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Zygomatic Bone-to-Implant Contact in 77 Patients With Partially or Completely Edentulous Maxillas

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Purpose: Specifically with zygomatic implants, the bone-to-implant contact (BIC) at the zygomatic bone correlates with the survival of the implant because there is little anchorage at the alveolus. The purpose of this retrospective study was to view and measure the BIC of zygomatic implants in the zygomatic bone.

Materials and Methods: The patients in this study received zygomatic implants at a single private dental implant center. All patients were treated with the same immediate-loading protocol followed by postoperative cone beam computed tomography. The scans were exported to a computer-aided design system, where the BICs could be measured digitally. The BIC was analyzed by gender, and any statistical difference was determined by analysis of variance.

Results: The study sample was composed of 77 patients (62.3% women) receiving 173 zygomatic implants. The mean age of the sample was 59 ± 8.7 years. The mean BIC was 15.3 ± 5.6 mm (range, 4.9 to 32.9 mm) in the zygomatic bone. On average, 35.9% ± 11.7% (range, 12.2% to 67.3%) of the implant came into contact with the zygomatic bone. The average BIC in men was 16.5 ± 6.0 mm, and the average BIC in women was 14.7 ± 5.4 mm, a statistically significant difference by analysis of variance ($P < .05$).

Conclusions: Evidence from this report indicates the zygomatic BIC varies greatly from patient to patient. These data show that the typical male patient has a greater zygomatic BIC than the typical female patient; however, these data do not support the hypothesis that the zygomatic BIC influences the zygomatic implant survival rate.

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Anchorage is the primary concern when treating patients with dental and skeletal dysgnathia.[1] Patients presenting with complex anchorage problems, such as those with partially or completely edentulous jaws, achieve anchorage through osseointegration. Osseointegration implies a firm and lasting connection between vital bone and titanium implants that is intended to distribute stress properly once connected to a permanent prosthesis.[2] Osseointegrated implants are proving to be a successful method for the replacement of lost teeth and related oral and facial structures.[3,4]

Patients with severe atrophy of the maxilla present a complicated problem that cannot be treated with traditional dental implants alone. The techniques used in patients with little or no bone for implantation include the restoration of an atrophic maxilla by increasing the bone volume in necessary anatomic areas and improving the topography of existing bone. These results may be achieved by grafting bone from the patient's iliac crest,[5] augmentation of the maxillary sinus,[6] and Le Fort I osteotomies coupled with interpositional bone grafting.[5] Although these techniques may have reasonable success rates, bone grafting procedures may be associated with intraoperative bleeding, postoperative infection, bone fracture,

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nerve dysfunction, perforation of the mucosa over the implant, the loss of a portion of the graft, ulcers, sinusitis, and wound dehiscence.[7,8]

Recent surgical techniques have been adopted to shorten recovery time, decrease the cost of treatment, and drastically lessen surgical and recovery complications in all fields of medicine.[7,9-15] One such technique involves the placement of implants in the zygomatic bone. Zygomatic implants provide craniofacial anchorage and allow for immediate prosthetic loading.[16-28]

The stress caused by occlusal forces is supported mainly through the zygoma. The stress from these forces is transferred predominantly through the infrazygomatic crest and divided to the frontal and temporal processes of the bone.[28,29] Therefore, it is important to understand how much of the implant comes into contact with the zygomatic bone because the success of an immediately loaded implant is directly dependent on the primary stability provided by the bone and the eventual osseointegration of the titanium implant.

The purpose of this retrospective study was to examine the zygomatic bone-to-implant contact (BIC). This was examined because the authors hypothesized that the survival and osseointegration of these implants correlated directly to the anchorage necessary for immediate prosthetic delivery in patients with little to no maxillary bone.

In this study, the BIC was determined in a sample of patients receiving zygomatic implants and the factors associated with the BIC were investigated to determine the set of variables associated with the BIC. Some of these variables depend on the patient and others on the clinician. The specific aims of this study were to enroll a cohort of subjects receiving zygomatic implants, measure the BIC, and identify factors associated with the BIC.

Materials and Methods

STUDY DESIGN/SAMPLE

This retrospective study follows the guidelines for IRB exemption according to Ethical & Independent Review Services. To address the research purpose, the investigators designed and implemented a retrospective cohort study in which all patients who had zygomatic implants placed at a private clinical facility (PI Dental Center, Institute for Facial Esthetics, Fort Washington, PA) were analyzed. All patients were treated according to the Teeth in A Day protocol,[30,31] that is, all implants were loaded within 2 hours of implant placement. Immediately after implant placement, the abutments were connected and an all-acrylic resin provisional prosthesis was delivered.[30]

The exclusion criterion was limited to patients who underwent zygomatic implantation without postoperative cone beam computed tomographic examination. Cone beam computed tomographic scans (i-CAT, Imaging Sciences International, Hatfield, PA) were reviewed in Digital Imaging and Communications in Medicine (DICOM) format.

STUDY VARIABLE—GENDER

The range of BIC varies across patients because of the unique anatomic features of each patient. Because the BIC would differ in typical male and female patients from the obvious size differences, gender was the primary predictor variable in this study.

OUTCOME VARIABLE—BIC

The outcome variable in the present study was the BIC in the zygoma. In this retrospective cohort study, the BIC was determined using postoperative cone beam computed tomography and measuring the apical portion of the zygomatic implant in contact with the zygomatic bone. The export of the uncompressed DICOM data to the Procera computer-aided design system (NobelGuide; Nobel Biocare, Yorba Linda, CA) provided digital 3-dimensional images of each implant and the surrounding anatomic structures. The 3-dimensional images allowed digital manipulation of the computed tomographic images, making it possible to view the implants that had previously been placed in the zygoma. The Procera software then provided the images necessary to obtain the measurements of the zygomatic BIC. Once a clear image of the implant in the zygomatic bone was visible, measurements of the BIC were obtained by a digital manipulation of the 3-dimensional images (Fig 1A, B). Only the BIC in the zygoma was determined. All bone in the zygoma (cortical or trabecular) was considered in the calculation. The limited BIC in the maxilla was not analyzed.

DATA ANALYSES

Statistical analysis was performed using analysis of variance with a 95% confidence level ($P < .05$). The database was maintained in Excel (Microsoft, Redmond, WA), and analysis of variance was performed on the study variables using the add-on statistical package.

Results

Seventy-seven patients (31 men, 46 women; mean age, 59 ± 8.7 yr; age range, 33 to 80 yr) who underwent oral reconstruction because of severely atrophied maxillas were treated with 173 zygomatic implants (range, 1 to 4 implants). The overall implant survival rate was 96.5% (Table 1). Sixty-three of 66 implants (95.5%) placed in men survived, whereas

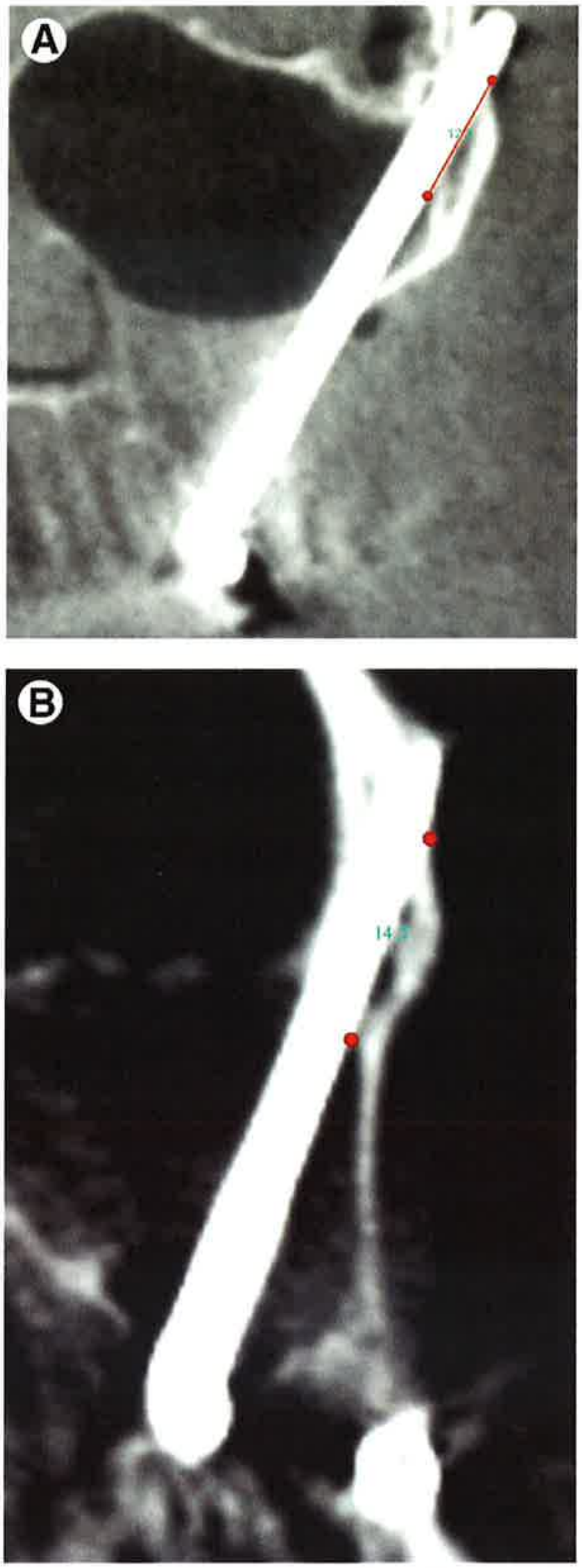

FIGURE 1. Screen captures from NobelGuide 3D Planning Software show zygomatic bone-to-implant contacts of *A*, 12.3 mm and *B*, 14.2 mm.

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Table 1. LIFE TABLE ANALYSIS OF 173 IMMEDIATELY LOADED ZYGOMATIC IMPLANTS

Period	Implants	Failures	Survival Rate	Cumulative Survival Rate
0-3 mo	173	1	99.42%	99.42%
3-6 mo	173	3	98.27%	97.69%
6-9 mo	173	0	100.00%	97.69%
9-12 mo	173	1	99.42%	97.11%
1 yr	163	1	99.39%	96.53%
2 yr	144	0	100.00%	96.53%
3 yr	139	0	100.00%	96.53%
4 yr	87	0	100.00%	96.53%
5 yr	69	0	100.00%	96.53%
6 yr	55	0	100.00%	96.53%
7 yr	36	0	100.00%	96.53%
8 yr	28	0	100.00%	96.53%
9 yr	18	0	100.00%	96.53%
≥10 yr	16	0	100.00%	96.53%

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104 of 107 implants (97.2%) placed in women survived. The survival rates between men and women were statistically similar ($P > .05$). The 6 zygomatic implant failures in this study are described in Table 2. All 3 zygomatic implant failures in men occurred in 1 patient, whereas 3 women each lost 1 zygomatic implant.

All completely edentulous patients were also treated with standard Brånemark System implants (Nobel Biocare) in the anterior maxilla. Some patients were also treated with Brånemark System implants in the pterygomaxillary region for added support and to eliminate distal cantilevers.[32,33]

The zygomatic BIC (measured using the Procera computer-aided design/computer-assisted manufacturing software) showed a mean implant contact of 15.3 ± 5.6 mm (range, 4.9 to 32.9 mm) in all 77 patients. Zygomatic implants placed ranged from 30 to 52.5 mm. On average, 35.9% ± 11.7% of the entire implant came into contact with the zygomatic bone. The BIC achieved is the basis of support for an imme-

Table 2. SIX ZYGOMATIC IMPLANT FAILURES

Gender	Zygomatic BIC (mm)	Implant in Zygoma (%)
F	16.3	40.75
F	17.1	38.0
F	12.2	28.7
M	14.4	36.0
M	18.3	34.8
M	17.8	33.9

Abbreviations: BIC, bone-to-implant contact; F, female; M, male.

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diately loaded prosthesis. The percentage of the BIC ranged from 12.2% to 67.3%.

The average zygomatic BIC in the 29 men in this study was 16.5 ± 6.0 mm. The average zygomatic BIC in the 48 women in this study was 14.7 ± 5.4 mm. The 1.8-mm difference between men and women led to a 12.0% increase of the BIC in men. According to analysis of variance, there was a statistically significant difference in the BIC between men and women (95% confidence level; $P < .05$).

Discussion

The purpose of this retrospective study was to examine the BIC by measuring how much of the apical portion of the zygomatic implant was in contact with the zygoma. This appeared to be an important topic of study because with an increased understanding of the BIC comes an increased understanding of the factors related to osseointegration and successful immediate prosthetic loading. With an increase of zygomatic BIC, there is an overall inherent increase in prosthetic anchorage in patients with a resorbed or atrophic maxilla. It is the anchorage provided by the zygomatic implants that makes immediate prosthetic loading possible for these patients with severe atrophy. The advantages include the smaller number of surgeries (no grafting), shortened surgical and recovery times, and increased immediate prosthetic functionality compared with the alternative surgical and prosthetic options.

Patients with atrophy of the maxilla present a complicated clinical condition that cannot be treated with traditional dental implants alone. The lack of quality bone in the maxilla leaves little space for implants and does not ensure stability after prosthetic loading.

The zygomatic implants placed in this study had an overall cumulative survival rate (CSR) of 96.5% (167/173), proving a viable option for restoring the atrophic maxilla.[17-21] The success of this technique resulted from the anchorage provided by the zygomatic implants (average BIC, 15.3 ± 5.6 mm). These data are comparable to the 2003 cadaver study performed by Van Steenberghe et al.[34] The present data indicated that as little as 4.9 mm of zygomatic BIC can immediately provide enough implant anchorage when the implant is rigidly connected to other implants in the dental arch. Permanent anchorage is achieved as osseointegration of the implants occurs. Therefore, implants placed in the zygoma obviate extensive and costly bone grafting procedures and provide superior prosthetic anchorage at the time of implant placement surgery.

The present data also indicated that BIC can differ by gender. In this study, male patients on average had 1.8 mm more BIC in the zygoma than did female patients. Although this result was statistically significant, the increase in BIC in the male patients did not reflect a higher zygomatic implant cumulative survival rate (CSR).

Another variable that changes the zygomatic BIC is the angle at which the implant is placed. As the angle of the implant placement changes, the implant contacts different anatomic portions of the zygoma; this can lead to an increase or decrease of the BIC. The angle of implant insertion, which should be prosthetically driven, can be estimated by the examination of preoperative computed tomographic scans, but is subject to change because the implants are placed free hand by the surgeon. The angle of zygomatic implant placement was not a study variable because there is no anatomic reference point that is constant from patient to patient.

Although zygomatic implants usually are not the sole implants placed (although only 4 zygomatic implants have been used successfully to support a fixed prosthesis[22]), these implants provide anchorage through an osseointegration that is predictable and superior to other implantation methods. This anchorage is necessary for immediate prosthetic support and is the backbone of an immediate-loading protocol for the severely atrophic maxilla. The high degree of fixed implant prosthetic success previously reported[17,22,30] corroborates and validates the importance of the BIC measured and discussed in this report.

The evidence from this report indicated that the zygomatic BIC varies greatly from patient to patient. The present data showed that the typical male patient has a greater BIC than the typical female patient. Contrary to the primary study hypothesis, the limited sample size in this report showed that an increased zygomatic BIC did not result in increased cumulative survival rates of the zygomatic implants.

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