist of 3.0-mm axial and coronal slices through the facial/orbital region. The CT and the facial bone flat films were evaluated and compared for positive and negative findings in the following categories:

- Lacrimal bone
- Superior, lateral, inferior, and medial orbital rims
- The eye
- Zygomatic arch
- Soft tissue swellings
- Sinus walls
- Lamina papyracea
- Orbital roof
- Zygomaticofrontal suture
- Orbital apex
- Nasoethmoidal complex

RESULTS

The requirements for the review were fulfilled by the charts of 164 patients, and they were included in the review. Of these, 149 (90.8%) patients presented with periorbital edema and/or ecchymosis (POE/E); of these, 79 (48.2%) patients also had subconjunctival ecchymosis. There were 21 (12.8%) patients with infraorbital paraesthesia, while the remaining 5 (<3.0%) patients presented with superficial lacerations and other minor injuries (Table 1). The distribution of patients in each category is presented in Table 2. Among patients who presented with POE/E alone, 21 of 53 (39.7%) had positive facial flat film findings, while the findings of 32 (60.3%) patients were negative; 49 of 61 (80.3%) patients had positive CT findings; 88 of 103 (85.4%) had maxillofacial skeletal injuries (MOS) had positive CT findings.

Overall, in the group of patients in whom flat film had recorded negative findings, 21 of 32 (65.6%) had positive CT findings. The observed frequency of CT scans and flat film findings with periorbital edema/ecchymosis are listed in Table 1. Orbital floor fractures were the most common. It was observed that the majority of lamina papyracea and orbital floor fractures benefited considerably from the utilization of the CT scans (Table 2). These were followed closely by the injuries to the lateral sinuses and nasoethmoidal fractures, respectively.

DISCUSSION

Computerized tomography is the best definitive means of facial trauma imaging currently available. Axial facial views can be obtained when the patient is able to lie quietly on the table within the CT gantry. Coronal CT views may be of vital use

Table 2

Radiographic Findings in Patients With Periorbital Injuries n=164

	Positive Findings (%)	Negative Findings (%)
FF (n=164)	39.6	60.4
FF (POE/E; n=164)	39.7	60.3
CT (n=164)	80.3	19.7
CT (MOS; n=103)	85.4	14.6
When FF(–), CT(+) (n=164)	65.6	34.4

(POE/E) = Periorbital edema/ecchymosis
(FF) = Flat film
(CT) = CT scan
(MOS) = Maxillofacial skeletal injury

in appraising facial injuries. Generally, CT views are best in portraying the structures that lie perpendicular to the axis of scanning. Therefore, when studied in axial CT views, the lateral and medial orbits and maxillary walls are well defined, as are the zygomatic arches. Direct coronal CT views allow excellent visual evaluation of the orbital roof, floor, palate, and the maxillary alveolar process. These views are obtainable only when the patient is able to assume a position with the neck in hyperextension, allowing the CT scanning plane to remain relatively coronal. The patient may be placed either in prone or supine position on the table top to obtain coronal views, and the neck must be stable when positioning the patient for a coronal study.[1,2]

Various authors have advocated only conventional radiographic examinations for these types of fractures.[3,4] It needs to be understood that the complexity of the facial bones and the various degrees of opacities and radiolucencies, complicated by the superimposition of adjacent bones and structures, limit flat film radiography in the interpretation of trauma of the periorbital region.[5,6] The resultant pictures obtained on flat film radiographs may sometimes be confused with superimposed images in the trauma patients.

The one important finding of this review is that the CT scans proved to be exceptionally useful in these clinical circumstances. CT scanning is obviously a more accurate radiographic medium with a high degree of definition and resolution. Of the 164 patients reviewed, 65.6% were diagnosed as having fractures where the flat films had been negative. This finding may be a significant factor in treatment planning for the trauma patient.

The finding is in agreement with previous observations made by Hermans et al in 1997.[1] These authors attributed the inaccuracies in flat film radiographs to the anatomic uniqueness of the maxillofacial skeleton. The surrounding maxillary and paranasal sinuses are important landmarks, reinforcing the credibility of this uniqueness. CT radiographs were able to reveal what was difficult or impossible to see on the flat films. The order of decreasing sensitivity versus benefit and effectiveness of CT scans in periorbital fractures were as follows: orbital fractures > lamina papyracea > zygomatic arch fractures > nasoethmoidal fractures.

This finding is in agreement with studies performed in 1993 by Iinuma et al, who found that CT was more sensitive in the use of orbital floor fractures than zygomatic fractures.[7] Trauma of the periorbital region could result in injuries leading to depression of the cheekbone with loss of projection, subconjunctival ecchymosis, and periorbital step deformities. The following symptoms may be present as well: lack of symmetry; absence of full range of motion of the extraocular muscles, especially on upward gaze; enophthalmos; ptosis; neurosensory deficits, such as paraesthesia or anesthesia of the affected side; posterior displacement of the zygomatic complex and lateral orbital wall; orbitoethmoidal fractures with blockade in the nasal cavity; and cerebrospinal fluid rhinorrhea. Usually, the thick orbital rim absorbs insult to the periorbital region. This leads to a resultant posterior displacement of the globe, thereby increasing the intraocular pressure. This increase results in the fracture of the lamina papyracea and the roof of the maxillary antrum. Herniation of the orbital contents into the adjacent tissue occurs next. Due to the entrapment of the extraocular muscles, ocular mobility is impaired, and diplopia soon follows. Paraesthesia of the infraorbital nerve with enophthalmos is not uncommon in these circumstances.

While clinical examination may be sufficient for provisional diagnoses in some of these cases, associated edema in acute cases makes the interpretation of fractures difficult when conventional radiography is used. Diagnosis can always be confirmed by a CT scan, which has the advantage of showing both — bony displacement and structural changes, demonstrated in the same plane. Furthermore, ocular muscle entrapment, requiring surgery for the release of muscular herniations, becomes evident immediately.[8,9]

CONCLUSION

It appears that unless periorbital trauma causes cerebrospinal fluid rhinorrhea and diplopia with enophthalmos, periorbital injuries may receive less priority in the initial trauma management. Neglected periorbital injuries due to poor radiographic assessment may result in significant deformities, disabilities, and sometimes fatalities.[10] Early identification of clinically occult facial fractures and periorbital tissue edema using CT scan will help in early management and, therefore, potentially improve the outcome.[11] It is the opinion of the authors that patients with periorbital injuries should have a CT scan to elucidate the complex injuries. The ability to demonstrate the relationship between soft tissues, nonopaque foreign bodies, paranasal sinuses, and bones makes CT scanning even more advisable over conventional radiography.

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CASE REPORT:

Facial Fractures as a Result of Dog Bite:
A Case Report

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Abstract:

Background and Objectives. *Dog bites in the face are common injuries in children; usually, they result only in soft tissue injury. Occasionally, injuries to the facial skeleton that result in fractures have been reported. The authors report a case — which they believe is unique, with soft tissue injuries and fractures of the facial skeleton at two sites — and discuss the management of this and related cases.*

Methods and Materials. *The injuries involved deep lacerations of soft tissue, the facial skeleton, and destruction of the inferior canaliculus of the nasolacrimal duct. Intraoperative radiographs and computerized tomography (CT) scans disclosed fractures in the right infraorbital region. The facial wounds were debrided and sutured, and antibiotics and blood transfusion were administered. Open reduction and fixation with resorbable miniplates and screws were performed 5 days subsequently. Medial canthopexy was used. The malar fracture was treated conservatively; the nasolacrimal duct was beyond reconstruction.*

Results and/or Conclusions. *Nine months postoperatively, there were no complications. The scars were settling, and the patient was maintained under a long-term review.*

Key Words: *Facial fractures, dog bite, and resorbable miniplates and screws.*

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CASE REPORT

A 1-year-old child was referred on an emergency basis after having been bitten 4 hours earlier by the family's pet rottweiler in the face and both orbits, sustaining deep lacerations (Figures 1 and 2). The child was transferred from home to the authors' clinic (a distance of 140 miles), and the wounds were debrided, irrigated, and explored under general anesthesia 6 hours following the injury. It became evident during the exploration that the injuries were more extensive, involving not only destruction of the inferior canaliculus of the nasolacrimal duct but the facial skeleton as well.

Intraoperative facial radiographs confirmed that fractures were present in the right infraorbital region. The frontal process of the left malar was indistinct, suggesting the possibility of

Figure 1. Preoperative right lateral view of a 1-year-old child who sustained dog bite injuries to the midface around the infraorbital and nasal region of the right orbit.

Figure 2. Preoperative left lateral view of the injuries sustained around the lateral aspect of the left orbit.

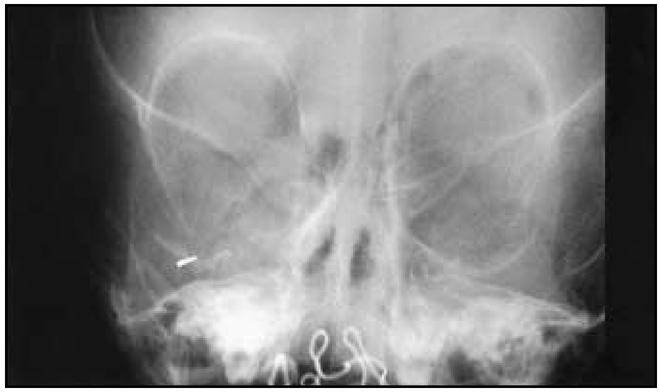

Figure 3. The radiograph reveals a displaced fracture of the right infraorbital region (arrowed) and the absence of a clear outline of the left lateral orbital wall.

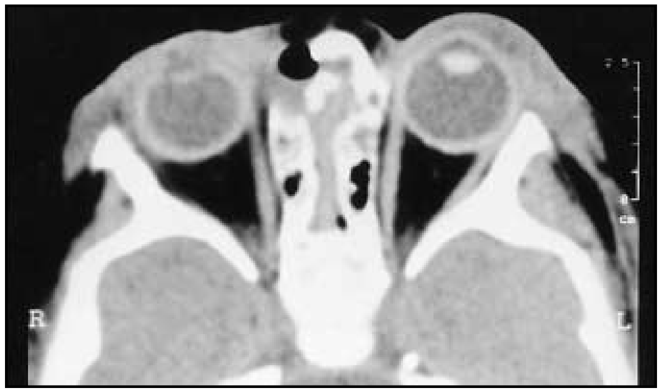

Figure 4. The CT scan demonstrates the full extent of the displacement of the right medial orbital fractures in the transverse plane.

another fracture (Figure 3). Therefore, prior to undertaking the definitive management, further clarification of the extent of the fractures was thought to be appropriate. The facial wounds were cleaned, debrided, disinfected, and sutured. Antibiotic treatment was commenced, while a simultaneous blood transfusion was performed.

A computerized tomography (CT) scan was performed on the following day to ascertain the exact nature and extent of the fractures. The scan revealed the presence of displaced fractures of the right nasoethmoidal complex (Figures 4 and 5) and a minimally displaced fracture of the left malar bone.

The facial swelling was allowed to subside for 5 days, at which time a second procedure was undertaken. The right infraorbital wounds were reopened to allow access. The examination revealed no evidence of infection. The displaced fractures of the nasoethmoidal complex were treated by open reduction and fixation, using resorbable miniplates and screws (Forth Medical Ltd, Newbury, UK) (Figure 6).

A medial canthopexy was undertaken to reestablish the position of the lids, since both the anterior and posterior limbs of the medial canthal ligament were damaged as part of the original injury, rather than during the surgical repair. The nasolacrimal duct was beyond reconstruction. The left malar fracture was treated conservatively. The lower and common canaliculi were both damaged during the injury. The damage resulted in the destruction of these structures for much of their length, so that reconstruction in a child of this age was impossible. As a result, the patient had difficulty with recurrent epiphora immediately postoperatively. Four days postsurgery, the patient was well enough to be discharged and has since been maintained under a regular review.

Eight months postoperatively, the recurrent epiphora had resolved spontaneously. No further surgery to the lacrimal system is planned in the absence of symptoms. Nine months postsurgery, the patient is well. The scars are settling (Figure 7), and no complications have resulted from the use of fixation plates. The patient is maintained under long-term review to ensure that facial growth is occurring normally.

DISCUSSION

Fractures of the facial skeleton in young children are not common, but when they do occur they are usually the result of traffic accidents, falls, or sporting injuries.[1] Conversely, dog bites to the faces of children are seen commonly, with the more severe injuries occurring in children under 2 years of age.[2] Associated injuries with dog bites may include disruption of lacrimal canaliculi[3]; damage to levator muscle of eye, producing ptois[3]; and damage to the nasal cartilage.[4] However, very few cases have been reported of facial *fractures* in children resulting from a dog bite.[3-5] In these cases, the fractures identified have been isolated injuries, either to the malar or the nasal bones.

There are two aspects in the management of these injuries — the treatment of the potentially infected tissues[6] and reconstruction of the skeletal and soft tissues. The priority in treatment planning is to first address the high risk of infection following a dog bite. This requires an early wound antisepsis to prevent infection, and its importance cannot be overstated.[3]

Figure 5. The computerized tomography scan demonstrates the same injuries in the coronal plane.

Figure 6. Intraoperative view of the right nasoethmoidal fracture, reduced and fixed with a resorbable plate.

Figure 7. Nine-month postoperative appearance of the patient.

Topical antibiotics are used commonly, although their role is uncertain if early wound debridement is undertaken. However, in cases where a delay has taken place prior to the treatment, or in children who have undergone previous splenectomy and are at risk for life-threatening fulminating septicemia,[7] a penicillinase-resistant penicillin or cephalosporin is recommended to provide an adequate spectrum for treatment of the canine oral flora.[8] In addition to infection resulting from the normal canine microbiologic flora, the possibility of transmission of rabies or tetanus should also be considered, and tetanus prophylaxis should be administered, if required.

The use of resorbable plates to hold the reduced fracture in the correct position has the obvious advantage that no additional procedure is necessary for their removal.[9] In children with active sutures, the resorbable fixation materials may have an additional advantage when compared to the conventional titanium plates. It has been demonstrated in animal studies that when metal plates are positioned across growing sutures, the plates may retard the skeletal growth.[10,11]

CONCLUSION

A case of an unusual injury has been presented, involving facial skeletal fractures and soft tissue injuries resulting from a dog bite. Details of the management of such injuries have been discussed. This case again highlights the need for a high index of suspicion of facial fractures in children who are victims of dog bites to the midface region and who are under 2 years of age.[3] Consequently, the use of radiographs should be considered as a part of the early assessment to identify any damage to the underlying skeleton in such children, even when the facial fractures are not clinically apparent, as they were in this case. It must be remembered that any delay should be avoided in treating the microbiologically contaminated tissues and in performing the surgery to reduce the fractures. Since the fractures heal rather quickly in children, a prompt treatment will prevent the development of complications, avoid any additional difficulties in reduction and fixation, and present the most optimal treatment results.

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CASE REPORT:

An Endoscopic Endonasal Approach for Repairing Medial Orbital Wall Fractures:
A Case Report

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Abdul Shamsi, BS‡
Nadine P. Connor, PhD§

Abstract:

Background and Objectives. *A search for improved methods in the repair of medial wall fractures has been created by the increased incidence and recognition of these fractures and the advancements in diagnostic techniques. Several new techniques have been reported in the literature. The objective of this case report is to present the working model of an endoscopic endonasal technique in repairing a medial orbital wall fracture.*

Methods and Materials. *A clinical case was selected from among the patients treated with the endoscopic endonasal technique at the University of Wisconsin Hospital. The patient had sustained right medial orbital wall blowout fracture in a motor vehicle accident. An endoscopic technique was performed to repair the fracture, and each step was documented for visual presentation to the reader who may wish to select this technique for application in own practice.*

Results and/or Conclusions. *The endoscopic endonasal approach restores the integrity of the orbit without an external incision and associated morbidity. The endoscope provides excellent visual access to the surgical site and, thereby, a more effective removal of the pathologic tissue. The normal tissue around the fractured site is preserved, and blood loss during the procedure is minimal.*

Key Words: *Endoscopic, endonasal approach, orbital wall fractures.*

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The incidence of orbital medial wall fractures has increased in recent years, due to an increased frequency of high-impact orbital injuries. The increased incidence of such fractures and recent advancements in radiologic diagnostic techniques have generated a need for a more efficient method for repair of orbital wall fractures.[1,2] Orbital medial wall fractures may occur independently, or they may be associated with other facial bone fractures, such as fractures of the orbital floor.[1,3,4] Exploration and intervention within a few days of injury are strongly recommended in order to treat and correct enophthalmos before adhesions and fibrosis make restoration of normal orbital volume more difficult.[3,5,6] Due to the complex 3-dimensional configuration of the orbit, orbital blowout fractures may cause variable degrees of enophthalmos. Enlargement of the orbital cavity may be the leading cause of enophthalmos[2] and may have adverse cosmetic and functional consequences. Axial, coronal, and sagittal computerized tomography (CT) scan views of complex orbital fractures provide high-resolution images of soft tissue, bone, and unsuspected intracranial injuries that are easily interpreted.[7]

The indications for surgical repair of orbital fractures are based primarily on abnormal clinical findings, such as herniated orbital contents, enophthalmos, muscle entrapment, and

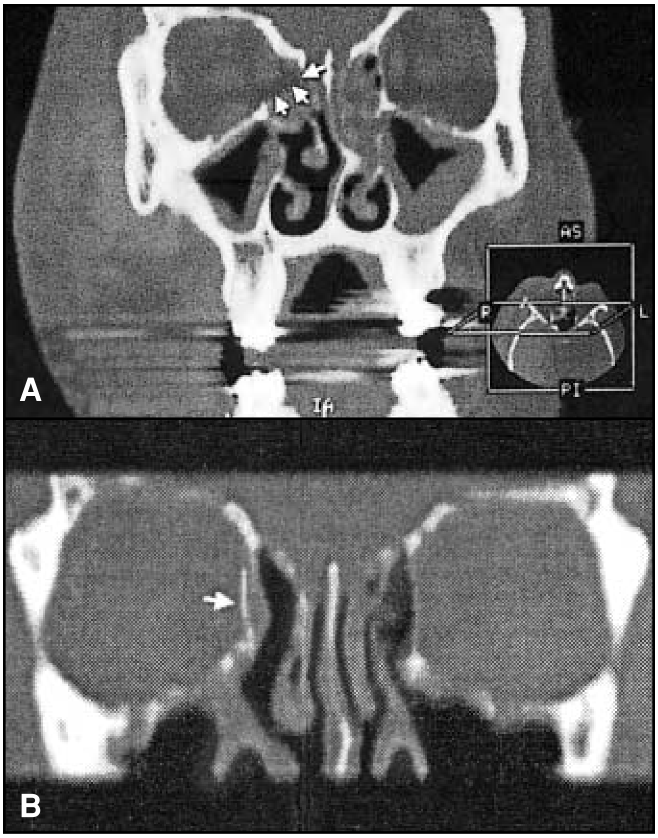

Figure 1A. Preoperative axial computerized tomography (CT) scan, showing medial orbital blowout fracture. Arrows identify the traumatic defect. **1B.** Postoperative axial CT scans.

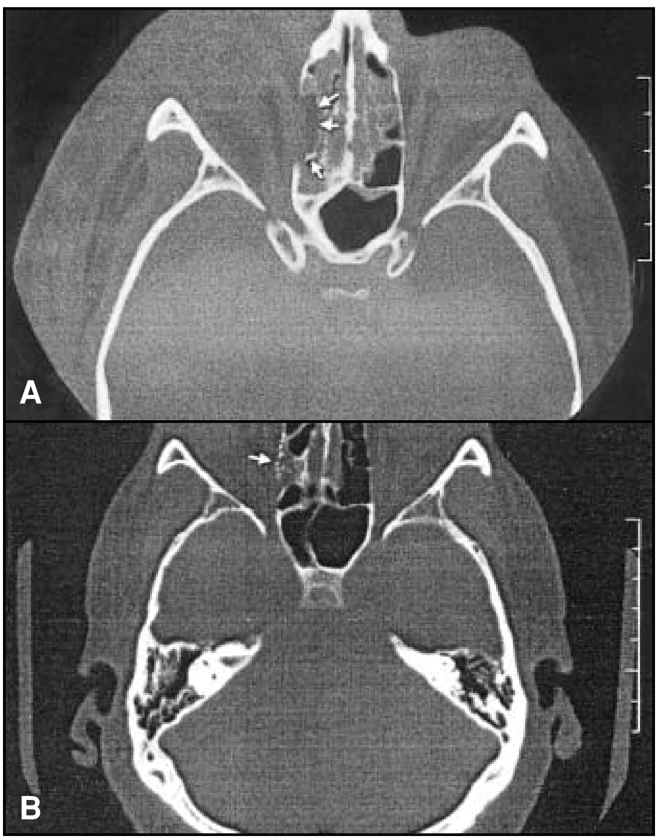

Figure 2A. Preoperative coronal CT scan, showing medial orbital blowout fracture. Arrows identify the traumatic defect. **2B.** Postoperative coronal CT scan.

the likelihood of potential future complications.[8] Numerous materials have been used to correct enophthalmos, including bone grafts, porous polyethylene, fascia lata, autogenous cartilage, silicone, and titanium mesh sheets.[8] Blowout fractures of the orbital wall may be treated with one of several surgical approaches, including the endonasal approach, the transorbital approach with external incision, and the maxilloethmoidal approach. Significant recent advances in the use of endoscopes for surgical exploration of the sinuses now allow excellent visual access to the endonasal region and access to the orbital walls for repair.

There are some risks associated with this technique. The most devastating complication would be injury to the optic nerve. Entrapment of the medial rectus is also a possibility. In this patient, the intact periorbita provided protection against rectus muscle adhesion. Our choice of titanium mesh with its barbed edges had its advantages as well as disadvantages. During our initial attempt to insert the mesh into position, the barbed edges of the trimmed mesh snagged repeatedly, but, once in place, the mesh provided the desired stability. The 14-month follow-up CT scans confirm the absence of any displacement. In absence of any posterior movement, the stability of the mesh provides protection to the posterior orbital contents, including the optic nerve.

Accordingly, the use of an endoscopic endonasal approach for repair of orbital blowout fractures is now feasible and has been reported in the literature.[1,4,8] The purpose of this report is to describe our use of an endoscopic endonasal technique for repairing a medial orbital wall fracture. Our goal is to provide a useful working model of this approach, with examples from an actual surgical situation to illustrate the technique for surgeons interested in clinical application of this method.

CASE PRESENTATION

A 34-year-old white male patient was transferred by ambulance to the University of Wisconsin Hospital following a motor vehicle collision. The patient had significant soft tissue edema of the right hemiface. Physical examination revealed an intact right orbital rim, a stable midface, and right hemotympanum. Cranial nerves II-XII were intact. The patient's visual acuity was 20/25 and 20/20. A full range of the extraocular movements was present, rendering the forced duction tests unnecessary; there was no diplopia. The intraocular pressure was slightly increased. CT scans revealed a right medial orbital wall blowout fracture, but no other associated facial fractures were identified (Figures 1 and 2). X-rays of the cervical spine showed no injury. Endoscopic surgical repair of a right medial orbital wall fracture was scheduled 11 days subsequently.

SURGICAL TECHNIQUE

General anesthesia was administered, and the patient was draped in the standard fashion for endoscopic sinus surgery. Oxymetazoline pledgets were inserted into the right nasal cavity. Following adequate time for vasoconstriction, the pledgets were removed, and the right nasal cavity was explored with a zero-degree endoscope. Using a Freer elevator, the middle turbinate was medialized.

The exposed middle meatus revealed a mass of comminuted fracture fragments and blood (Figures 3 and 4). These fragments were carefully removed, one piece at a time, revealing the bulging herniated periorbita of the medial wall that filled the middle meatus (Figure 5). The lamina was fractured extensively. While viewing the fracture posteriorly, the superior turbinate was trimmed, which provided an improved view of the posterior portion of the fracture (Figures 6 and 7). Further bone fragments and residual mucosa were removed in order to expose the herniated periorbita completely (Figures 8 through 13).

Using a Freer elevator, the periorbita was then circumferentially elevated from the edges of the medial orbital wall defect. Titanium mesh was cut to a size slightly larger than the laminar defect. In order to permit the use of up-biting forceps to grasp the mesh, a wire cutter was used to cut septations anterior and posterior to the center of the mesh (Figure 14). The mesh was advanced into the ethmoid cavity (Figure 15) and placed initially into the posterior aspect of the defect, lateral to the edges of the blowout fracture defect. Using the up-biter, the mesh was then carefully slid under the remaining edges of the bony defect and advanced anteriorly until it was held in position circumferentially (Figures 16 through 18). After placement, repeat examinations revealed proper fit with anatomic reduction of the periorbita. The ethmoid cavity was then suctioned and packed (Gelfoam, Upjohn/Pharmacia, Kalamazoo, MI). The patient tolerated the procedure well, was transferred to the recovery room, and extubated. The patient's condition was evaluated as stable. Upon awakening, a full range of extraocular movements was present, without any visual changes. The 14-month postoperative follow-up CT scan shows the mesh securely in place.

DISCUSSION

Traditional transorbital approaches for correcting medial orbital wall fractures utilize a transcutaneous incision over the inner canthus, a medial brow incision, or transconjunctival incision.[9] These methods may be time consuming and may result in a greater risk of wound infection, a noticeable scar, or skin webbing.[1,10] In contrast, the endoscopic endonasal approach is an

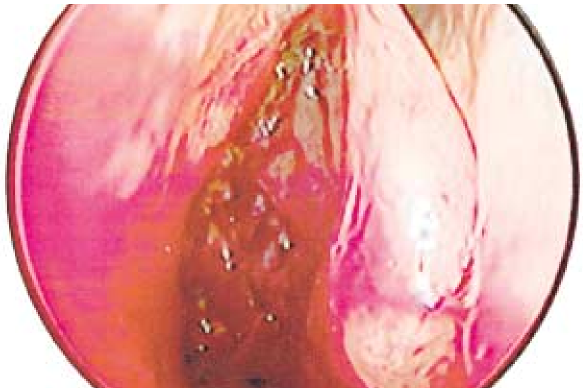

Figure 3. View of middle meatus, showing comminuted medial orbital wall.

Figure 4. View of middle meatus, showing comminuted medial blowout fracture.

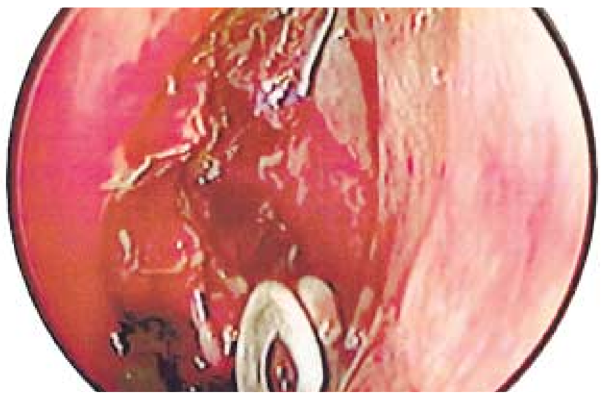

Figure 5. The fragments are cleared from the fracture and ethmoid contents.

Figure 6. The superior turbinate is trimmed to gain posterior exposure to blowout defect.

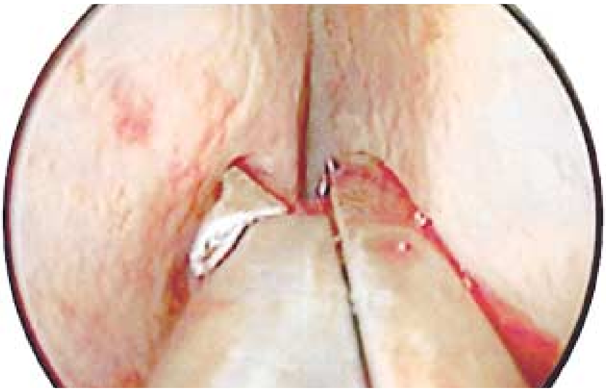

Figure 7. Cut stump of the superior turbinate.

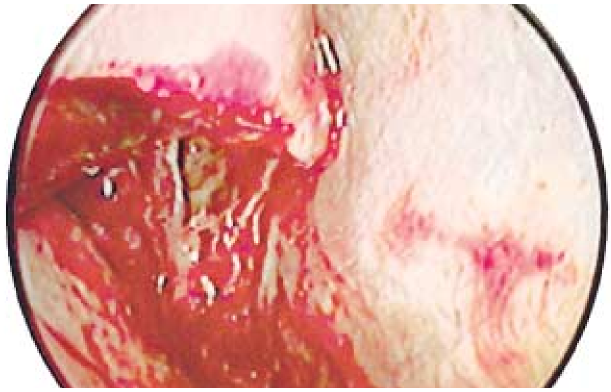

Figure 8. View of the posterior ethmoid labyrinth in an improved exposure.

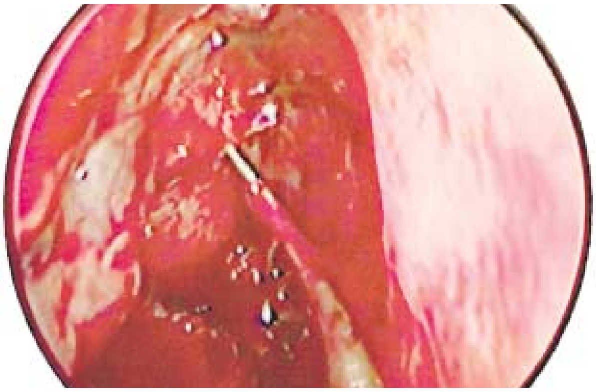

Figure 9. Fracture fragments of the comminuted medial orbit wall are removed.

Figure 10. Bulging periorbita (star) in middle meatus.

Figure 11. View of the probe behind a fragment of fractured medial orbit wall.

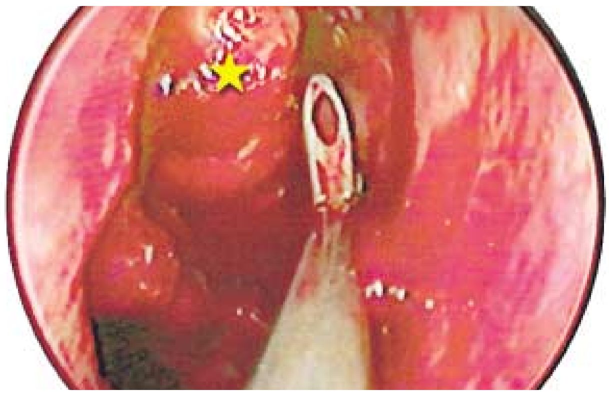

Figure 12. Final cleanout of comminuted fragments of the medial blowout. Star identifies the bulging periorbita.

exciting new method for restoring the integrity of the orbit, without an external incision and its associated morbidities. Other advantages of this approach include the preservation of normal tissue around the fractured site and the removal of pathologic tissue from the ethmoid sinus.[9] The blood loss during the procedure is minimized.

The endoscopic technique described in this report affords an opportunity for the surgeon to perform medial orbital wall repairs endonasally, to see the fractured site, and to access it with minimal complications. Our success with this new technique is consistent with the reports of other case series[1,4,8,11] and with reports of other endoscopic surgical techniques, such as orbital/optic nerve decompression, dacryocystorhinostomy, cerebrospinal fluid leak repair, hypophysectomy, choanal atresia, and mucocele repair. When compared to the conventional external approaches, endoscopic techniques offer reduced morbidity and a shorter hospital stay.[12]

CONCLUSION

We have presented a detailed description of a new endoscopic endonasal approach for repairing medial orbital wall fractures. Each step in the implementation of this technique is illustrated

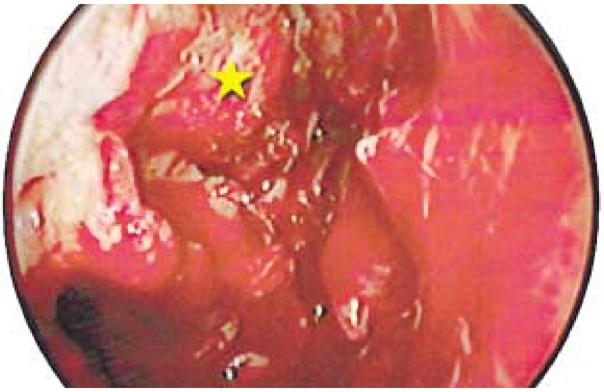

Figure 13. Exposed periorbita of a blowout fracture. Star identifies the bulging periorbita.

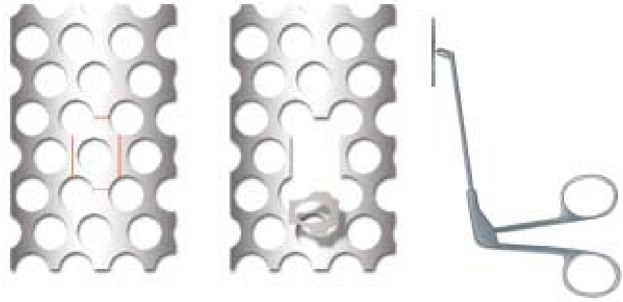

Figure 14. A drawing to demonstrate how 3 cuts through mesh in red lines fold along the dotted line, thereby forming a "grip" for "up forceps."

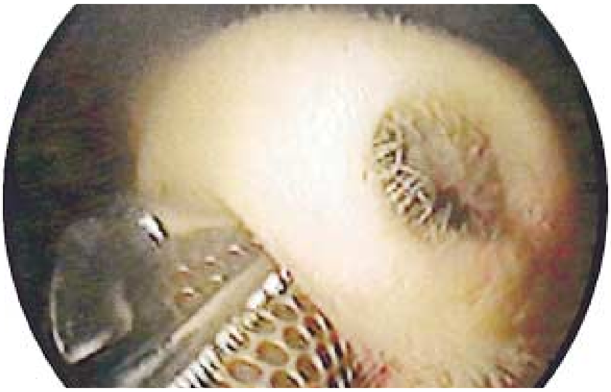

Figure 15. Placement of titanium mesh into the right naris.

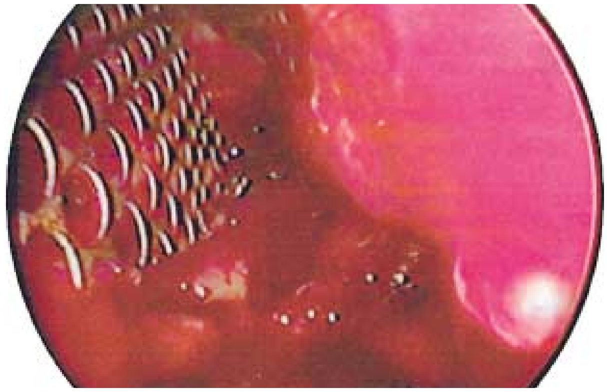

Figure 16. Mesh is being inserted into the bony defect, reducing displaced periorbita.

Figure 17. The soft tissue is tucked under the edge of titanium mesh.

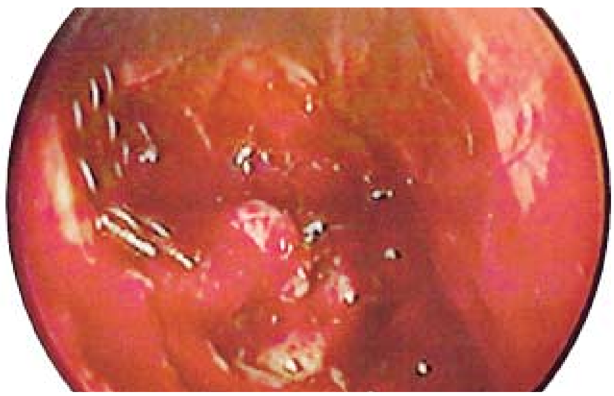

Figure 18. View of the mesh in place.

by photodocumentation, acquired during a successful surgical case. Facial reconstructive surgeons may find this report useful in developing this technique for incorporation into their own surgical practice.

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TECHNICAL NOTE

A Limited-Access Approach to the Superior Ilium for Harvesting Bone for Oral Reconstruction

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Abstract:

Background and Objectives. *In reconstruction of the jaws where tooth loss and alveolar avulsion have occurred, the use of bone grafts and dental implants has become the "gold" standard. Donor site morbidity is an important factor, and serious complication have been reported. To provide an alternative technique, this paper presents a limited-access technique for approaching the superior iliac crest for cancellous bone harvesting.*

Methods and Materials. *The anterior ilium is a common harvest site, since it provides sufficient cancellous bone and marrow for grafting small- to moderate-size alveolar defects. A limited-access approach that does not require osteotomies or the reflection of the coxal musculature reflection permits harvesting bone for jaw reconstruction on an outpatient basis. The iliac crest is preserved, and bleeding is minimal.*

Results and/or Conclusions. *Using this approach, endoscopic guidance may be used via a small skin incision, and postsurgical morbidity is limited. The procedure should not be used in children, extremely obese patients, or in cases where extensive amounts of graft are required. These observations suggest that this approach may be an optimal alternative procedure for cancellous bone graft harvesting of limited and moderate-size alveolar defects.*

Key Words: *Bone harvesting, limited-access approach.*

A variety of donor sites are available for harvesting bone for the reconstruction of defects in maxillofacial trauma patients. The sites may include the ilium,[1,2] tibia,[3-5] rib,[6-9] calvarium,[10,11] and femur.[12] Due to the potential for complications secondary to routine or aggressive harvesting, these techniques are generally performed in the hospital. However, other available techniques may be used to perform in-office outpatient bone harvesting. Trauma to the dento-alveolar region may cause avulsion of teeth and tooth/bone segments. These oral defects pose a significant challenge for rehabilitation with oral prostheses, due to the long prosthetic span, the lever system that develops as a result of removable prosthetic cantilevers, the contracture of mucosa and gingiva, and the deficiencies in the width and height of the alveolar ridge. Osseointegrated dental implants are the optimal solution for many of these rehabilitation problems; however, bone grafting is frequently required to augment alveolar ridge height and width in order to permit implant placement. Several alveolar ridge augmentation methods are appropriate for in-office outpatient procedures. Intraoral harvesting techniques (from the ramus and genial regions) have been developed to restore selected alveolar deficiencies. Other augmentations require more bone than is obtainable from intraoral harvest sites or do not permit the use of block cortical grafts. Percutaneous limited open approaches to the ilium and tibia are particularly

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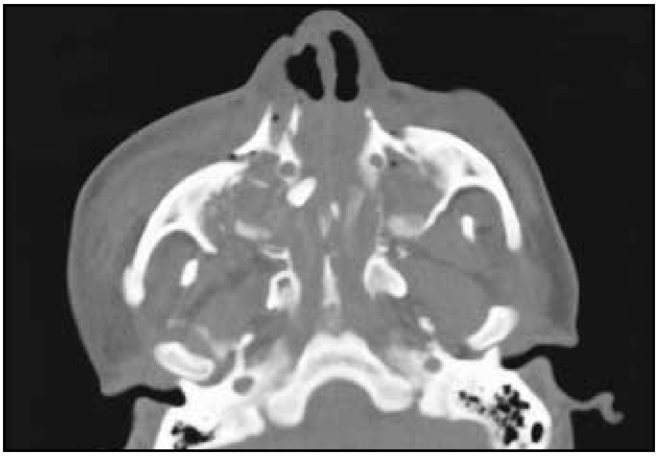

Figure 1. Axial CT scan, demonstrating facial fractures and tooth root in the nasal cavity.

Figure 2. Presurgical photograph 5 months following the original injury. Note the thin maxillary alveolus after the loss of the entire buccal plate of bone.

well suited for cancellous bone graft harvesting in facilities equipped with recovery rooms and/or rooms for overnight stays.

Numerous techniques have been devised to harvest iliac bone grafts. The design has been based on 1) the amount of bone required, 2) the need for the corticocancellous block, and 3) a desire to reduce morbidity. The spectrum of approaches for iliac bone harvesting includes bone biopsy needles,[13,14] trephination,[13-18] the anterior-superior approach,[19] the anterior-medial approach,[20-22] the anterior-lateral approach,[23,24] and the posterior approaches.[2,25]

This article presents a limited-access open approach to the ilium that may be used to harvest particulate cancellous bone for grafting alveolar defects of the maxilla or mandible. This technique utilizes a relatively small incision to gain direct access to the superior crest of the anterior ilium. Major muscle reflection or medial or lateral osteotomies for access are not required. Dissection to access the iliac crest occurs in an avascular plane, without the need to transect muscular attachments. This technique is rapid, provides substantial cancellous bone for most alveolar reconstructions, and is well suited for outpatient surgery.

CASE PRESENTATION AND SURGICAL TECHNIQUE

A 25-year-old white male patient was admitted for treatment following a rollover motor vehicle (truck) accident. Examination established the presence of multiple facial lacerations, a Le Fort III fracture with exposure of a comminuted nasal fracture, a right orbital floor fracture, complex left and right zygoma fractures, avulsion of teeth #7, #8, and #9 with the alveolar ridge multiple tooth fractures, and bilateral globe injuries. Tooth fragments were avulsed superiorly into the nose and ethmoid sinus (Figure 1). Repairs of bilateral open globe injuries were performed by the Ophthalmology Department; tracheotomy, closed reduction of the maxillary fractures with maxillomandibular fixation, and repair of multiple intraoral and extraoral lacerations were also performed. The immediate postsurgical recovery period was uneventful.

Two months postoperatively, the final intraoral examination revealed multiple tooth fractures, loss of teeth #7, #8, and #9, and a narrow alveolar ridge secondary to avulsion of the buccal plate of the anterior maxilla (Figure 2). The alveolar base of bone was inadequate for the placement of osseointegrated dental implants. A bone graft, harvested using the limited-access approach, was planned as an outpatient procedure to augment the anterior maxillary alveolar ridge.

SURGICAL PROCEDURE

General anesthesia was administered, and the patient was placed in a supine position. A rolled towel was placed under one buttock to elevate the iliac crest. The anterior-superior iliac spine and posterior-superior iliac spine were identified by palpation, and the locations were marked on the skin. The skin lateral to the iliac crest was pulled medially, so that the incision would lie 2 cm lateral to the crest. A line was drawn over the crest of the ilium, starting 2 cm cephalic and lateral to the anterior iliac spine. The extension of this line was 2.5 cm (approximately 1 inch).

A skin incision was made with needle electrocautery (Colorado Needle, Colorado Biomedical, Evergreen, CO) and continued down to the bone. A periosteal incision was made, and the periosteum was reflected to expose the crestal cortex. The dissection was made in a plane just lateral to the insertion of the external oblique muscle. A small self-retaining Weitlaner retractor was used for soft tissue retraction (Figure 3). As the

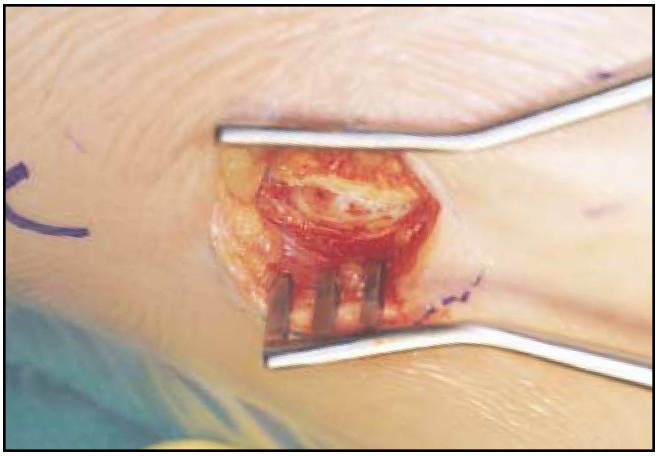

Figure 3. Initial surgical exposure of the iliac crest. The right mark delineates the anterior iliac spine; the posterior mark delineates the tubercle of the ilium.

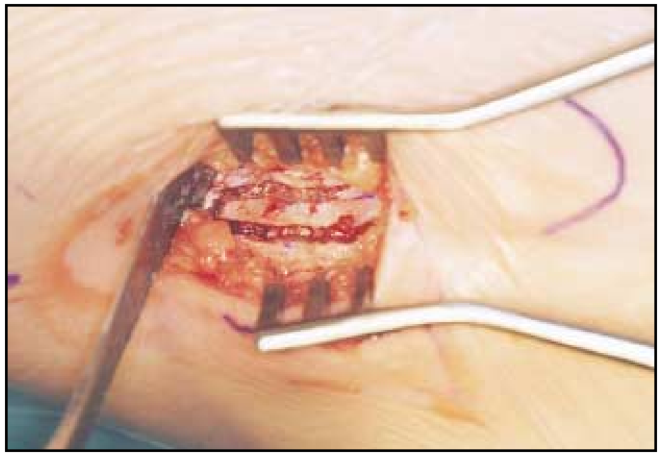

Figure 4. View of the initial osteotomy, outlining the window to be used for exposure of cancellous marrow.

periosteum over the iliac crest was approached, the dissection was in a relatively avascular plane — between the gluteus minimus laterally and the external oblique muscle medially. No muscle attachments were reflected from the crest of the ilium.

A bony window (2 cm × 1 cm) was created in the superior aspect of the ilium using a high-speed surgical drill and copious saline irrigation (Figure 4). A flat osteotome was used to remove the cortex, exposing the cancellous marrow of the ilium (a curette may be used for this purpose as well). Bone (approximately 5 cc) was removed with an orthopaedic curette and stored in normal saline (Figure 5). When direct visual access was not possible, a 4-mm 30-degree endoscope (Karl Storz Endoscopy America Inc, Culver City, CA) was used to locate areas within the ilium containing abundant marrow (Figures 6 and 7) and to assist with removal.

After the harvest, the defect was irrigated and packed with a postoperative dressing (Gelfoam, Pharmacia Upjohn, Kalamazoo, MI), and the periosteum was closed. A postoperative analgesic (Bupivacaine, 0.75%, Sanofi Winthrop Pharmaceutical, New York, NY) was infiltrated into the adjacent musculature and soft tissue. A subcutaneous running suture and a pressure dressing over the wound completed the procedure; no drain was used.

The harvested bone was combined with demineralized freeze-dried bone (1 cc Musculoskeletal Transplant Foundation, Holmdel, NJ; 2 cc Bio-Oss, OsteoHealth, Shirley, NY) and used to reconstruct the anterior maxilla with titanium mesh (SofamorDanek, Memphis, TN) (Figure 8). The patient remained overnight in an outpatient facility and was discharged the next day. On the day of the procedure, the patient complained of discomfort but was able to walk a short distance without a cane.

DISCUSSION

Donor site morbidity is an important factor when selecting donor sites for bone grafting in reconstructive surgery. Serious complications have been reported when using the ilium as a donor site, and they may be grouped into several major categories characterizing surgical morbidity:

- Neurologic sequelae (resulting in paresthesia and meralgia paresthetica).[26-28]
- Local wound healing complications (hematomas, seromas, pain, gait disturbances, wound infection).[2,8]
- Abdominal complications (false aneurysm, hernia, adynamic ileum).[29-31]
- Urologic complications (ureteral injury).[32]
- Skeletal complications (fractures, stress fractures, pelvic instability, and contour defects.[8,33-37]

Most superior approaches to the ilium (eg, “clam shell,” “trap door,” “Tschopp”) either reflect coxal musculature or split the cortex into medial and lateral cortices in order to obtain direct exposure to cancellous bone.[38] These approaches open the ilium for cancellous bone harvesting. A percutaneous/trephine technique has been advocated as a method to reduce donor site morbidity.[39] Trephine and bone biopsy techniques use relatively small incisions (5 mm to 10 mm) to gain access to the iliac crest. A trephine or CORB needle may be used either in a motor-driven apparatus or by hand to cut through the cortical bone of the iliac crest and into marrow to harvest cancellous bone. Percutaneous techniques using a trephine are associated with significantly reduced postoperative pain, less pain on ambulation, and less local tenderness when compared to open methods involving reconstruction of the iliac crest. Other studies have demonstrated that techniques which used

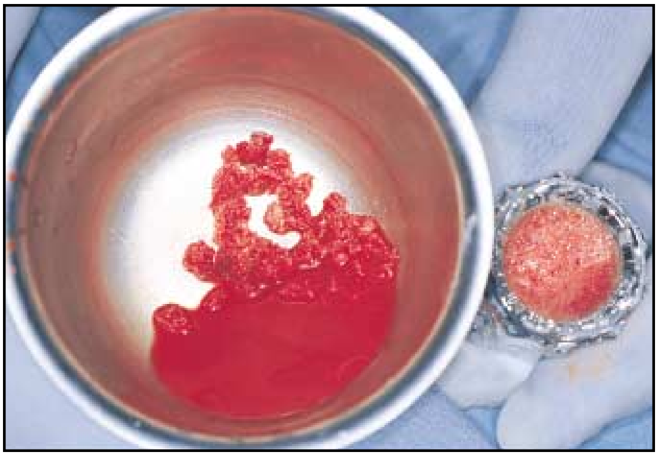

Figure 5. Cancellous bone, harvested by using the limited-access approach. To the right is a sterile glass jar, which contains graft additives (Bio-Oss, OsteoHealth, Shirley, NY) and demineralized freeze-dried bone.

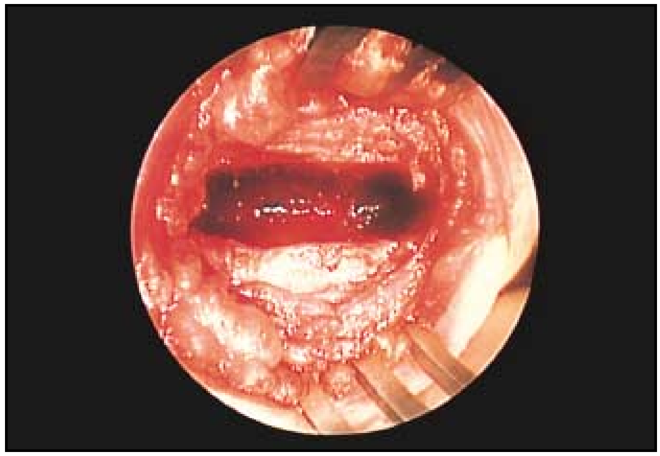

Figure 6. Endoscopic view of the access cavity within the ilium. The osteotomy site measures 1 cm wide by 2 cm long. No muscle reflection has been attempted.

trephines to remove cancellous cores resulted in fewer pre-ambulation days, shorter hospitalization, and reduced post-operative pain when compared to the harvesting of cortico/cancellous blocks.[40]

A minimally invasive technique, using stab incisions in children, employs a curette to obtain cancellous bone through the cartilaginous cap of the iliac crest.[41] However, while these techniques may provide sufficient bone for grafting alveolar clefts, the authors' experience with these techniques has yielded less than the required amount of cancellous bone for moderately sized maxillary and mandibular reconstructions. Recent reports have documented meralgia paresthetica, caused by neurotmesis of the lateral femoral cutaneous nerve following the harvesting of core grafts, taken blindly from the iliac crest.[42] Since these grafts are often harvested using a percutaneous approach, direct visibility may be a limiting factor in avoiding nerve injury.

Trocars have also been used to harvest bone marrow, applying aspiration techniques. The dense bone of the iliac crest usually requires a mallet to perforate the iliac crest. Aspiration of the ilium may be performed; however, the ilium contains a significant amount of cancellous bone as well as marrow, making aspiration difficult, if not impossible. Therefore, trocar aspiration is not advocated for retrieval of bone useful for bone grafting.

When analyzing complications associated with iliac bone grafting, techniques that require creation of osteotomies in the ilium, dissections that fail to maintain a subperiosteal plane, and excessive dissection of coxal musculature emerge as the leading causes of surgical morbidity. A limited-access approach to the superior ilium, which does not reflect coxal musculature or involve medial and lateral cortical osteotomies, has numerous advantages when compared to other approaches. First, since the technique does not involve significant muscle reflection, it has the potential to reduce morbidity and encourage early ambulation. Second, it preserves the iliac crest, thereby eliminating unaesthetic contour defects. Third, it may be guided endoscopically through a small incision. Fourth, it may be performed rapidly with minimal bleeding. Finally, it is capable of providing up to 15 ml of uncompressed particulate cancellous bone and marrow for grafting defects of the alveolus.[25] These characteristics suggest that this approach may be an ideal method for cancellous bone graft harvest for limited alveolar defects of the mandible or maxilla on an outpatient basis.

CONTRAINDICATIONS

When compared to the open approaches, any limited-access approach to the ilium has several limitations, which must be taken into consideration when planning approaches for bone graft harvesting. When large amounts of cancellous bone are required (eg, grafting large continuity defects of the mandible), a medial or lateral approach to the anterior or posterior ilium is a better choice because of the ability to obtain larger quantities of bone. Additionally, the limited-access approach is not suitable for harvesting cortico/cancellous block grafts that may be required for other maxillary or mandibular augmentation techniques. Finally, this technique may be impractical for harvesting bone grafts in obese patients for technical reasons or in children when a cartilaginous iliac crest is present.[43]

CONCLUSION

Significant complications have been reported following the use of the ilium for harvesting cancellous bone grafts. A

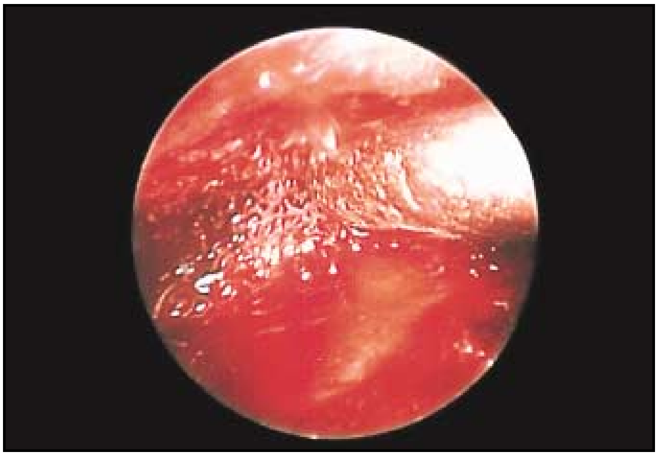

Figure 7. Endoscopic view within the ilium. The suction is visible to the right. Cancellous bone available for harvest is visible to the left.

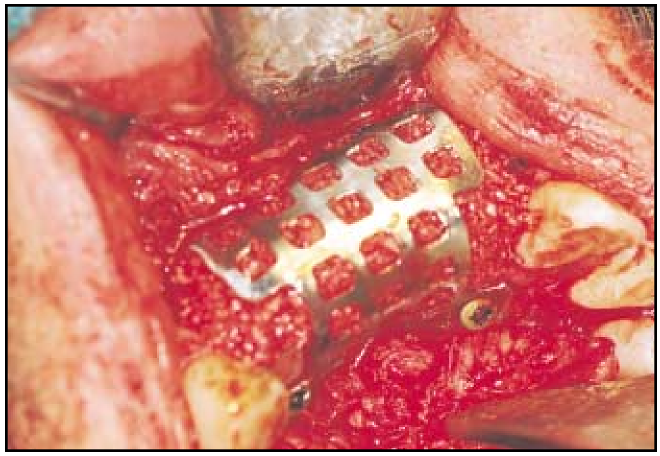

Figure 8. View of the graft in place in the anterior maxilla. Graft is contained within a titanium mesh tray and secured with two 2-mm screws.

limited-access open approach is presented that offers the potential for minimizing or eliminating some of these complications. Because of the reduced morbidity, this technique may have the potential for providing bone for grafting limited defects of the maxilla and mandible on an outpatient basis.

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Title Index

Author Index

Author Index (continued)