



Guidelines for Positioning External Hexagon Implants in Screw-Retained Multiple Prostheses Using Rotational Abutment-Type Components

Andre da Costa Salgado, CD,* Aldir Nascimento Machado, CD, MScD,† Waldimir Carvalho, CD, MScD,‡ Eliane Porto Barboza, CD, MScD, DScD,§ and Cresus Vinicius Depes de Gouvêa, CD, DScD||

The increasing use of implants for the restoration of partially edentulous patients with the introduction of new concepts has extended the capabilities of dental prostheses. The primary function of a dental implant is to act as an abutment for a prosthetic device, similar to that of a natural tooth root and crown.¹ However, the success of implant-supported prostheses depends largely on the passivity achieved and stress distribution patterns. No stress concentration should be localized.² The implant abutment that is set on the implant platform provides a standard axial angulation to prosthesis placement.³ A less than optimal fit may result in bacterial aggregation leading to peri-implant inflammation, and it may also lead to breakage of components.⁴⁻⁷

When a bar is used to connect the implants and distribute forces,⁸ passive

Purpose: This study measured the maximum angulation between 2 implants allowed by the internal walls of the component in screw-retained multiple prostheses using rotational abutment-type components.

Materials and Methods: Thirty specimens of 3 different brands (Conexão; Neodent; and SIN), consisting of titanium rotational abutments connected to external hexagon abutment analogs with standard platforms, were divided into 3 groups. The specimens were internally filled with polyester resin, screw retained, torque, and sectioned to assess the space existing between the internal wall of the rotational abutment component, edge, and vertex of the hexagon. The measurements were performed using 3-dimensional equipment.

Results: When the implant hexagons were oriented edge-to-edge, groups 1, 2, and 3 presented 40.75, 45.00, and 31.89 degrees, respectively. Vertex-to-vertex hexagon orientation showed 9.79, 18.18, and 3.27 degrees for groups 1, 2, and 3, respectively.

Conclusions: The maximum mean angulation in the mesio/distal direction between the 2 implants with hexagon-oriented vertex-to-vertex is 10.41 degrees, and hexagon-oriented edge-to-edge is 39.54 degrees. This study suggests guidelines for positioning external hexagon implants for interference-free screw-retained multiple prostheses using rotational abutment-type components. (Implant Dent 2014;23:602–606)

Key Words: dental implant, rotational abutment, external hexagon implant

*Graduate Student, Department of Prosthodontics, Fluminense Federal University School of Dentistry, Rio de Janeiro, Brazil.

†Assistant Professor, Department of Prosthodontics, Fluminense Federal University School of Dentistry, Rio de Janeiro, Brazil.

‡Assistant Professor, Department of Prosthodontics, Laboratory of Applied Biotechnology, Fluminense Federal University School of Dentistry, Rio de Janeiro, Brazil.

§Associate Professor, Department of Prosthodontics, Fluminense Federal University School of Dentistry, Rio de Janeiro, Brazil.

||Chairman, Department of Prosthodontics, Laboratory of Applied Biotechnology, Fluminense Federal University School of Dentistry, Rio de Janeiro, Brazil.

Reprint requests and correspondence to: Aldir Nascimento Machado, CD, MScD, Rua Morais e Silva 139 c 01, Maracanã, Rio de Janeiro, Brazil 20271-031, Phone: 55 (021) 38521997, Fax: 55 (021) 22406087, E-mail: aldirmachado@gmail.com

fit is a primary objective.⁹ In many cases, passive fit can be difficult to establish.¹⁰ The component attachment screws in splinted prosthetic suprastructures often fail because of the inadequate placement of these structures, which creates tension on the screws, leading to plastic deformation and consequently to fracture.¹¹ A component fracture in osseointegrated implants is a clinical sign that excessive forces and/or improper forces are acting on the suprastructure.¹² The causes of the fractures have been divided into 3 groups:

- (1) defects inherent to the implant itself,
- (2) lack of passive fit in the placement of the metal prosthesis structure, and
- (3) physiological or biomechanical overload.¹³

The rotational abutments are widely used and were designed for multiple prostheses because they do not have an antirotational system at the base. These bases can be made of gold, nickel-chromium, cobalt-chromium, and titanium.¹⁴ The bases have a circular shape inside, which enables them to be used in multiple prostheses, and their main

advantage is presented as allowing the use of reduced interocclusal spaces. It is known that internal abutments accomplish the need for reduced spaces; however, these abutments can not be used in multiple splinted screwed prostheses. Several techniques have been shown for the use of these components to restore implants angulation using telescopic crowns and horizontal screws by fixing superstructures to these components.¹⁵

The objective of this study was to measure the maximum angulation between 2 implants allowed by the internal walls of the component in screw-retained multiple prostheses using rotational abutment-type components. A guideline for positioning external hexagon implants will be reported.

MATERIALS AND METHODS

Ten titanium abutments with rotational systems, 10 external hexagon-type abutment analogs with standard platform (4.1 mm), and 10 titanium abutment screws from 3 Brazilian companies (Conexão [group 1; São Paulo, Brazil]; Neodent [group 2; Curitiba, Brazil], and SIN [group 3; São Paulo, Brazil]) were selected for this study.

The abutments' analogs were embedded up to half of the base in a block of acrylic resin (JET; Clássico, São Paulo, Brazil). The rotational components were screw-retained on the abutment analogs using the torque recommended by the manufacturers (32 N·cm). The interior of the set was filled with neutral polyester resin (Fibramix, Rio de Janeiro, Brazil) with black-colored pigment to prevent it from being invaded by residues from cutting. In addition, this procedure made it easier to take the digital microphotograph, analyze the images, and take measurements. The rationale of selecting this resin was because it has no compound that confers mechanical properties that could prevent seating of the rotational abutment on the analogs and also because it facilitates visualization of the internal spaces of the set. The set was sectioned using a low-speed precision cutter (Labcut 1010; Extec Corp, São Paulo, Brazil) with a 0.3-mm thick diamond disk, automatically cooled in accordance with the standard, ASTM E 3 Preparation of Metallographic Specimens.

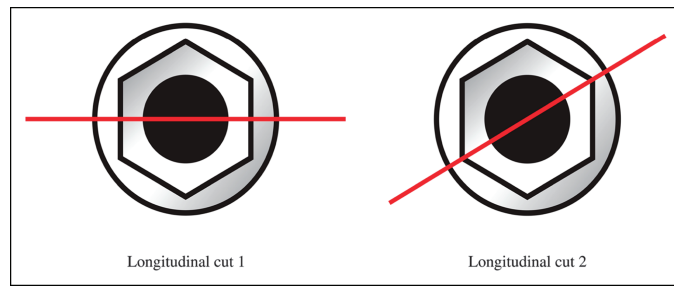


Fig. 1. Longitudinal cuts of the rotational abutment. Longitudinal cut 1 was performed from edge-to-edge, dividing in half. Longitudinal cut 2 was performed from vertex-to-vertex, dividing in half.

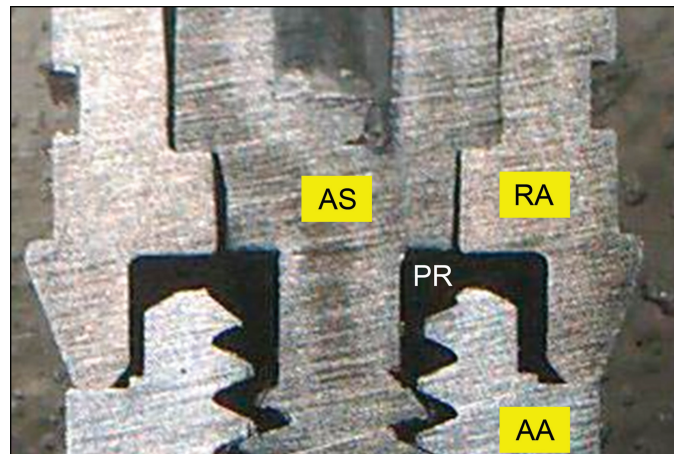


Fig. 2. Longitudinal cut of the set. Images were captured from AA, RA, AS, PR. Note that the polyester resin exhibits the internal space of the set. This method was used to obtain data of the distance between the internal wall of the vertex and the edge of the hexagon. AA indicates abutment analog; RA, rotational abutment; AS, abutment screw; PR, polyester resin.

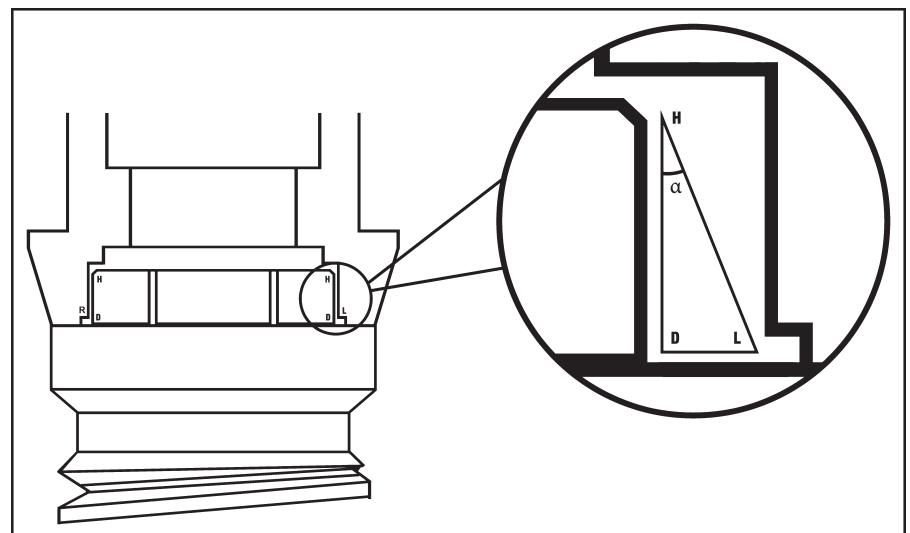


Fig. 3. Triangle (H/D/L) formed between the inner wall of rotational abutment and the edge or vertex of the hexagon of the implant. The angle α represents the maximum angle obtained for inserting a rotational abutment without interferences for a single implant.

Table 1. Measurements Between the Internal Face of the Abutment and the Edge of the Hexagon for Rotational Components

Components	HD, mm	DR, mm	DHR α Angle	HD, mm	DL, mm	DHL α Angle	Sum of the Angles
Group 1	0.7	0.26	20.37643521	0.7	0.26	20.37643521	40.75287043
Group 2	0.7	0.29	22.5035285	0.7	0.29	22.5035285	45.007057
Group 3	0.7	0.2	15.9453959	0.7	0.2	15.9453959	31.8907918

HD indicates platform base height to the end of the hexagon; DR, hexagon distance (edge or vertex) to the internal wall of the rotational abutment on the right side; DHR α angle, angle formed by the DR and HD distance inside a right triangle; DL, hexagon distance (edge or vertex) to the internal wall of the rotational abutment on the left side; DHL α angle, angle formed by the DL and HD distance inside a right triangle; sum of the angles, sum of the DHR angles of the implant and the DHL of the adjacent implant.

Table 2. Measurements Between the Internal Face of the Abutment and the Vertex of the Hexagon for Rotational Components

Components	HD, mm	DR, mm	DHR α Angle	HD, mm	DL, mm	DHL α Angle	Sum of the Angles
Group 1	0.7	0.06	4.899092454	0.7	0.06	4.899092454	9.798184908
Group 2	0.7	0.112	9.090276921	0.7	0.112	9.090276921	18.18055384
Group 3	0.7	0.02	1.636577042	0.7	0.02	1.636577042	3.273154083

HD indicates platform base height to the end of the hexagon; DR, hexagon distance (edge or vertex) to the internal wall of the rotational abutment on the right side; DHR α angle, angle formed by the DR and HD distance inside a right triangle; DL, hexagon distance (edge or vertex) to the internal wall of the rotational abutment on the left side; DHL α angle, angle formed by the DL and HD distance inside a right triangle; sum of the angles, sum of the DHR angles of the implant and the DHL of the adjacent implant.

Fifteen test specimens were submitted to a longitudinal cut to the rotational abutment passing through the middle of the hexagon edges dividing in half (longitudinal cut 1). The other 15 test specimens were submitted

to a longitudinal cut to the rotational abutment passing through the vertices of the hexagon dividing in half (longitudinal cut 2; Fig. 1).

The test specimens were ground using a metallographic grinding and polishing machine (PLO2D; Teclago, São Paulo, Brazil) with silicon carbide abrasive paper of 600, 1200, and 2000 grains (Norton, São Paulo, Brazil), and then taken to capture the images (Anatomic Opton Stereo Microscopic, Stuttgart, Germany) in accordance with the standard ASTM E 88 3 Metallographic Photomicrography and Measurement (Fig. 2). The measurements of the internal space were taken to estimate the distance between the internal wall of the vertex and edge of the hexagon.

The 3-dimensional measurement equipment (7.27.010; Werth, Giessen, Germany) with accuracy of 0.0001 mm was used to obtain the mean values by means of mathematical approximation. The values found were attributed to the walls (base) of a right triangle, visualized within the space between the edges or vertices of the hexagon and the internal wall of the rotational abutment (Fig. 3). An angle α was formed between the adjacent line and the obtained hypotenuse using Pythagoras' theorem and the sine table of an angle. This was the maximum angle obtained for inserting a rotational abutment type without interferences for a single implant.

To obtain the maximum angulation between 2 implants using 2 joined rotational abutments, the angle α on the right side of an implant was added

to the angle α on the left side of the adjacent implant.

RESULTS

Components of group 2 presented the largest space between the edge or vertex of the hexagon and the internal wall of the rotational abutment. This provides a larger angle possible (up to 45 degrees) between implants, if hexagon orientation is edge-to-edge (Table 1). However, if hexagon orientation is vertex-to-vertex, it provides a work angulation up to 18.18 degrees (Table 2). Group 1 presented a work angulation up to 40.75 degrees when hexagon orientation is edge-to-edge (Table 1) and up to 9.79 degrees when hexagon orientation is vertex-to-vertex. Group 3 components presented the smallest space, providing a work angulation up to 31.89 degrees with edge-to-edge hexagon orientation (Table 1) and 3.27 degrees with vertex-to-vertex hexagon orientation (Table 2).

The maximum mean angulation in the mesiodistal direction between the implants with vertex-to-vertex hexagon orientation was 10.41 degrees (Fig. 4), and when the hexagon orientation was edge-to-edge, it was 39.54 degrees (Fig. 5).

DISCUSSION

This study measured the maximum angulation between 2 external hexagon implants that is allowed by the internal walls of the components in screw-retained multiple prostheses using rotational abutment-type components.

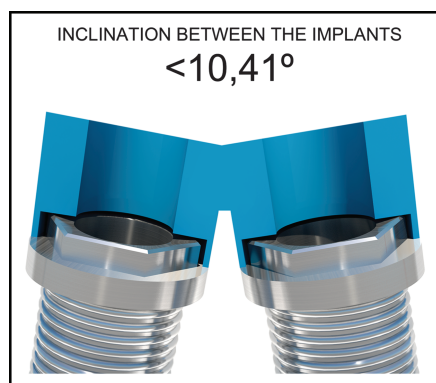


Fig. 4. The maximum angle of 10.41° was found for the insertion of the abutments with implants positioned with the edge of the hexagon directed toward the buccal region.

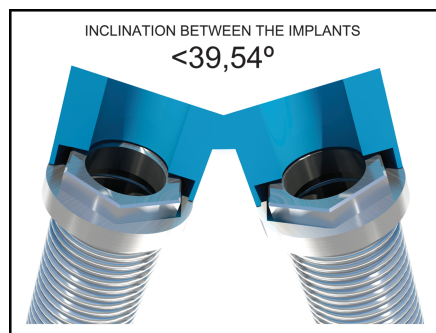


Fig. 5. The maximum angle of 39.54° was found for the insertion of the abutments with the implant positioned at the vertex of the hexagon directed toward the buccal region.

The results showed that, during the implant placement, if implant angulation is needed in the mesial/distal direction, the implants should be positioned with the hexagons edge-to-edge. This position may increase the framework fit, allowing the prostheses passivity.

Implant-supported fixed prostheses comprise essentially screw-retained and cement-retained superstructures.^{16,17} In this study, external hexagon-type implant analogs 4.1 platforms were used, associated with nonrotational UCLA abutments. External hexagon-type implants have been widely used^{18,19} for both posterior and anterior regions, for single or multiple prostheses, and in cases in which the implants are not aligned among themselves. The use of a UCLA abutment contributes to a single direction for the insertion of the final restoration by the milling of interferences. This type of abutments is also popular to correct malpositioned implants, enhance esthetics, and improve function. Long-term evaluation of custom-milled abutments suggests that the real concern for the use of the UCLA abutment was not the fit of an individual casting to an implant but rather the fit of an implant restoration to multiple implants.¹⁴

The three-dimensional implant positioning has been studied to obtain better esthetic outcomes.^{20,21} However, little importance has been given to the study of problems concerning implant misalignment. The position of the implant hexagons is an important concern for an interference-free placement of a screw-retained multiple prosthesis using rotational abutment-type components. The results of this study showed that when the edges of 2 implants are parallel, vertices facing to the buccal region, it allows a greater angulation between the implants in the mesio/distal direction. However, when the implants are positioned vertex-to-vertex, edges facing to the buccal region, angulation in the same direction becomes limited.

Passive fit is assumed to be a significant prerequisite for the maintenance of the bone-implant interface. This vital requirement may be provided by simultaneous and even mating of the complete inner surfaces of all retainers by all abutments.²² When a passive fit is achieved, the stress is widely distributed

in all components, producing less peak stress in each component.²³ For a screw-retained prosthesis, if the marginal gaps between the framework and abutments are excessive, large external preloads are introduced on the implant abutments and fixation screws, causing loosening or fracture.^{24,25} A revision study evaluated the clinical significance of passive fit on the final marginal of implant-supported restorations. The authors recommended that the implant-abutment assembly should result in a passive connection, not inductive of tension in implant components and adjacent bone.²² This study suggests that up to 39.54 degrees (mean value) of angulation between the implants in the mesio/distal direction, an interference-free insertion is possible with the rotational abutment-type components, considering implants positioned with the vertex of the hexagon directed toward the buccal region.

CONCLUSIONS

The maximum mean angulation in the mesio/distal direction between 2 implants with hexagon-oriented vertex-to-vertex is 10.41 degrees and hexagon-oriented edge-to-edge is 39.54 degrees. During the implant placement, if implant angulation is needed in the mesial/distal direction, the implants should be positioned with the hexagons edge-to-edge. This study suggests guidelines for positioning external hexagon implants for interference-free screw-retained multiple prostheses using rotational abutment-type components.

DISCLOSURE

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

REFERENCES

1. Misch CE, Perel ML, Wang HL, et al. Implant success, survival, and failure: The International Congress of Oral Implantologists (ICOI) Pisa Consensus Conference. *Implant Dent*. 2008;17:5–15.
2. Assunção WG, Gomes EA, Rocha EP, et al. Three-dimensional finite element analysis of vertical and angular misfit in implant-supported fixed prostheses. *Int J Oral Maxillofac Implants*. 2011;26:788–796.

3. Carvalho W, Ferreira V, Barboza E. Multiple abutment positional guide. *Implant Dent*. 2009;18:5–9.
4. Harder S, Dimaczek B, Açil Y, et al. Molecular leakage at implant-abutment connection—In vitro investigation of tightness of internal conical implant-abutment connections against endotoxin penetration. *Clin Oral Investig*. 2010;14:427–432.
5. Scarano A, Assenza B, Piattelli M, et al. Retrospective evaluation of the microgap between implants and abutments in 272 titanium implants retrieved from man: A 16 years experience (1989–2004). *J Oral Implantol*. 2005;31:269–275.
6. Rangert B, Krogh PH, Langer B, et al. Bending overload and implant fracture: A retrospective clinical analysis. *Int J Oral Maxillofac Implants*. 1995;10:326–334.
7. Cantwell A, Hobkirk JA. Preload loss in gold prosthesis—Retaining screws as a function of time. *Int J Oral Maxillofac Implants*. 2004;19:124–132.
8. Dietsh F, Misch CE, Robertson E. The clinical utility of a premounted abutment for cement retention. *Compendium*. 1998;19:10–16.
9. Sahin S, Cehreli MC. The significance of passive framework fit in implant prosthodontics: Current status. *Implant Dent*. 2001;10:85–92.
10. Cheshire PD, Hobkirk JA. An in vivo quantitative analysis of the fit of Nobel Biocare implant superstructures. *J Oral Rehabil*. 1996;23:782–789.
11. Naert I, Quirynen M, Van Steenbergue D, et al. A Study of 589 consecutive implants supporting complete fixed prostheses. Part II: Prosthetic aspects. *J Prosthet Dent*. 1992;68:949–955.
12. McGlumphy EA, Mendel DA, Holloway JA. Implant screw mechanics. *Dent Clin North Am*. 1998;42:71–89.
13. Balshi TJ, Hernandez RE, Pryszyk MC, et al. A comparative study of one implant versus two replacing a single molar. *Int J Oral Maxillofac Implants*. 1996;11:372–378.
14. Lewis SG, Llamas D, Avera S. The UCLA abutment: A four-year review. *J Prosthet Dent*. 1992;67:509–515.
15. Ramos MB, Pegoraro LF, Takamori E, et al. Evaluation of UCLA implant-abutment sealing. *Int J Oral Maxillofac Implants*. 2014;29:113–120.
16. Hebel KS, Gajjar RS. Cement-retained versus screw-retained implant restorations: Achieving optimal occlusion and esthetics in implant dentistry. *J Prosthet Dent*. 1997;77:28–35.
17. Taylor TD, Agar JR, Vogiatzi T. Implant prosthodontics: Current perspective and future directions. *Int J Oral Maxillofac Implants*. 2000;15:66–75.
18. Misch CE, Barboza ESP, Steigenga J, et al. Short dental implants in

posterior partial edentulism: A multicenter retrospective 6-year case series study. *J Periodontol*. 2006;77:1340–1347.

19. Misch CE, Misch-Dietsh F, Silc J, et al. Posterior implant single-tooth replacement and status of adjacent teeth during a 10-year period: A retrospective report. *J Periodontol*. 2008;79:2378–2382.

20. Garber DA. The esthetic dental implant: Letting restoration be the guide. *J Am Dent Assoc*. 1995;126:319–325.

21. Funato A, Salama MA, Ishikawa T, et al. Timing, positioning, and sequential staging in esthetic implant therapy: A four-dimensional perspective. *Int J Periodontics Restorative Dent*. 2007;27:313–323.

22. Sahin S, Cehreli MC. The significance of passive framework fit in implant prosthodontics: Current status. *Implant Dent*. 2001;10:85–92.

23. Kunavisarut C, Lang LA, Stoner BR, et al. Finite element analysis on

dental implant-supported prostheses without passive fit. *J Prosthodont*. 2002;11:30–40.

24. Kallus T, Bessing C. Loose gold screws frequently occur in full-arch fixed prostheses supported by osseointegrated implants after 5 years. *Int J Oral Maxillofac Implants*. 1994;9:169–178.

25. Balshi TJ. An analysis and management of fractured implants: A clinical report. *Int J Oral Maxillofac Implants*. 1996;11:660–666.