Safety of Zygomatic Bone Harvesting: A Prospective Study of 32 Consecutive Patients with Simultaneous Zygomatic Bone Grafting and 1-Stage Implant Placement

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Purpose: *The purpose of this prospective study was to evaluate the safety of zygomatic bone harvesting and to determine whether a particulated zygomatic bone graft can be used simultaneously with 1-stage dental implants to reconstruct resorbed edentulous alveolar ridges.* ***Materials and Methods:*** *Altogether, 82 dental implants were placed in 32 patients. Particulated bone grafts harvested from the zygomatic process were used in 72 of the implant sites. The volume of bone harvested, intraoperative complications, morbidity, and complications on follow-up visits were recorded. Implant survival was examined prospectively.* ***Results:*** *As a harvest site, the zygoma yielded enough bone to complete the reconstructions in each case. The average zygomatic bone graft volume was 0.90 mL (SD 0.30). Perforation of the maxillary sinus occurred at 11 zygomatic sites. None of these perforations led to postoperative problems. No paresthesias or other complications were noted during follow-up examinations. Mean duration of postoperative swelling was 4.5 days, and patients used pain medication for a mean duration of 4 days. After the mean follow-up period of 26.9 months postplacement, 80 of 82 implants were osseointegrated (survival rate 97.6%).* ***Discusssion:*** *Zygomatic bone is an alternative donor site for bone harvesting with low morbidity. The bone graft yielded is sufficient for use in 2 to 3 implant sites.* ***Conclusions:*** *The zygoma was a safe intraoral bone harvesting donor site in this patient population. Further, the use of simultaneous particulated zygomatic bone grafts and 1-stage implant placement appears to be an effective procedure.* Int J Oral Maxillofac Implants 2005;20:245–252

Key words: *autologous bone grafts, bone augmentation, bone defects, dental implants, morbidity, osseointegration, zygomatic bone*

Alveolar ridge resorption in partially or completely edentulous patients may result in defects of the alveolus that prevent, or at least interfere with, ideal positioning of dental implants. Alveolar ridge defects can also be the result of congenital maldevelopment, trauma, periodontal disease, or surgical ablation. Alveolar ridge resorption after tooth loss has been shown to follow a predictable pattern. The buccal aspect of the alveolar crest is the principal site of resorption; it becomes reduced first in width and later in height.[1,2] To expect a favorable prognosis for dental implants, a sufficient volume of healthy bone should be present. Therefore, augmentation of alveolar ridge defects is often undertaken prior to or simultaneously with placement of dental implants. Alveolar ridge augmentation can be performed with autogenous bone grafts[3–5] or allogeneic or alloplastic bone substitutes.[6]

Autogenous bone is considered the gold standard for osseous reconstruction of the craniomaxillofacial skeleton, as its successful use is well documented.[3,7–9] It does not produce immunologic reactions, and it contains osteoinductive components. Autogenous

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Table 1 Etiology of Edentulism in 32 Patients

Diagnosis	n
Cleft lip and palate	10
Oligodontia	9
Trauma	6
Acquired edentulism	4
Keratocyst	2
Hypoplastic dentition related to irradiation as an infant	1

bone graft donor sites can be categorized as local or distant. If the defect requiring a graft is small, the yields from intraoral donor sites are usually sufficient. However, when moderate to substantial amounts of bone are required, extraoral donor sites are needed to provide additional graft material. Intraoral sites are often preferred, since they allow harvesting of bone from the area adjacent to the reconstruction, and a second distant surgical site and the extraoral scar can be avoided. Intraoral harvesting can usually be performed on an outpatient basis under local anesthesia.[5,10]

Simultaneous bone grafting and implant placement have been performed with corticocancellous onlay bone grafts from the iliac crest.[11,12] Marx and associates have used cancellous bone grafts from the posterior iliac crest for the so-called "tent pole" approach, where simultaneously placed implants support the bone graft, tenting or stretching out the periosteum.[13] Mandibular symphyseal bone blocks have also been used for grafting simultaneously with dental implant placement to edentulous alveolar ridges.[14] Bone chips from implant preparation sites have been used to cover marginal or apical bone defects around the placed implants.[15] More often, bone grafting of the resorbed alveolar crest has been performed as a 2-stage procedure. In the first stage, a defect is augmented with a bone graft, and in the second stage, the dental implants are placed at the reconstructed site. The recommended healing period for bone grafts is 4 to 6 months[4,6,16]; it may even be longer than 6 months if barrier membranes are used.[17]

The purpose of this study was twofold: first, to evaluate the safety of the zygomatic bone harvesting; and second, to determine whether a particulated corticocancellous bone graft from the zygoma could be used simultaneously with 1-stage dental implants to reconstruct edentulous resorbed alveolar ridges.

MATERIALS AND METHODS

Between June 2001 and July 2002, 32 consecutive patients who underwent bone grafting from the zygomatic bone and simultaneous 1-stage dental implant placement were included in the study. The study sample consisted of 12 men and 20 women with a mean age of 26.8 years (range: 16 to 61 years). The indication for implant treatment in each patient case is summarized in Table 1.

The preoperative examinations included a panoramic tomograph, plaster diagnostic casts, and photographs. A surgical guide was fabricated to aid optimal implant positioning. The patients were informed that bone graft harvesting might be necessary during the operation. Patients who underwent general anesthesia were informed that a bone graft would be harvested from either the anterior iliac crest or from an intraoral donor site.

All operations were performed by the same surgical team. Local anesthesia was used in 7 cases, and in 20 cases local anesthesia was combined with nitrous oxide sedation. Five procedures were performed under general anesthesia. After administration of a local anesthetic agent, a crestal incision was made at the edentulous site and continued in the marginal sulcus on buccal and palatal sides of the teeth. Relieving incisions were not used unless necessary for access. Once the alveolar crest was exposed, implant preparation proceeded. Bone chips from the implant preparation site were collected using a custom-made bone collector (CSMT, Toronto, Canada). The implant shoulder was placed close to the crest of the alveolar bone, and a cover screw was selected depending on the soft tissue thickness to achieve 1-stage placement. All but 2 implants were placed using a 1-stage procedure (nonsubmerged). All 82 implants used were solid screw-type Straumann Implants with a sandblasted, acid-etched (SLA) surface (Straumann, Waldenburg, Switzerland). In 17 sites 3.3-mm-diameter implants (length 10 to 14 mm) were used; in 44 sites, 4.1-mm-diameter implants (length 10 to 14 mm) were used; and in 21 sites, 4.8-mm-diameter implants (length 8 to 14 mm) were used. A bone graft was needed in 72 implant sites. Table 2 summarizes the types of defects treated with bone grafting.

A total of 33 zygomatic bone harvests were performed. After implant placement, bone was harvested from the zygoma as described in a previous report by the authors.[18] Following infiltration of local anesthetics into the tissue innervated by the infraorbital nerve, posterior and middle superior alveolar nerves, and zygomaticofacial nerve, the zygomatic bone was exposed through a vestibular incision. The incision was made through the alveolar mucosa about 5 mm above the mucogingival junction, starting between the first and second molars and continuing anteriorly to the first premolar area. The subperiosteal dissection was extended to the inferior

Table 2 Bone Graft Placement and Recipient Defects at 72 Implant Sites

Description of graft recipient site	n
Alveolar defects	
Apical fenestration of implant	22
Apical fenestration and marginal palatal bone defect	4
Apical fenestration and gap in an implant socket	2
Lack of cancellous bone in an implant socket	1
Marginal buccal exposure of implant	29
Marginal buccal and palatal exposure of implant	3
Total	61
Combined alveolar and sinus floor defects	
Marginal buccal exposure; osteotome sinus augmentation required	4
Osteotome sinus augmentation required	5
Sinus floor augmentation required	2
Total	11

Apical, buccal, and palatal marginal defects were included in the study if at least 3 mm of the implant's SLA surface was exposed. A bone graft was placed into the implant socket if there was a defect or a lack of cancellous bone. Osteotome sinus augmentation was performed through an alveolar crest with osteotomes and bone graft. Sinus floor augmentation was performed through a lateral window.

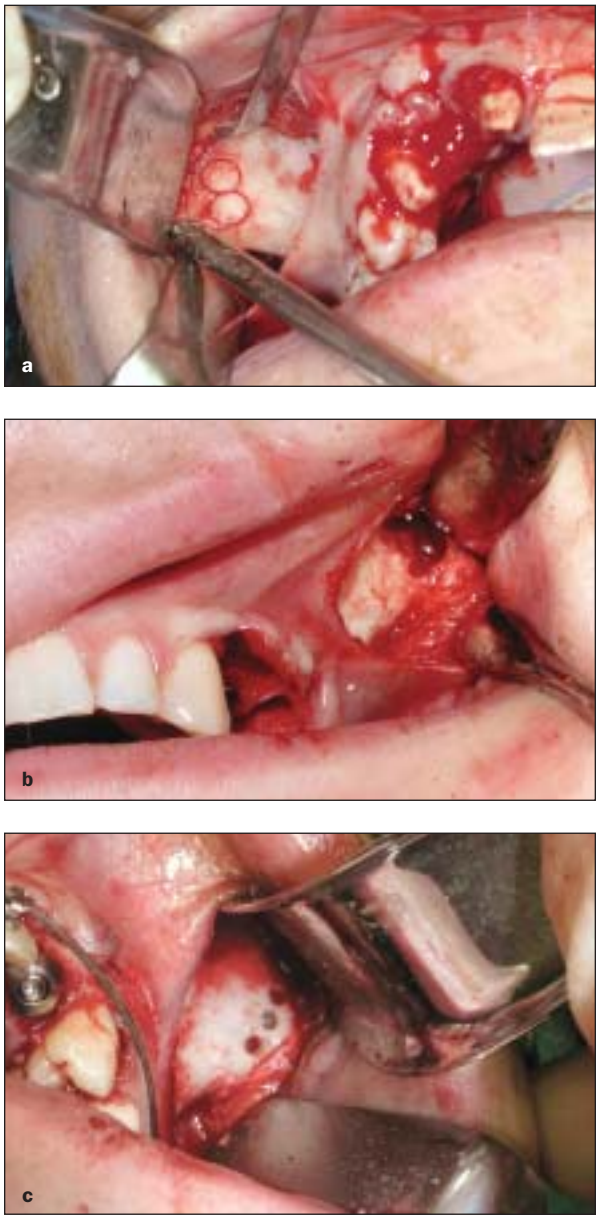

Fig 1 *(Right)* Examples of different zygomatic bone harvesting techniques. *(a)* Two holes have been created with a 4.6-mm trephine bur (Nobel Biocare). *(b)* Bone is harvested from the left zygomatic bone with a 4-mm round bur (Meisinger). *(c)* Bone is harvested with a 2.2-mm implant twist drill (Straumann) and continued with larger-diameter implant drills. Bone chips are collected with the bone collector.

aspect of the infraorbital nerve and around the inferior half of the body of the zygoma. Bone harvesting was started several millimeters superior to the inferior border of the zygomatic rim and lateral to the maxillary sinus. A trephine bur (Nobel Biocare, Göteborg, Sweden), round bur (Meisinger, Neuss, Germany) or implant twist drill (Straumann) in a straight handpiece was used to harvest bone from the anterior aspect of the zygomatic bone (Fig 1). All drilling of bone was done using copious saline irrigation. The irrigant was suctioned through the custom-made bone collector (Figs 2a and 2b) to collect bone chips. The trephine or twist drill was kept at an angle of approximately 45 degrees to the occlusal plane and was not used to drill deeper than 12 to 14 mm. When round burs were used, bone was shaved from the anterior part of the zygoma, and the drilling was extended into the body of zygoma. When implant twist drills were used, 2 to 4 holes were created using a 2.2-mm-diameter drill, then enlarged sequentially using the 2.8-, 3.5-, and 4.2-mm-diameter drills. The 4.2-mm bur was not used in all cases.

Once the cortical bone was removed from the anterior part of the zygomatic bone, more bone was collected from inside the zygoma using a round bur. When harvesting was completed, the area was rinsed with saline. The incision was closed with running resorbable sutures (Vicryl Rapid; Ethicon, Somerville, NJ). Complications encountered during the harvesting procedure were recorded.

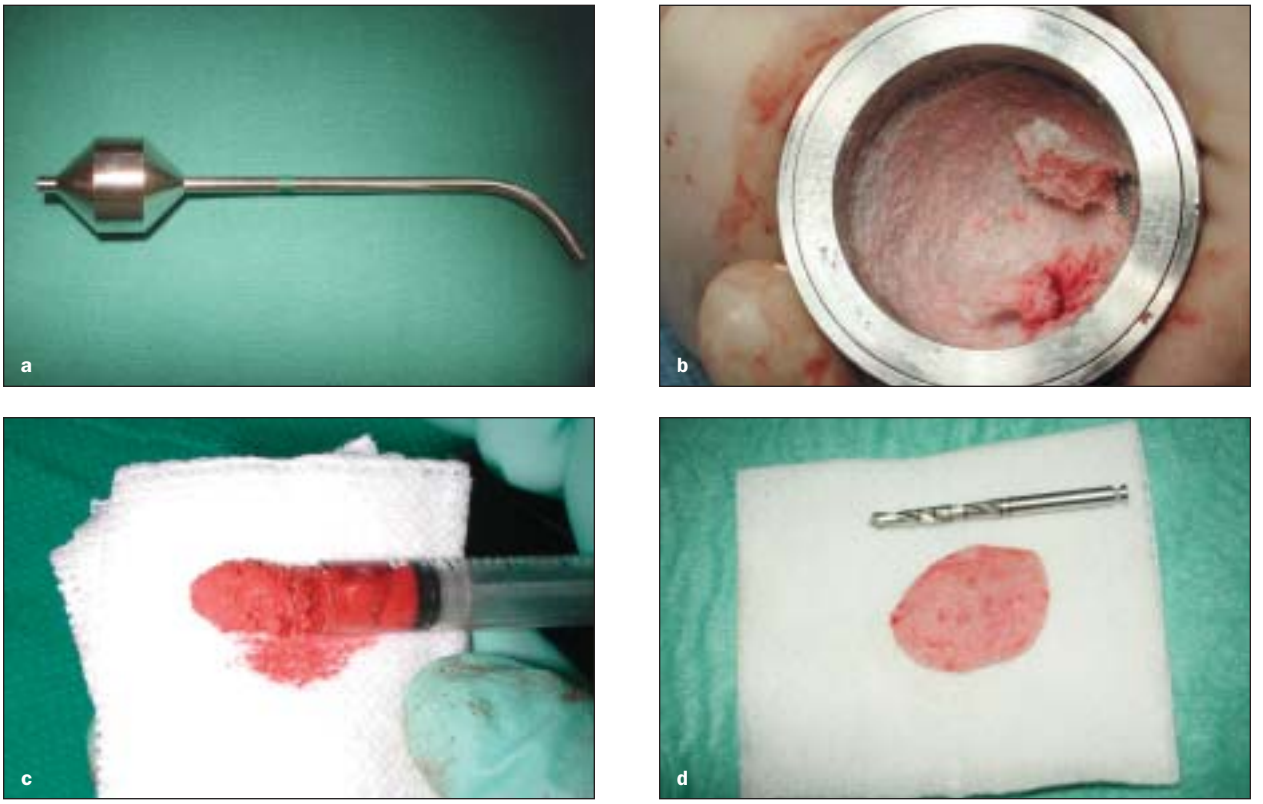

Fig 2 *(a)* The custom-made bone collector used in this study. *(b)* The collector opened after harvesting bone from zygoma. *(c)* The bone harvested was compressed and measured in a syringe and injected onto a gauze. *(d)* The bone graft was dried between layers of gauze.

The volume of bone harvested from each zygoma was measured using a syringe or a scaled plastic cup (Fig 2c). Bone from the implant preparation sites was also used for grafting but not included in the graft volume measurement. The collected bone slurry was dried between layers of gauze (Fig 2d) to produce a moldable particulate graft that could be adapted easily to irregularly shaped bony defects. Bony defects around the implants were covered with tightly packed bone chips. Marginal and apical defects were grafted if at least 3 mm of the implant's threaded SLA surface was exposed. In a situation where the maxillary sinus was pneumatized and the posterior maxillary alveolar height was reduced to 6 to 8 mm, the implant site was prepared with osteotomes (Straumann), and the sinus floor was augmented with a particulated bone graft before implant placement.

The implant sites were closed with resorbable interrupted sutures (Vicryl Rapid; Ethicon). Mouth rinsing with 0.12% chlorhexidine gluconate was prescribed for each patient for 2 weeks postoperatively. Amoxicillin (500 mg 3 times daily) was prescribed for 1 week, and for penicillin-allergic patients clindamycin (300 mg 4 times daily) was used. For pain, 500 mg acetaminophen with 30 mg of codeine 3 times daily was prescribed.

On follow-up visits extraoral and intraoral examinations were performed. Paresthesia of the skin innervated by the infraorbital and zygomaticofacial nerves was tested with a sharp probe. On the first follow-up visit, 1 to 2 weeks postoperatively, the patients were interviewed and asked to describe the amount and duration of swelling and bruising and the duration of use of pain medication.

A minimum of 4 months was permitted to elapse following placement before implants were restored. During restoration, all implants were subjected to a torque of approximately 35 Ncm using a handheld torque wrench (Straumann). Panoramic tomographs and photographs were taken following restoration.

RESULTS

A total of 33 zygomatic donor sites were used in 32 patients. In 2 cases bone was harvested with a 4.6-mm trephine drill and minced with a bone mill (Osteodisc, GenSci, Irvine, CA). In 22 cases bone was harvested with 3- to 4-mm round burs and in 9 cases with implant twist drills and round burs. In 1 case bone was harvested from both zygomae to perform bilateral sinus floor elevation procedures. The only

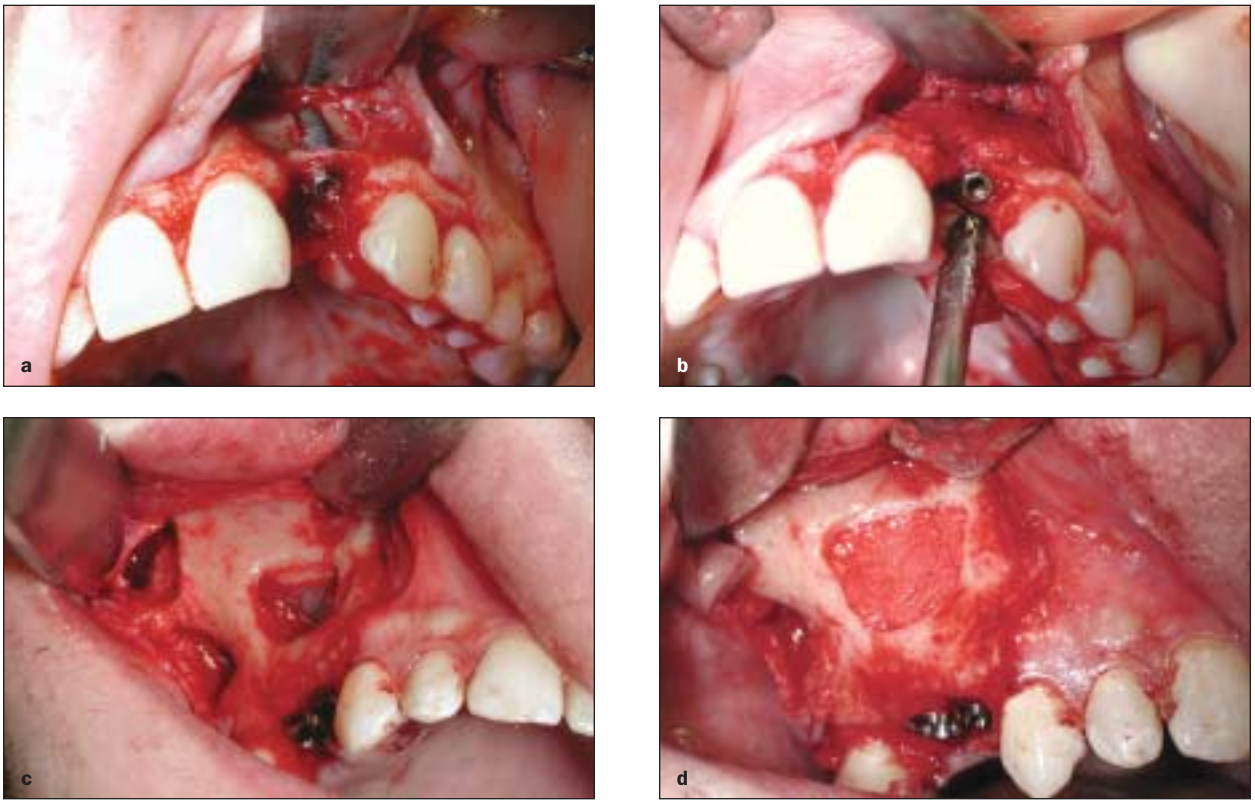

Fig 3 *(a)* A 3.3-mm implant placed into an alveolar cleft site, leaving the SLA surface of the implant exposed buccally and apically. *(b)* A bone graft was tightly packed over the defect. *(c)* One-stage sinus floor elevation and implant placement. A bone graft was harvested from the right zygoma using implant drills and a round bur. *(d)* The sinus floor was augmented with bone chips.

intraoperative complication encountered in this study group was perforation of the maxillary sinus, which occurred in 11 zygomae (34%). The diameter of the perforations ranged from 2 to 5 mm. None of these patients experienced any postoperative problems related to the perforation. Sinus perforation occurred in the 2 zygomae (100%) in which a trephine bur was used for harvesting, in 8 of the 22 zygomae (36%) in which a round bur was used for harvesting, and in 1 of the 9 zygomae (11%) in which implant twist drills were used for harvesting. Patients who underwent zygomatic bone harvesting under local anesthesia tolerated the procedure well, and none of them experienced any pain intraoperatively.

At the first follow-up visit, sensory nerve function in the distribution of the infraorbital and zygomaticofacial nerves was normal in all patients. Eight of the patients (25%) developed postoperative bruising over the donor site area. The mean duration of postoperative swelling as reported by the patients was 4.5 days (range, 0 to 12 days; SD 2.34). Postoperative pain medication was used for a mean duration of 4 days (range, 1 to 9 days; SD 2.08). There were no postoperative infections in any of the bone graft recipient or donor sites. After 3 to 4 weeks there was no soreness of the donor sites when the zygoma area was palpated extraorally, and the donor defect was not palpable. Grafted sites healed remarkably well without signs of irritation of the soft tissues, and no obvious signs of graft resorption were noted.

Together with relatively minimal contribution from the implant preparations, the zygoma sites yielded sufficient quantities of bone to complete the required reconstructions in all 32 cases. The average zygomatic bone graft volume was 0.90 mL (SD 0.30). Zygomatic bone grafting was employed at 72 of the 82 implant sites in this series. In 2 cases where implant stability was not achieved primarily, the bone graft was used to fill the gap between bone and implant and also to augment the apical fenestration. In 1 patient where the implant socket had a lack of cancellous bone, the bone graft was packed into the socket before implant placement. In 2 implant sites where the maxillary sinus was pneumatized and the alveolar height was less than 6 mm, a standard sinus floor augmentation through a lateral window approach was done. Two cases of the study group are presented in Fig 3. A total of 3 of the grafted implants lacked primary stability. At restoration, 2 of the 3 implants lacking primary stability were found

Table 3 Survival Rates of Implants After a Mean Follow-up Period of 19.4 Months* After Prosthetic Loading

	Osseointegrated implants (%)	Failed implants (%)
Implants with grafts (n = 72)	70 (97.2)	2 (2.8)
Implants not requiring grafts (n = 10)	10 (100.0)	0 (0.0)
Total (n = 82)	80 (97.6)	2 (2.4)

*Range, 11 to 23 mo.

to be loose. Survival rates of the implants are summarized in Table 3. The mean follow-up time after the surgery was 26.9 months (range, 18 to 30 months) and after the prosthetic loading was 19.4 months (range, 11 to 23 months). During the follow-up period there were no other implant losses.

DISCUSSION

Use of the zygoma as a donor site for alveolar bone grafting was introduced in a previous report by the authors,[18] and the safety of this technique has been demonstrated in a cadaver model.[19] This prospective study examined the bone augmentation obtained, implant survival, intraoperative complications, donor site morbidity, and patient discomfort during the postoperative healing phase after simultaneous bone grafting with zygomatic bone and 1-stage dental implant placement.

Patients needed pain medication for a mean of 4 days. Generally, it was difficult for the patient to decide which of the sites was more painful, the donor or recipient site. The usual finding after surgery was moderate swelling which resolved within a mean time of 4.5 days. Patients did not demonstrate any paresthesias or altered sensations in the donor site area. The literature lacks studies comparing the morbidity of different intraoral donor sites. The mandibular symphysis is the largest intraoral donor site, but the major disadvantage with its use is the potential for postoperative altered sensation of the teeth and chin area. In a recent study, 9 of 21 patients (43%) reported decreased sensibility in the symphyseal donor site. In 7 patients the paresthesia persisted, and 4 of these 7 patients also reported meteorotropism (weather-dependent discomfort).[20] Nkenke and colleagues reported a prospective study in which 8 of 20 patients had sensory disturbances in the chin area 1 month after chin bone harvesting. Sensory disturbances resolved in most cases during 12 months of follow-up, but in 1 patient the paresthesia, and in 2 patients hypoesthesia and hypalgesia, remained until the 12th month.[21] The mandibular retromolar area is a reliable source of cortical bone, and fairly large defects can be grafted with bone blocks harvested from the ramus with minimal morbidity and few complications.[4,22] When implants are placed in the maxilla and bone grafting is needed, it is more convenient and potentially less morbid to harvest the graft from the neighboring zygomatic area than, for example, from the mandible.

In this study all defects in the alveolar bone and around implants were too large for grafting only with the bone chips from the implant preparation sites. As a harvest site, the zygoma yielded sufficient quantities of bone to complete the required reconstructions in all 32 cases. The mean volume of the zygomatic bone harvest was 0.9 mL (SD 0.30). A 0.9-mL graft was sufficient to reconstruct the alveolar defects around 2 or 3 implants. The bilateral sinus floor augmentation for 1 implant required 1.5 mL of bone from each zygoma in addition to 0.6 mL of bone from 2 implant preparations. In a clinical study by Misch,[4] the average volume of a mandibular symphysis graft was 1.74 mL, and the average volume of a retromolar graft was 0.9 mL. The average bone volume from the zygoma of 0.9 mL compares favorably to a retromolar bone graft and is roughly half the volume of a symphyseal graft. Montazem and coworkers measured the quantity of bone in the mandibular symphysis in dentate adult cadavers.[23] The average monocortical bone harvest was 4.84 mL when a 5-mm safety margin from the donor site to the tooth apices was used; the mental foramen and the inferior border of the mandible were maintained.[23] Bone harvest volumes from extraoral donor sites are much larger than those from intraoral donor sites. The volumes of cancellous bone graft available from the anterior and posterior iliac crests are 72 mL and 82 mL, respectively.[24] The mean volume of the bone graft obtainable from the proximal tibia is 22.4 mL.[25]

When a particulated bone graft is used, the bone should be packed firmly. The graft is stable when blood has created a clot-type adhesion to the graft. The incision is easy to close without tension, because the bone chips are adapted by the pressure of overlying soft tissues. The particulated bone is supported by the walls of the bony defect and the underlying dental implants. In this study barrier membranes were not used, and the grafts were covered with intact periosteum. Intact periosteum or a split palatal or gingival flap are regarded by some as natural membranes, and their use may obviate the need for a barrier membrane.[26]

Collection of bone chips during the preparation of an implant bed is done using copious irrigation, but contamination from saliva is possible.[27,28] Zygomatic

bone harvesting is performed using a "keyhole" approach, through a small incision, in which it is easy to keep the saliva away from the operative area. In this way, the risk of contamination of the graft with oral microorganisms is minimized. One potential problem occurs when bone is harvested and there is concomitant bleeding in the operation field. Suctioning blood will clog some bone collectors fairly quickly, and bone procurement becomes minimal.[29]

Two of the grafted implants failed, yielding a survival rate of 97.2% for grafted implants and 97.6% for the entire study group. Both of the failed implants lacked primary stability. One of the failed implants had been placed in an edentulous maxilla using an osteotome sinus floor augmentation. The 5 remaining implants placed in this patient's maxilla osseointegrated, and the prosthodontic treatment was carried out as planned. The other failed implant had been placed into a grafted mandibular implant socket lacking in cancellous bone. The failure in osseointegration was noted 12 weeks postoperatively. That site was reimplanted 6 weeks after removal of the failed implant and was successfully restored with a crown. During the mean follow-up of 19.4 months after prosthetic loading, there were no other implant losses.

The complications and morbidity following zygomatic bone harvesting are minimal, and the zygomatic bone can be regarded as a safe intraoral bone harvesting donor site. The only intraoperative complication with this technique was perforation of the maxillary sinus in 33% of the zygomatic sites, and none of these patients experienced any postoperative problems. The safest technique regarding the sinus perforation was harvesting with implant twist drills.

CONCLUSION

The amount of bone that can be harvested from the zygoma is sufficient for the augmentation of alveolar defects around 2 or 3 implant sites. The clinical data presented show that particulated bone grafts harvested from zygomatic bone and used with simultaneously placed 1-stage dental implants can be an effective and safe method of treating resorbed edentulous alveolar ridges in partially edentulous patients.

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