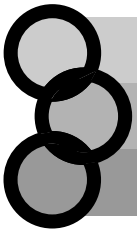
Vol. 93 No. 4 April 2002



ORAL SURGERY
ORAL MEDICINE
ORAL PATHOLOGY

ORAL AND MAXILLOFACIAL RADIOLOGY Editor: Stephen R. Matteson

Use of imaging guides in preimplant tomography

Dov M. Almog, DMD,[a] Eduardo Torrado, DDS,[b] Mark E. Moss, DDS, PhD,[c] Sean W. Meitner, DDS, MS,[d] and Frank LaMar, DDS,[e] Rochester, NY
UNIVERSITY OF ROCHESTER

Objectives. The objective of this study was to quantify the variation in use and type of imaging guides used by community-based specialists and general practitioners during dental implant treatment planning phases. The specific aim of this study was to test the hypothesis that specialists are more likely to use some form of cross-sectional imaging in conjunction with imaging guides during the preoperative assessment of dental implant procedures.
Study design. Records from 630 patients with implants (1640 implants) referred for cross-sectional tomography were reviewed. Imaging guide type and implant sites were noted.
Results. The distribution of referring dentists by specialty was as follows: general practitioners (42.2%), periodontists (35.1%), oral and maxillofacial surgeons (13.3%), and prosthodontists (7%). Of patients referred for tomograms, 52% were referred without a surgical guide.
Conclusion. Specialists ordered tomograms in conjunction with imaging guides more often than did general practitioners. Prosthodontists and periodontists preferred to use more restrictive guides than did general practitioners or oral and maxillofacial surgeons.
(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;93:483-7)

Accomplishing predictable reconstruction and esthetic results for single or multiple tooth replacement with dental implants is challenging. Historically, residual bone height observed on panoramic radiographs and residual bone trajectory or angulation observed during surgery determined implant size and trajectory, at times compromising mechanical and esthetic needs. The final trajectory of an implant, especially in a buccolingual direction, does not always conform to that of the natural tooth or the planned prosthetic trajectory. This may be primarily because of buccal bone loss in the first 1 to 3 years after tooth loss.[1]

Although evidence has not yet been established, probably one of the most common problems encountered in treating the dental implant patient is the lack of adequate treatment planning. This is most often an issue when implants are placed in esthetic zones that require precise consideration for tooth position requirements. Examination of study casts, anesthetizing and probing the depth of the mucosa over the bone, and the use of panoramic and lateral skull radiographs are methods frequently used to determine the adequacy of bone. A number of previous reports documented that optimum, and at times critical, implant size and orientation can be aided by a cross-sectional, three-dimensional radiographic exam.[2-7] Moreover, in a recent article, the AAOMR recommended that some form of cross-sectional imaging be used for implant cases.[8]

To further enhance the realm of diagnostic information obtained with advanced imaging, some authors have advocated the use of an imaging guide in conjunction with a cross-sectional radiographic exam.[9-15] Although the tomogram revealed the outline of the bone and its width and height, only the use of the guide illustrated the bone-to-implant and the bone-to–planned prosthetic trajectory correlation. Several different types of imaging guides were used consisting of radiopaque indicators, which the patient wore during the cross-sectional exam. The authors demon-

[a]Associate Professor, Prosthodontics.
[b]Graduate Student, Prosthodontics.
[c]Assistant Professor, Department of Community and Preventive Medicine.
[d]Assistant Professor, Periodontics.
[e]Assistant Professor, General Dentistry.
Received for publication Jun 13, 2001; returned for revision Aug 19, 2001; accepted for publication Oct 21, 2001.

1079-2104/2002/$35.00 + 0 **7/16/121389**
doi:10.1067/moe.2002.121389

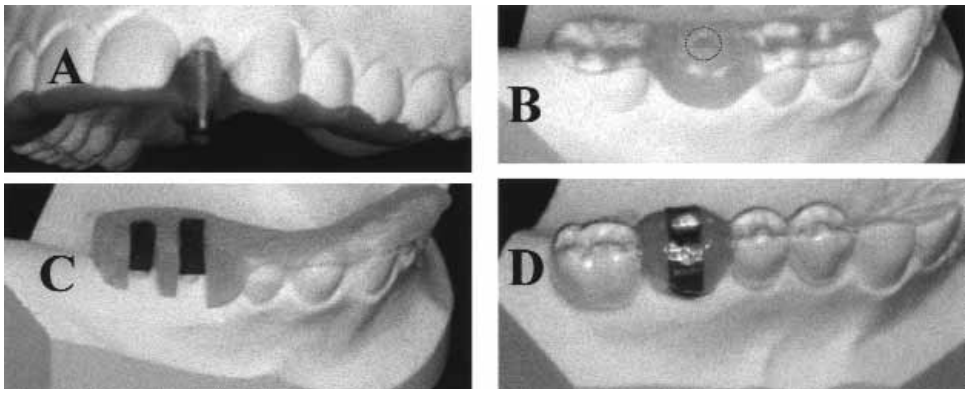


Fig 1. **A,** Metal tube guide in the area of tooth #22. The anterior 3.0-mm metal guide sleeve is constructed in the desired prosthetic location and trajectory of a missing maxillary left lateral. **B,** Gutta-percha guide in the area of tooth #36. Gutta-percha is used to fill the access hole serving as a radiopaque implant trajectory indicator. **C,** Vertical lead strip guide in the area of teeth #46 and 47. In this guide an access groove is drilled over the planned prosthetic implant site and a vertical lead strip is glued on the lingual wall of the groove. **D,** Circumference guide in the area of tooth #26. The lead strip outlines the buccal, occlusal, and lingual surfaces, delineating the waxed tooth over the implant site.

strated how to transfer the information obtained from the imaging phase to both the surgical and restorative phases of treatment.

The numerical relationship between dental implant treatment success or failure and cross-sectional imaging used in conjunction with and without imaging guides is unknown and awaits prospective trials. As a precursor, the objective of this study was to quantify the variation in use and type of imaging guides used by community-based specialists and general practitioners during treatment planning phases. The specific aim of this study was to test the hypothesis that specialists are more likely to use some form of cross-sectional imaging in conjunction with imaging guides in the preoperative assessment of dental implant procedures.

MATERIAL AND METHODS

Data entries from all 630 consecutive patients referred over the past 6 years to the Craniofacial Diagnostic Imaging facility for dental implant tomography exams were selected for this study. The Craniofacial Diagnostic Imaging facility functions as a dental imaging facility and is dedicated to the dental profession. The facility is part of the Division of Eastman Dental Center at the University of Rochester (UREDC). Referrals originated from local general practitioners, periodontists, oral and maxillofacial surgeons, and prosthodontists. Implant site location, guide type, and referral source were noted.

For those referred patients with an imaging guide, once the guide was positioned in the mouth, a cross-sectional image was made through each of the radiopaque indicators. For those referred patients with no guides, cross-sectional images were made through the estimated prescribed implant site region. Linear tomography was used with referrals dated back approximately to the first 5 years of the dataset (Quint Sectograph; American Dental, Hawthorne, Calif). Complex motion tomography was used on more recent referrals (CommCAT; Imaging Sciences International, Hatfield, Pa).

Referring dentists and dental labs were contacted and queried for information regarding guide fabrication. All imaging guides were constructed on study casts. Guides were categorized into 6 groups, as follows:

1. *None*.
2. *Metal tube guide*: fabricated with stainless steel sleeves (De Plaque Corp, Victor, NY) supported by a base material. The sleeve is positioned in the desired prosthetic location and trajectory (Fig 1, *A*). This guide serves as a surgical stent.
3. *Gutta-percha guide*: fabricated with gutta-percha filling. The access hole(s) are drilled over the planned prosthetic implant site(s), serving as a radiopaque indicator (Fig 1, *B*). A similar guide is demonstrated in conjunction with cross-sectional tomography (Fig 2). This guide serves as a surgical stent.
4. *Vertical lead strip guide:* fabricated with a vertically placed lead strip, serving as a radiopaque indicator, and supported by a base material. Access grooves are positioned over the planned prosthetic implant site(s) (Fig 1, *C*). This guide serves as a surgical stent.
5. *Circumference guide:* fabricated with a 2-mm-wide lead strip supported by a base material. The lead strip is attached to the buccal, occlusal, and lingual surfaces, outlining the tooth over the implant site(s)

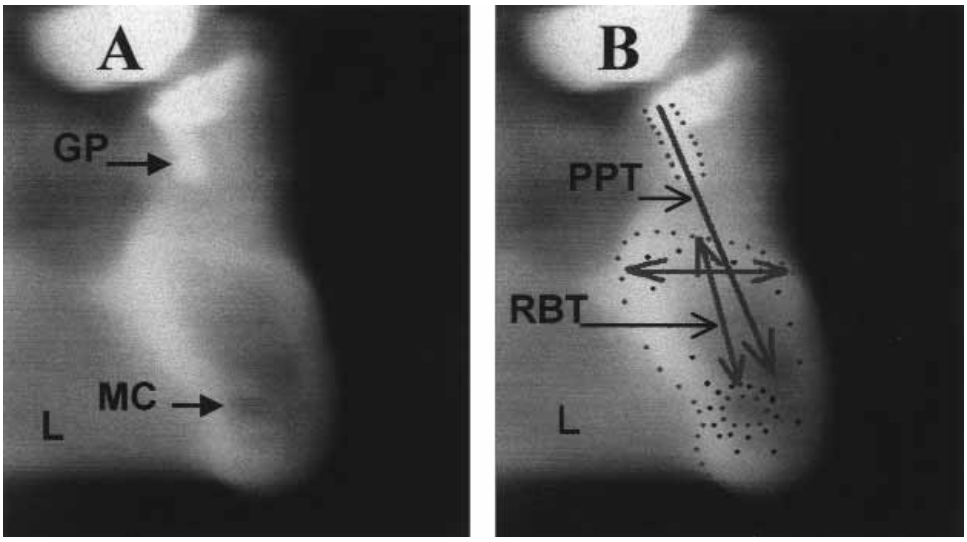


Fig 2. **A**, Cross-sectional tomogram representing area #36 taken in conjunction with a gutta-percha guide like the one seen in 1, *B. L,* Lingual; *GP,* gutta-percha; *MC,* mandibular canal. **B,** Tracing of tomogram A. In this tomogram the planned prosthetic trajectory (*PPT*) and the residual bone trajectory (*RBT*) are compatible.

(Fig 1, *D*). This guide does not serve as a surgical stent.

6. *Other:* a variety of other radiopaque indicators and base designs.

Data analyses were performed to compare frequency distributions of imaging guides by referral source. A Cochran-Mantel-Haenszel chi-square test was used for these comparisons.

RESULTS

The 630 consecutive patients referred for preimplant diagnostic cross-sectional tomography had a total of 1640 tomograms made in different locations in the mouth.

The frequency of referrals by guide type is displayed in Table I. Results indicated that 326 (52%) patients had no imaging guide furnished at the time they arrived for their imaging exam and 304 (48%) referrals had been outfitted with a custom-made imaging guide. Of those 304 referrals outfitted with an imaging guide, 92 (15%) patients had circumference guides, 80 (13%) had metal-tube guides, 65 (10%) had gutta-percha guides, 19 (3%) had vertical lead strip guides, and 48 (8%) had other types of guides.

The frequencies by location of the 1640 implant site tomograms are displayed in Table II. The average number of implant sites designated for cross-sectional imaging per referral was calculated to be 3. The following 6 location categories were established: 442 (27%) mandibular right and left molars; 330 (20%) maxillary anteriors; 266 (16%) mandibular right and left bicuspids; 221 (13%) maxillary right and left bicuspids; 191 (12%) maxillary right and left molars; and 190 (12%) mandibular anteriors.

Table I. Frequency of referrals by guide type

Guide type	*Frequency*	*Percent (%)*
None	326	52
Circumference	92	15
Metal tube	80	13
Gutta-percha	65	10
Vertical strip	19	3
Other	48	7
Total referrals	630	100

The frequency of referrals for tomograms by referral source is displayed in Table III. Frequencies of use by guide type and referral source are displayed in Table IV. In general, more imaging guides were used when specialists ordered implant tomography. The specialists also used more uncompromising guide types, ie, metal tubes, gutta-percha, and vertical lead strips.

Based on a Cochran-Mantel-Haenszel chi-square test, general practitioners and specialists were statistically different in their use and selection of imaging guides at $P < .01$. Among the specialists, the oral and maxillofacial surgeons preferred to use the circumference type, which was a less restrictive guide. Statistically, they were different from periodontists and prosthodontists in their use and selection of imaging guides at $P < .01$.

DISCUSSION

The study involved cross-sectional imaging in conjunction with a variety of imaging guides. Some of these guides also serve as surgical stents. During the

Table II. Frequency of implant sites by location

Location	*Frequency*	*Percent (%)*
Mandibular Molars	442	27
Maxillary Anteriors	330	20
Mandibular Bicuspids	266	16
Maxillary Bicuspids	221	13
Maxillary Molars	191	12
Mandibular Anteriors	190	12
Total	1,640	100

Table III. Frequency of referrals by referral source

Referral source	*Frequency*	*Percent (%)*
General practitioners	266	42.2
Periodontists	221	35.1
OMFS	84	13.3
Prosthodontists	44	7
Other*	15	2.4
Total Referrals	630	100

**Other* includes 1 referral from a pediatric dentist and 14 referrals from an unknown referral source.
OMFS, Oral and maxillofacial surgeons.

Table IV. Frequency of use by guide type and referral source

Guide type	*GP*	*Percent (%)*	*Perio*	*Percent (%)*	*OMFS*	*Percent (%)*	*Prostho*	*Percent (%)*	*All Specialists*	*Percent (%)*	*Other*
None	204	76.7	83	37.5	38	45.2	1	2.3	122	34.7	0
Circumference	26	9.8	22	10.0	35	41.7	9	20.5	66	18.8	0
Metal tube	5	1.9	49	22.2	1	1.2	25	56.8	75	21.4	0
Gutta-percha	7	2.6	53	24.0	2	2.4	3	6.8	58	16.5	0
Vertical strip	5	1.9	10	4.5	0	0.0	4	9.1	14	4.0	0
Other	19	7.1	4	1.8	8	9.5	2	4.5	14	4.6	15
Total referrals	266	100	221	100	84	100	44	100	349	100	15

osteotomy, the stent is used to guide the pilot surgical drill in the right trajectory until it reaches the prescribed depth. Based on personal communication with several of the referral sources, the sleeve indicators were anecdotally considered to be most accurate since they served both as an imaging indicator and as a less compromising—yet more precise—surgical drilling guide. The gutta-percha and vertical lead strip guides were considered dual-purpose as well, although they allowed for greater latitude during the surgical procedure. The circumference lead strip only delineated the prosthesis over the implant site in the radiograph, and therefore was the least specific of the indicators related to the planned prosthetic trajectory. It served only as an imaging indicator, allowing for greater surgical latitude in preparation of the osteotomy sites.

It appears that tomograms were ordered more often in conjunction with an imaging guide, during the pretreatment phase by specialists than by general practitioners. When guides were supplied for the imaging procedure, the general practitioners and oral and maxillofacial surgeons preferred to use the circumference lead strip, the least restrictive guide. Prosthodontists and periodontists preferred to use a more precise guide, primarily the metal tube or gutta-percha guides. Although speculative, without actual data regarding motives of those practitioners prescribing cross-sectional tomography exams, it appears that periodontists and prosthodontists are more detailed in their approach to dental implants. What is important is that while the overall success rate of dental implants is high, even without the use of cross-sectional imaging, there is a rapid proliferation of implant placement by a variety of practitioners, experienced and inexperienced alike.[8]

There are approximately 750 dentists in the Seventh District, the geographic region serviced by the UREDC Craniofacial Diagnostic Imaging Lab. There are 4 other medical imaging groups that are equipped to provide computed tomography services for dental implants in this region. The UREDC Craniofacial Diagnostic Imaging Lab is the largest provider of dental implant cross-sectional imaging services in the region (personal communications). The UREDC Craniofacial Diagnostic Imaging Lab represented the bulk of the implant cases when cross-sectional diagnostic imaging was part of the treatment planning. However, it should be noted that the total number of dental implants in this geographic region, with or without cross-sectional tomography studies and or surgical guides, is unknown.

One important question that remains is whether use of guides and/or type of guide influenced clinical outcome. Ideally, a randomized clinical trial should be conducted to resolve this question. Another limitation of this study was the lack of an assessment of case complexity in relation to guide type and possibly referral source.

As dental implants become a more accessible treatment for missing teeth, we may encounter more random anatomic situations. Unless we use all of the diagnostic resources available to us including the use of imaging guides in conjunction with tomography, we may be putting the patient and ourselves at needless risk for failure. Therefore, understanding the correla-

tion between advanced imaging and imaging guides, case complexity, reconstruction, and esthetic outcome is essential. This suggests that further investigation with numerical data to support the success-to-failure ratio after the concomitant use of cross-sectional tomography and imaging guides is needed.

We would like to thank the Craniofacial Diagnostic Imaging Lab from the Division of Eastman Dental Center, University of Rochester, Rochester, NY, for their logistic and administrative support.

REFERENCES

1. Pietrokovski J. The bony residual ridge in man. J Prosthet Dent 1975;34:456-62.
2. Clark DE, Danforth RA, Barnes RW, Burtch ML. Radiation absorbed from dental implant radiography: a comparison of linear tomography, CT scan, and panoramic and intra-oral techniques. J Oral Implantol 1990;16:156-64.
3. Grondahl K, Ekestubbe A, Grondahl HG, Johnsson T. Reliability of hypocycloidal tomography for the evaluation of the distance from the alveolar crest to the mandibular canal. Dentomaxillofac Radiol 1991;20:200-4.
4. Petersson A, Lindh C, Carlsson LE. Estimation of the possibility to treat the edentulous maxilla with osseointegrated implants. Swed Dent J 1992;16:1-6.
5. Fredholm U, Bolin A, Andersson L. Preimplant radiographic assessment of available maxillary bone support. Comparison of tomographic and panoramic technique. Swed Dent J 1993;17:103-9.
6. Weinberg LA. CT scan as a radiologic data base for optimum implant orientation. J Prosthet Dent 1993;69:381-5.
7. Lam EW, Ruprecht A, Yang J. Comparison of two-dimensional orthoradially reformatted computed tomography and panoramic radiography for dental implant treatment planning. J Prosthet Dent 1995;74:42-6.
8. Tyndall AA, Brooks SL. Selection criteria for dental implant site imaging: a position paper of the American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000;89:630-7.
9. Petrikowski CG, Pharoah MJ, Schmitt A. Presurgical radiographic assessment for implants. J Prosthet Dent 1989;61:59-64.
10. Kassebaum DK, Nummikoski PV, Triplett RG, Langlais RP. Cross-sectional radiography for implant site assessment. Oral Surg Oral Med Oral Pathol 1990;70:674-8.
11. Modica F, Fava C, Benech A, Preti G. Radiologic-prosthetic planning of the surgical phase of the treatment of edentulism by osseointegrated implants: an in vitro study. J Prosthet Dent 1991;65:541-6.
12. Israelson H, Plemons JM, Watkins P, Sory C. Barium-coated surgical stents and computer-assisted tomography in the preoperative assessment of dental implant patients. Int J Periodontics Restorative Dent 1992;12:52-61.
13. Mecall RA, Rosenfeld AL. The influence of residual ridge resorption patterns on implant fixture placement and tooth position. 2. Presurgical determination of prosthesis type and design. Int J Periodontics Restorative Dent 1992;12:33-51.
14. Almog DM, Onufrak JM, Hebel K, Meitner SW. Comparison between planned prosthetic trajectory and residual bone trajectory using surgical guides and tomography–-a pilot study. J Oral Implantol 1995;21:275-80.
15. Almog DM, Sanchez R. Correlation between planned prosthetic and residual bone trajectories in dental implants. J Prosthet Dent 1999;81:562-7.

Reprint requests:

Dov M. Almog, DMD
Associate Professor, Prosthodontics
University of Rochester Eastman Department of Dentistry
625 Elmwood Ave
Rochester, NY 14620
dov_almog@urmc.rochester.edu