ACP AMERICAN COLLEGE OF PROSTHODONTISTS Your smile. Our specialty.

Evaluation of the Efficacy of a Prosthodontic Stent in Determining the Position of Dental Implants

Naina Talwar, MDS,[1] Pooran Chand, MDS,[2] Balendra Pratap Singh, MDS,[3] Jitendra Rao, MDS,[3] U. S. Pal, MDS,[4] & Hari Ram, MDS[4]

[1]Department of Prosthodontics, Faculty of Dental Sciences, C.S.M. Medical University, Lucknow, India
[2]Associate Professor, Department of Prosthodontics, Faculty of Dental Sciences, C.S.M. Medical University, Lucknow, India
[3]Assistant Professor, Department of Prosthodontics, Faculty of Dental Sciences, C.S.M. Medical University, Lucknow, India
[4]Associate Professor, Department of Oral and Maxillofacial Surgery, Faculty of Dental Sciences, C.S.M. Dental University, Lucknow, India

Keywords
Stent; dental implants; CT scan; prostheses; implants; edentulous.

Correspondence
Dr. Balendra Pratap Singh, Flat No. 101, New Teachers Apt., TG Hostel, Chowk, Lucknow-226003, India. E-mail: balendra02@yahoo.com

Accepted March 1, 2011

doi: 10.1111/j.1532-849X.2011.00789.x

Abstract

Purpose: To evaluate the efficacy of a dual purpose (diagnostic and surgical) acrylic resin stent with gutta percha marker used in conjunction with 3D imaging in determination of the position and inclination of dental implants.

Materials and Methods: This study was performed as a case control study. A total of 41 implants, of which 20 had been placed without the use of stents and 3D imaging (control group) and 21 were placed using stents and 3D imaging (study group), were studied. A diagnostic and surgical stent with radio-opaque indicator (gutta percha) was fabricated to determine the planned prosthetic position and inclination of the implant. Computed tomography images were obtained and were analyzed using Denta Scan software. The position of the implant was analyzed in mesiodistal and buccolingual dimensions in terms of both position and angulation. SPSS v15.0 was used for statistical analysis ($p < 0.05$ was considered statistically significant).

Results: The study group demonstrated an overall 98.9% efficacy of the test technique being used in the study. On qualitative assessment, the results obtained were within the defined ideal threshold level for four of five parameters (distance from buccal and lingual cortical plate, inter-implant distance, and buccolingual angulation of the implant relative to underlying alveolar bone). For mesiodistal distance from adjacent teeth, the observation was not above threshold value for only one case. For the control group, the overall efficacy was 66.9%.

Conclusion: The technique of combined use of a prosthodontic stent and 3D imaging is an efficacious and better technique in achieving an ideal position of dental implants as compared to conventional techniques using periapical and panoramic radiographs and a cast.

Despite significant advances in devices and techniques, placement of dental implants at a correct position as per the esthetic, biological, and functional perspective still remains a challenge, because the trajectory of implants is seldom consistent with that of natural teeth due to the bone loss that follows extraction. Pietrokovski[1] found that buccal bone resorption occurs at a rapid rate in the first 3 years of extraction of teeth, thus changing the amount and direction of alveolar bone. Thus it is of paramount importance to plan the position and angulation of implants in accordance with the underlying bone angulation. Garber[2,3] emphasized the importance of implant site analysis during the treatment planning stage and the importance of implant placement in the final restoration to achieve optimal esthetics and function. Branemark et al[4] stated that correct fixture spacing, alignment of fixture, and interarch space are critical to the success of a prosthesis. One of the most common mistakes while treating the implant patient is inaccurate treatment planning. Inadequate treatment planning and lack of coordination between the surgeon who places the implant and the restorative dentist leads to unacceptable results. Incorrectly positioned, malaligned, and nonparallel implants lead to nonaxial loading of the prosthesis, in turn leading to improper load distribution, an overall increase in stress concentration, and eventual loss of osseointegration.[5] Horiuchi et al[6] used finite element analysis to demonstrate that stress was most evenly distributed in cortical bone when occlusal force was directed at the center of the implant through its axis. Weinberg[7] concluded that overload of an implant is an etiologic factor in implant failure after a prosthesis is fabricated.

Thus, accurate placement of dental implants is critical in achieving a pleasing esthetic result and the correct alignment for withstanding occlusal force. For a successful implant-supported restoration, current surgical principles should be based on the prosthetically dictated patient assessment emphasizing the role of prosthodontists in planning the final position and angulation of implants.

Conventional diagnostic aids such as diagnostic casts, probing depths of mucosa over bone, and periapical and panoramic radiographs are routinely used for determining the adequacy and angulation of bone while determining the position of implants, but none of these can determine the 3D position of an implant. Petersson et al[8] stated that panoramic evaluation alone is not sufficient, as it produces images that distort the jaws nonuniformly. Weinberg[7] documented that optimum implant orientation can be aided by a 3D radiographic database provided by a computed tomography (CT) scan when used in conjunction with a diagnostic stent. Lam et al[9] compared CT to panoramic imaging for dental implant treatment planning and found that CT is the most accurate method of implant site evaluation.

Hence, the current techniques in determining correct implant position should potentially use an imaging/surgical stent in conjunction with 3D imaging. Engelman et al[10] documented that implants placed using a surgical guide are more accurately placed than those placed without a guide. The use of a stent with CT scan imaging is an inexpensive method, making treatment planning for implants a more precise and dependable procedure.[11]

Few studies have assessed the efficacy of the use of a stent for implant localization, but according to the literature, an acrylic resin stent with gutta percha marker can be used as a material of choice because of its effectiveness and ease of use.[12-14] Thus, the purpose of this study was to evaluate the efficacy of the technique of combined use of a dual-purpose acrylic resin stent with 3D imaging in determining the position of dental implants.

Materials and methods

The study was carried out with a case-control design. This study was approved by institutional ethical committee of C.S.M. Medical University, Faculty of Dental Sciences, Lucknow, India. A total of 41 implants (21 study group, 20 control group) were analyzed. In the study group, the implants were placed with the help of a stent and CT imaging. The control group was selected from the patients in whom the implants had already been placed without the use of a stent and CT scan. The same surgeon placed the implants in both groups to prevent interoperator variability.

A dual purpose (diagnostic as well as surgical) stent was fabricated on the study casts using autopolymerizing acrylic resin (Rapid Repair Monomer and Polymer, Dentsply India Pvt. Ltd, Noida, India). Diagnostic wax-up was used to establish the desired prosthetic position of the implant. Prosthetic determination of the most appropriate placement of the access holes and implant inclination (trajectory) was made for each implant placement site. In multiple implant situations, the relative parallelism of the adjacent implants was done with the help of a dental surveyor (Unident Instrument Pvt. Ltd, New Delhi, India). Gutta percha cones (Meta Biomed Co. Ltd, Chungbuk, Korea) were used as radio-opaque indicators and placed in the access holes.

The stent was placed in the patient's mouth, and CT scan images were obtained. The images were analyzed using Denta Scan software (Single slice spiral CT Scan machine, General Electric, Fairfield, CT) to obtain reformatted images. Cross-sectional, axial, and panoramic images where gutta percha rods were visible were selected for determining the 3D position of the implant.

Linear and angular measurements were made on reformatted CT scan images using Denta Scan software. The linear measurements included the distance of the implant from the buccal and lingual cortical plate, distance between implant and the adjacent tooth, and the interimplant distance. The angular measurements included angulation of the implant relative to the underlying alveolar bone and the relative parallelism between the adjacent implants. Thus, five parameters were obtained for the implants in both the study group and the control group.

To get these angular measurements, the cross-sectional and panoramic images were traced on tracing sheets. For determination of buccolingual angulation of implants, the outline of the bone and the radio-opaque marker was traced on tracing sheets. For the purpose of the study, the radiographic bone trajectory (RBT) is defined as the direction in which maximum bone is available in both buccolingual and superioinferior directions. The planned prosthetic trajectory (PPT) was determined by drawing a line through the center of the radio-opaque indicator perpendicular to the occlusal plane. With a protractor, the difference between the two trajectories was recorded. The RBT was designated as the zero mark from which the deviation of PPT was calculated. To determine the relative parallelism between the adjacent implants, panoramic images were traced, and lines were drawn through the long axis of the radio-opaque marker, and their angulation was recorded relative to the occlusal plane.

If the values of the above-mentioned parameters were within the defined threshold values, the diagnostic stent was converted into the surgical stent by removal of gutta percha from the access hole and was used for implant placement. A CT scan was done about 2 weeks after implant placement, and the same values for the different parameters were recorded to analyze the achieved position of the implant.

The values obtained for parameters in the study group and control group were compared to the threshold values (Table 1)

Table 1 Parameters analyzed for implants and their threshold values

Parameter	Ideal threshold value
Distance of implant from buccal and lingual cortical plate	>0.5 mm
Distance of implant from the adjacent tooth (at cementoenamel junction)	>1.5 mm
Interimplant distance	>3.0 mm
Buccolingual angulation of implant in relation to underlying alveolar bone	<20°

Table 2 Qualitative assessment of results obtained for test specimens (study group) for various parameters

Parameter	Study group Total No.	No. of specimens within limit	Percentage	Ideal threshold value
Distance of implant from buccal cortical plate (mm)	21	21	100	>0.5 mm
Distance of implant from lingual cortical plate (mm)	21	21	100	>0.5 mm
Buccolingual implant angulation (°)	20	20	100	<20°
Mesiodistal linear distance from adjacent tooth (mm)	19	18	94.7	>1.5 mm
Interimplant distance (mm)	10	10	100	>3 mm
Overall efficacy (sum of all parameters/5)			98.9%	

for these parameters to obtain the efficacy of the test technique. A single examiner measured every parameter, twice at 2-week intervals. The mean values were used for statistical analysis.

A comparison of the values obtained was also made between the cases and controls. The statistical analysis was done using SPSS v15.0 (SPSS Inc., Chicago, IL). A probability value of less than 0.05 was considered statistically significant.

Results

The study group demonstrated a 98.9% overall efficacy for the test technique being used (Table 2). For the control group, the overall efficacy was 66.9% (Table 3). The comparison of qualitative assessment in both groups is shown in Table 4 and Figure 1.

The difference of mean values for all parameters between cases and controls and standard deviations are shown in Table 5. In multiple implant situations, deviation from relative parallelism between adjacent implants was higher in the control group than in the study group (Table 6).

Discussion

As implants have become a more common treatment modality for missing teeth, dentists are challenged with more and more unpredictable anatomical situations. Unless all the information required for 3D orientation of the implant is available, the final restoration may be put at unnecessary risk. The implant should be placed in accordance with the predetermined final prosthesis.

In our study, we used a dual-purpose (diagnostic as well as surgical) stent in conjunction with CT scan imaging in the determination of the position of implants. Various stent designs[15-20] have been documented in the literature, varying from simple (i.e., those made from vaccuform matrix) to more complex (i.e., those made of clear self-cure acrylic incorporating metal disks and tubes). The gutta percha acrylic resin stent serves both as an imaging and surgical stent. It serves as a radio-opaque indicator transposing the planned prosthetic angulation to a cross-sectional tomogram; the access hole later can serve as an osteotomy guide after the removal of gutta percha. The metal tubes and disks are also both imaging and surgical osteotomy guides. They provide high precision, but can produce artifacts on radiographs. Also, they do not allow flexibility during the placement procedure and are technique sensitive in comparison to acrylic resin gutta percha stents.[14] An acrylic resin stent also offers the advantages of ease of fabrication and cost effectiveness. It can be used in partially and completely edentulous patients and in single- as well as in multiple-implant situations.

The results in our study showed that the study group had a higher overall efficacy (98.9%) than the control group (66.9%) (Tables 2 and 3). On qualitative assessment (Table 4), the results obtained were within the defined ideal threshold level for four of five parameters (distance from buccal and lingual cortical plate, interimplant distance, buccolingual angulation of implant relative to underlying alveolar bone). For mesiodistal linear distance from adjacent tooth, in only one of nineteen cases was the value less than threshold value (98.9% efficacy).

Table 3 Qualitative assessment of results obtained for control specimens for various parameters

Parameters	Control group Total No.	No. of specimens within limit	Percentage	Ideal threshold value
Distance of implant from buccal cortical plate (mm)	20	6	30	>0.5 mm
Distance of implant from lingual cortical plate (mm)	20	18	90	>0.5 mm
Buccolingual implant angulation (°)	20	14	70	<20°
Mesiodistal linear distance from adjacent tooth (mm)	8	5	62.5	>1.5 mm
Interimplant distance (mm)	11	9	81.8	>3 mm
Overall efficacy (Sum of all parameters/5)			66.9%	

Table 4 Comparison of qualitative assessment in two groups

Parameters	Study group		Control group		Statistical significance	
	Total no.	No. within limit	Total no.	No. within limit	χ^2	p
Distance of implant from buccal cortical plate (mm)	21	21	20	6	22.322	<0.001
Distance of implant from lingual cortical plate (mm)	21	21	20	18	2.208	0.137
Buccolingual implant angulation (°)	20	20	20	14	7.059	0.008
Mesiodistal linear distance from adjacent tooth (mm)	19	18	8	5	4.636	0.031
Interimplant distance (mm)	10	10	11	9	2.010	0.156

For the control group, the maximum efficacy was achieved for the parameter distance of implant from lingual cortical plate (90%). This shows that the implants had been displaced towards the buccal cortical plate, thus leaving more bone on the lingual/palatal aspect and less bone on the buccal/facial aspect of the implant.

While considering the position of the implant in a mesiodistal plane, proximity of the implant to adjacent teeth is the greatest limiting determinant. For optimum esthetics and function it has been suggested that the implant placement should be at least 1.5 mm from the adjacent tooth, and there should be a minimum of 3.0 mm distance between the surfaces of adjacent implants. In the buccolingual plane, the implant should be at least 0.5 mm away from buccal and lingual cortical plates.[21]

On comparing the data statistically, the difference between the cases and controls was found to be significant (Fig 1, Table 5). The study group showed significantly greater values for the distance of the implant from the buccal cortical plate as well as for buccolingual implant angulation ($p < 0.001$). For the control group, although the distance from the lingual cortical plate was significantly greater ($p < 0.001$) than for the study group, it demonstrated that the implants in the control group had been displaced facially/buccally. The study also revealed that the mean mesiodistal linear distance between implant and adjacent teeth could be better maintained in the study group as compared to that of the control group.

In the buccolingual plane the trajectory of the implant should be consistent with underlying alveolar bone. For our study, it was observed that as compared to the control group, the study group demonstrated a more consistent trajectory of the implant when compared to the underlying alveolar bone ($p < 0.001$), leading to the assumption that the superstructure over the implants in the control group is susceptible to failure due to offset forces. This is one of the primary factors leading to loss of osseointegration. Moderate differences (up to 20°) can be compensated with the use of angled abutments. Extreme deviation (over 20°) may result in biomechanical, technical, and esthetic compromises.[22]

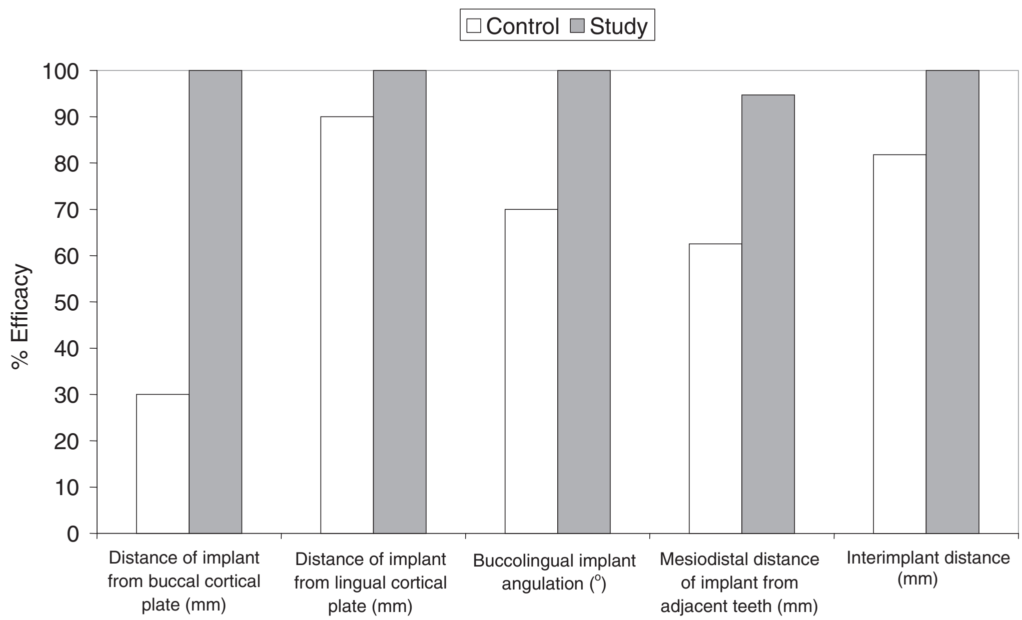

Figure 1 Comparison of qualitative assessment of two groups.

Table 5 Comparison of quantitative assessment in two groups

Parameters	Study group (n = 5) Mean	SD	Control group (n = 5) Mean	SD	Ideal threshold value	"t"	"p"
Distance of implant from buccal cortical plate (mm)	1.795	0.631	0.755	1.122	>0.5	3.683	<0.001
Distance of implant from lingual cortical plate (mm)	1.59	0.477	2.44	1.097	>0.5	3.430	<0.001
Buccolingual implant angulation (°)	6.55	4.097	15.70	7.974	<20	4.567	<0.001
Mesiodistal linear distance from adjacent tooth (mm)	2.811	0.920	1.863	1.066	>1.5	2.336	0.028
Interimplant distance (mm)	3.33	0.452	7.18	3.977	>3.0	3.038	0.007

In cases of multiple implants, the relative parallelism between adjacent implants is also important. Non-parallel implant placement is the primary cause of non-axial loading during function and also poses difficulties in determining the path of insertion of the prosthesis. The implant parallelism should occur in both mesiodistal and buccolingual directions. In our study, it was found that deviation from relative parallelism between adjacent implants was higher in the control group as compared to the study group (Table 6). The results obtained from this study demonstrate that a more accurate implant placement could be obtained with a stent and 3D imaging as compared to implant placement without the use of a stent.

Conclusions

The following conclusions were drawn after performing the study and by careful interpretation of results:

1. Distance of the implant from the buccal cortical plate and lingual cortical plate showed a high within-group variability for the control group subjects. These distances were found to be more consistent in the study group.
2. Distance of the implant from adjacent teeth, interimplant distance, and buccolingual implant angulation also showed higher consistency in the study group than in the control group, thereby showing that in the study group, implant placement was more accurate and precise.
3. Qualitative assessment of implant placement in the study group showed an almost absolute efficacy (98.5%) as compared to only one-third efficacy (66.9%) in the control group.
4. Comparison of item-wise qualitative efficacy did not show a significant difference between the two groups for the parameters interimplant distance and distance of implant from lingual cortical plate.
5. In multiple implant situations, deviation from relative parallelism between adjacent implants was higher in the control group than in the study group.

Table 6 Deviation from relative parallelism in multiple-implant situation control versus study group

Parameter	Control group (n = 21) Mean	SD	Study group (n = 15) Mean	SD	"t"	"p"
Mesiodistal	7.48	8.44	3.27	3.18	1.835	0.075
Buccolingual	6.52	4.35	1.40	0.83	4.482	<0.001

On the basis of the above inferences it can be concluded that the technique of combined use of prosthodontic stents and 3D imaging is an efficacious and better technique in achieving the ideal position of dental implants as compared to the conventional technique of using periapical and panoramic radiographs or casts. The only care that needed to be taken was in the conversion of the stent from radiographic to surgical use. It should be taken into consideration that there may be a discrepancy between the angulation and position of the radio-opaque marker and ideal implant location and angulation if the conversion process is carried out improperly. Since there have not been many studies on determining the efficacy of stents, we have attempted to evaluate the efficacy of an acrylic stent with a gutta percha marker in determining the position and angulation of dental implants; however, it is not the only technique to do so. Before establishing any clinical guidelines for a stent, numerical data must be obtained on the success-to-failure ratios of various stent designs after concomitant use of cross-sectional tomography.

References

1. Pietrokovski J: The bony residual ridge in man. J Prosthet Dent 1975;34:456-462
2. Garber DA: The esthetic dental implant: letting restoration be the guide. J Am Dent Assoc 1995;126:319-325
3. Garber DA, Belser UC: Restoration driven implant placement with restoration generated site development. Compend Contin Educ Dent 1995;16:796-804
4. Branemark, P-I, Zarb G, Albrektsson T: Long-term treatment results. In Branemark P-I, Zarb G, Albrektsson T (eds): Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry. Chicago, Quintessence, 1995, pp. 175-186
5. Taylor TD, Agar JR, Vogiatzi T: Implant prosthodontics: current perspective and future directions. Int J Oral Maxillofac Implants 2000;15:66-75
6. Horiuchi M, Ichikawa T, Kanitani HW, et al: Pilot hole prepration for proper implant positioning and enhancement of bone formation. J Oral Implantol 1995;21:318-324
7. Weinberg LA: CT scan as a radiologic data base for optimum implant orientation. J Prosthet Dent 1993;69:381-385

8. 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
9. 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;74:42-46
10. Engelman MJ, Sorenson JA, Moy P: Optimum placement of osseointegrated implants. J Prosthet Dent 1988;59: 467-473
11. Higginbottom FL, Wilson TG Jr: Three-dimensional templates for placement of root-form dental implants: a technical note. Int J Oral Maxillofac implants 1996;11:787-793
12. Pesun IJ, Gardner FM: Fabrication of a guide for radiographic evaluation and surgical placement of implants. J Prosthet Dent 1995;73:548-552
13. Urquiola J, Toothaker RW: A modified template for quick intraoperative reference to computed tomographic scan images. J Prosthet Dent 1997;77:340-341
14. Almog DM, Torrado E, Meitner SW: Fabrication of imaging and surgical guide for dental implants. J Prosthet Dent 2001;85: 504-508
15. Adrian ED, Ivanhoe JR, Krantz WA: Trajectory surgical stent for implant placement. J Prosthet Dent 1992;67:687-691
16. Akca K, Iplikcioglu H, Cehreli MC: A surgical guide for accurate mesiodistal paralleling of implants in the posterior edentulous mandible. J Prosthet Dent 2002;87:233-235
17. Neidlinger J, Lilien BA, Kalant DC Sr: Surgical implant Stent: a design modification and simplified fabrication technique. J Prosthet Dent 1993;69:70-72
18. Solow RA: Simplified radiographic-surgical template for placement of multiple, parallel implants. J Prosthet Dent 2001;85:26-29
19. Atsu SS: A surgical guide dental implant placement in edentulous posterior regions. J Prosthet Dent 2006;96:129-133
20. Shotwell JL, Billy EJ, Wang HL, et al: Implant surgical guide fabrication for partially edentulous patients. J Prosthet Dent 2005;93:294-297
21. Misch CE: Available bone and implant dentistry. In Misch CE (ed): Dental Implant Prosthodontics. St. Louis, Mosby, 2005, pp. 105-110
22. Almog DM, Sanchez R: Correlation between planned prosthetic and residual bone trajectories in dental implants. J Prosthet Dent 1999;81:562-567