

Fabrication of a Functionally Generated, Implant-Retained Fixed Partial Denture

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Partially edentulous patients are frequently restored with implant-supported restorations between and opposing natural teeth. Differences in horizontal and vertical mobility of teeth and dental implants necessitate occlusal contact modification to create prostheses that harmonize with the opposing dentition. This article describes a functionally generated path technique to achieve optimal articulation between an implant-retained fixed partial denture and the patient's dentition.

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PARTIALLY EDENTULOUS patients are frequently restored with implant-retained restorations that oppose natural teeth. Natural teeth and implant restorations exhibit significant differences in horizontal and lateral mobility.¹ Rudd et al² reported that the normal lateral mobility of natural teeth ranges from 56 μm for the posterior teeth to 108 μm for the anterior teeth. In addition, investigations by Parfitt³ found the average vertical mobility of natural teeth to be 28 μm . Sekiene⁴ reported that dental implants have an average lateral mobility of 50 μm and vertical mobility of 10 μm . These mobility differences between natural teeth and implant-retained restorations necessitate a decrease in the magnitude of occlusal contact, to minimize the potential damage from lateral forces on the implant restoration during excursive movements.¹ Patients receiving dental implant restorations may present with a worn dentition that has reduced or absent anterior guidance. In addition, these patients may demonstrate group function articulation during lateral movements. In patients

in whom group function occlusion is planned, control of the occlusion and cuspal movement paths is critical. The functionally generated path technique is indicated for the fabrication of these restorations.

The functionally generated path technique for the fabrication of complete denture occlusion has been described by many authors and, according to Bergstrom, dates back to the late 1800s.⁵⁻¹³ In 1901 Christensen⁵ described a method of letting the patients "chew-in" wax occlusion rims, thus generating articulation paths used to set the articulator. In 1923 Paterson⁶ introduced a method similar to that of Christensen using "bite plates" and a mixture of carborundum and plaster to create a patient-generated plane of occlusion. In 1934 Meyer described a technique similar to that of Christensen that used multiple base plates to create plaster "functional occlusal paths," allowing fabrication of complete dentures with bilateral balanced articulation.^{5,7,8} Meyer stated that the principle of the functionally generated path was the "automatic determination of the geometric harmonious relationship between the occlusal path (the functional occlusal path) and the condylar paths at a chosen vertical dimension."^{7,8} Application of the functionally generated path technique for the fabrication of fixed partial dentures can also be attributed to Meyer.¹⁴ In addition, Mann and Pankey¹⁰ and Dawson¹⁵ described using the functionally generated path technique for fixed prosthodontic occlusal rehabilitation.

The dental literature describes multiple techniques for using the functionally generated path technique to fabricate fixed restorations. Many of these techniques use a functional impression wax

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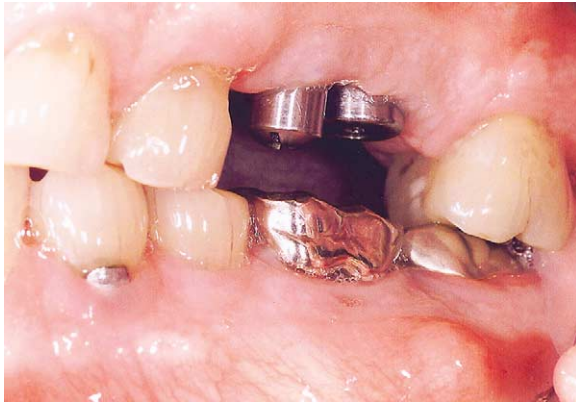


Figure 1. Left buccal view showing the MIP and moderate occlusal wear.

(Tackywax; H.J. Bosworth, Chicago, IL) as the means of recording functional movements. This wax may be applied directly to the prepared tooth or, more commonly, to an acrylic resin recording table. Fast-set dental stone is then applied directly to the generated wax path to produce a stone core of the recording. The stone core is transferred to a simple hinge articulator and mounted opposing the preparation.¹⁴⁻¹⁹ Other techniques have attempted to simplify the functionally generated technique for fixed restorations by using a “double-casting” method,²⁰ a direct-wax technique on prosthesis copings,²¹ or acrylic resin crown forms.²²

This article describes the use of a functionally generated path technique to aid in the development of optimal articulation for an implant restoration.

Technique

The patient presented with moderate occlusal wear and unilateral group function articulation. Implants were placed in sites #12 and #13 (Fig 1).

1. Final impressions were made, and soft tissue mouldage material was added around the implant replicas (Durabase Soft Cushion Rebase; Reliance Dental, Worth, IL). Then the master cast was poured in type IV dental stone (Silky Rock; WhipMix Corp., Louisville, KY) (Fig 2).
2. Single-tooth provisional crown copings (Steri-Oss Direct Abutment, Hexed, Temporary; Nobel Biocare USA, Yorba Linda, CA) were attached to the implant replicas, and acrylic resin (Pattern Resin; GC Corp., Tokyo, Japan) was placed around the copings.

3. The acrylic resin copings were milled to have parallel walls and an internal keyway to aid in the frictional attachment of the recording table.
4. The acrylic resin copings were lubricated, and a detachable acrylic resin recording table was fabricated to fit over the milled copings. The recording table was extended to the mesial and distal contacts and was 12 mm wide (facial-lingually), to accommodate working and nonworking movements (Fig 2). The detachable recording table facilitated the addition of recording wax during the functional recording procedure.
5. The copings and recording tables were placed onto the patient's implants. Approximately 2–3 mm of functional impression wax (Korecta Wax #4; D-R Miner Dental, Concord, CA) was added onto the occlusal surface of the recording table.
6. The recording was made by guiding the patient's movements, beginning with guiding the patient to close into the wax in the maximal intercusp position (MIP). Next, the patient was guided from a lateral working position back into the MIP, then from a nonworking position back to the MIP, and finally from a protrusive position back to the MIP.^{10,17} Wax was added to the areas where the opposing cusps did not carve the wax. Once these movements were completed, the patient was guided to move from the MIP out through all lateral excursive movements (working, nonworking, and protrusion). Finally, the patient moved through combinations of movements.¹⁶ Figure 3 shows the final functional recording.
7. The recording table was removed from the patient's mouth, and the assembly was replaced on

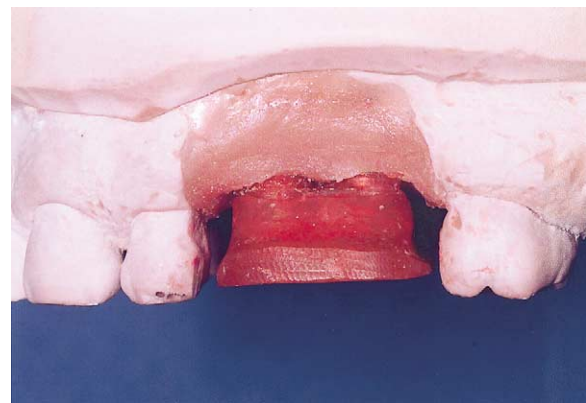


Figure 2. The detachable acrylic resin recording table is placed over the milled retaining coping.

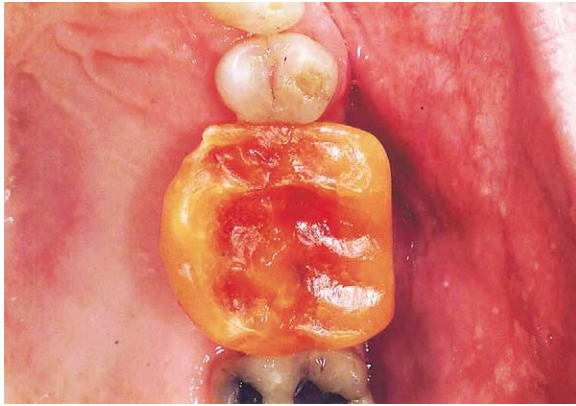


Figure 3. The functionally generated path wax recording is completed using the resin recording table and Korecta Wax #4.

the master maxillary cast. A dental stone core (Mounting Stone; WhipMix Corp.) was gently poured into the wax recording and then mounted to the lower member of the articulator (Model 100; WhipMix Corp.) (Fig 4).

8. The final restorations were then fabricated. First, custom abutments (Steri-Oss Direct Abutment, Hexed, Gold Alloy/Plastic; Nobel Biocare USA) were waxed and cast in high noble alloy (Jelenko #7; Jelenko Dental Health Products, Armonk, NY) (Fig 5). Next, the fixed partial denture wax pattern was created opposing the stone core (Fig 6). The fixed partial denture wax pattern completely covered the occlusal screw holes of the custom abutments. In addition, 2 setscrew assemblies were placed into the lingual surface of the wax pattern (#99-001450; Attach-

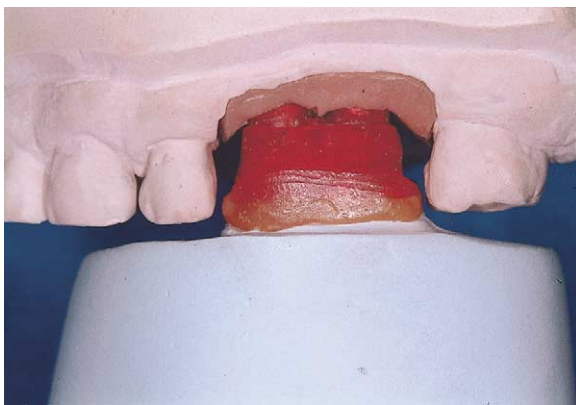


Figure 4. The wax recording is replaced on the master cast, and the opposing stone core is mounted to the lower member of the articulator.

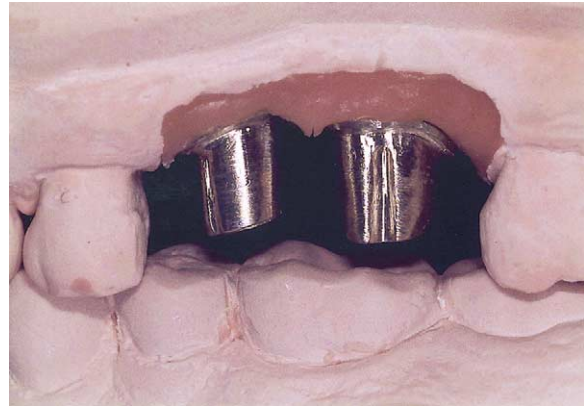


Figure 5. The milled custom abutments are prepared for fabrication of the fixed partial denture.

ments International, San Mateo, CA). These setscrews allowed the restoration to have a fixed-detachable configuration without occlusal screw holes. Finally, the occlusal surface of the completed wax pattern was relieved by approximately 38 μ using 3 thicknesses of shimstock (Artus Occlusal Registration Strips; Artus, Englewood, NJ). This procedure compensated for the differences in vertical displacement of the periodontal ligaments of the adjacent and opposing teeth versus the implants under functional loads.¹⁻³ It also eliminated potentially destructive lateral occlusal contacts.¹

9. The custom abutments and the final restorations were inserted. The occlusion and excursive movements were checked using articulating paper (Accufilm II; Parkel, Farmingdale, NY) and shimstock, to ensure proper clearance (Fig 7). To seal the margins, a small amount of resin-

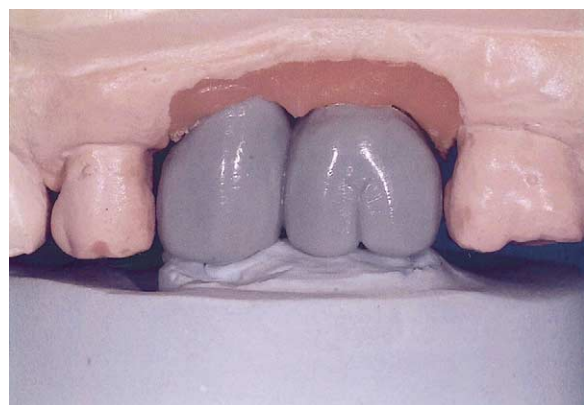


Figure 6. The final, full-contour wax pattern is shown opposing the stone core.

based cement (Panavia 21; J. Morita USA, Irvine, CA) was placed on the margins of the fixed partial denture. The setscrews were then hand-tightened, as recommended by the manufacturer, to complete the insertion procedure (Fig 8).

Summary

The use of implant restorations in partially edentulous patients may require alteration of occlusal contacts depending on the type and character of the patient's disocclusion. Patients with occlusal wear and minimal lateral disocclusion may have group function articulation. The procedure presented here describes a technique that addresses differences in vertical and horizontal mobility of the natural tooth complex versus the implant restoration. This functionally generated path technique allows the dentist to accurately determine all of the occluding and articulating paths of cuspal movement, then adjust the implant restoration to ensure that the prosthesis is in harmony with the patient's occlusion and articulation, without destructive lateral occlusal forces.

We note that the functionally generated path implant prosthesis presented here could have been designed as a simple fixed-detachable restoration with occlusal screw holes. However, the occlusal screw holes, which range from 2.5 mm to 3.5 mm in diameter, would have significantly disrupted the occlusal tables, occlusal contact areas, and functional recording method. Unfortunately, the most common complication associated with implant res-



Figure 7. The final prosthesis is inserted. The left lateral movement shows an optimal occlusal relationship with opposing dentition.



Figure 8. The prosthesis displays an intact occlusal surface and lingual setscrews.

tations is screw loosening,^{23,24} and covering the occlusal screw holes with a cement-retained restoration would hamper periodic maintenance procedures. The setscrew-retained, functionally generated path implant fixed partial denture provides an intact occlusal surface and allows for periodic maintenance.

References

1. Misch CE, Bidez MW: Implant-protected occlusion: A biomechanical rationale. *Compendium* 1994;15:1330-1344
2. Rudd KD, O'Leary TJ, Stumpf AJ: Horizontal tooth mobility in carefully screened subjects. *Periodontics* 1964;2:65-68
3. Parfitt GJ: Measurement of the physiological mobility of individual teeth in an axial direction. *J Dent Res* 1960;39:608-618
4. Sekeine J, Komiyama T, Hotta H, et al: Mobility characteristics and tactile sensitivity of osseointegrated fixture-supporting systems, in Van Steenberghe D (ed): *Tissue Integration in Oral and Maxillofacial Reconstruction. Proceedings of an International Congress. Brussels, Amsterdam, Excerpta Medica, 1985, pp 326-332*
5. Bergstrom G: On the reproduction of dental articulators by means of articulation. *Acta Odontol Scand* 1950;9(4):15-16
6. Paterson AH: Construction of Artificial Dentures. *Dent Cosmos* 1923 1923;65:679-689
7. Meyer FS: A new, simple and accurate technic for obtaining balanced and functional occlusion. *J Am Dent Assoc* 1934; 21:195-203
8. Meyer FS: The generated path technique in reconstruction dentistry, Part I: Complete dentures. *J Prosthet Dent* 1959; 9:354-366
9. House JE: The design and use of dental articulators in the United States from 1840-1970. Unpublished master's thesis, Indiana University School of Dentistry, 1970, pp 285-330
10. Mann AV, Pankey LD: Oral rehabilitation, Part II: Reconstruction of the upper teeth using a functionally generated path technique. *J Prosthet Dent* 1960;10:151-162

11. Rudd KD: Dr. Fred S. Meyer, a pioneer in prosthodontics. *J Prosthet Dent* 1966;16:1165-1169
12. Vig RG: A modified chew-in and functional impression technique. *J Prosthet Dent* 1964;14:214-220
13. Schmitt SM: Combination syndrome: A treatment approach. *J Prosthet Dent* 1985;54:664-671
14. Meyer FS: The generated path technique in reconstruction dentistry, Part II: Fixed partial dentures. *J Prosthet Dent* 1959;9:432-440
15. Dawson PE: Functionally generated path techniques for recording border movements intraorally, in Reinhardt RW, Slaten M (eds): *Evaluation, Diagnosis and Treatment of Occlusal Problems* (ed 2). St. Louis, MO, Mosby, 1989, pp 410-433
16. Rhoads JE, Rudd KD, Morrow RM: Dental casting, in Warfel D, Steuben M (eds): *Dental Laboratory Procedures*, Vol 2. St. Louis, MO, Mosby, 1986, pp 175-184
17. Schillingburg HT, Hobo S, Whitsett LW, et al: The functionally generated path technique, in Bateman LA (ed): *Fundamentals of Fixed Prosthodontics* (ed 3). Chicago, IL, Quintessence, 1997, pp 355-364
18. Kafandaris NM: A modified functionally generated path technique for making maxillary posterior ceramometal restorations. *J Prosthet Dent* 1981;46:29-31
19. Engleman MA, Engleman CL, Zamaloff V: Use of functionally generated path to establish precise occlusion in restorative dentistry. *Quintessence Int* 1983;14:799-811
20. Minagi S, Tanaka T, Sato T, et al: Double-casting method for fixed prosthodontics with functionally generated path. *J Prosthet Dent* 1998;79:120-124
21. Curtis SR: Functionally generated path for ceramometal restorations. *J Prosthet Dent* 1999;81:33-36
22. Hammad IA, Nourallah H: Simplified procedure for making fixed partial dentures with a functionally generated path. *J Prosthet Dent* 1996;75:344-345
23. Jemt T, Lindén T, Lekholm U: Failures and complications in 127 consecutively placed fixed partial prostheses supported by Brånemark implants: From prosthetic treatment to first annual checkup. *Int J Oral Maxillofac Implants* 1992;7:40-44
24. Eckert SE, Meraw SJ, Cal E, et al: Analysis of incidence and associated factors with fractured implants: A retrospective study. *Int J Oral Maxillofac Implants* 2000;15:662-667

Journal of Prosthodontics Announces New Section Editor

Dr. Stephen C. Bayne was recently named as a new Section Editor in the Basic Science Research Section of the *Journal of Prosthodontics*, effective January 1, 2004. According to Editor-in-Chief Dr. David Felton, most of the submissions (nearly 80%) to the *JP* are in the Basic Science Research section. Dr. Bayne is Professor and Section Head of Biomaterials in the Department of Operative Dentistry at the University of North Carolina School of Dentistry. He received his M.S. (1973) and Ph.D. (1978) in Biological Materials from Northwestern University in Evanston, Illinois. He has been recognized with 19 Teacher Excellence Awards from UNC dental classes, the first UNC Student Research Group Mentor-of-the-Year Award, and the prestigious UNC Richard F. Hunt Award for excellence in teaching, the highest award at UNC for teaching faculty. Dr. Bayne is part of a select group of non-dentists with memberships in the Academy of Restorative Dentistry and OKU. He has received numerous awards including the Award of Merit from the Academy of Dentistry International, Lecturer-of-the-Year Award from the Greater New York Academy of Prosthodontics in 2000, and the 2003 Distinguished Alumni Achievement Award from Carleton College. He is a past-President of the Academy of Dental Materials, IADR Dental Materials Group, and AADR. He is involved in funded clinical research trials involving posterior composites, CAD/CAM inlays, dentin bonding systems, and bleaching materials. His research has been published in 43 chapters in several books, 93 journal articles, and 186 abstracts. He has made 149 scientific and 225 continuing dental education presentations. According to Dr. Felton, "We are absolutely delighted to have someone of the caliber of Dr. Bayne join our excellent team of Section Editors. I am confident that his addition will help expedite the editorial review process." Dr. Bayne joins Dr. Steven E. Eckert of the Mayo Clinic and Dr. David A. Beck of the Medical College of Virginia School of Dentistry as Section Editors in the Basic Science Research area.