

<https://doi.org/10.46344/JBINO.2023.v13i01.01>

“IMPORTANCE OF FUNCTIONALLY GENERATED PATH TECHNIQUE IN PROSTHODONTICS – A NARRATIVE REVIEW”.

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ABSTRACT

The functionally generated path technique (FGP) technique involves replicating the patient's mandibular movements to determine the most natural and functional path of tooth contacts during various jaw movements. This technique helps in achieving optimal occlusion and masticatory function. It typically involves utilizing an adjustable articulator and registering dynamic records to mimic jaw movements accurately. FGP aims to create a restoration that harmonizes with the patient's natural occlusal dynamics, enhancing both comfort and function.

Introduction

To evaluate proper occlusion, it is mandatory that diagnostic cast must be articulated in same relation as in patient's mouth. Dentistry has recognized functional path articulations as a viable way of developing occlusion more than 60yrs.

Meyer SF described this functional generated path technique (FGP) in 1933 as means of obtaining the functional occlusal path for bridges fabricated by direct /indirect technique and for dentures.¹

The functionally generated path (FGP) is a static representation of the opposing cusp's dynamic eccentric movements from a centric position to realize optimal articulation and occlusal harmony. The FGP technique can record such eccentric movements at the correct occlusal vertical dimension (O.V.D), as the eccentric movements are influenced by both the anterior guidance and the condylar guidance.¹ The conventional construction technique is sometimes unsuccessful in producing a prosthesis that can be inserted without intra-oral occlusal adjustment. The functionally generated path technique uses a different approach to achieve occlusal harmony between restoration and other teeth in the mouth.²

There is no need for semi adjustable /fully adjustable articulator that has been programmed to match the patient's mandibular movements because the

patient's own functional jaw movement were used to form 3D opposing cast or template.

It represents the dynamic of mandibular movement and eliminates the need for articulator capable of eccentric movements. Hence this review assumed to discuss the technique which represents its dynamic mandibular movements.

History

Von Spee, in 1890 described the vertical overlap "overbite" of the cuspids, which was overlooked entirely. In 1915, he gave the masticating functions of the teeth, and he was the first to describe the scheme of canine protected occlusion.

McCollum and Stuart, in 1955, described the Gnathological concept. Incisal guidance is an independent entity and is independent of condylar guidance. On the side, they stated the condylar path or posterior guidance is a fixed entity.³

Meyer, in 1959 discussed the "functional occlusal path" as the harmonious relationship between the occlusal and cuspal paths, the condylar paths, and the neuromuscular system. Pankey and Mann adapted the principles discussed by Meyer to describe a "functionally generated path" record in the fabrication of maxillary restorations.⁴

Dawson stated that the lateral eccentric movements of the mandibular posterior dentition are established by an anterior determinant and a posterior determinant. When understood and appreciated, the F.G.P. technique is a simple and practical method for achieving harmonious occlusal anatomy of restorations with the anterior determinant/anterior guidance and the posterior.⁵

Pre-Requisites for FGP

a. Presence of optimal occlusion; b. Appropriate anterior guidance; c. Elimination /absence of posterior interference; d. No missing /broken down opposing teeth; e. Bodily rotated /caries/poorly restored teeth will not provide occlusal pathways needed for shaping the occlusal surfaces⁶

Advantages of FGP

a. Eliminates the need for adjusting the articulator; b. Eliminates the use of face bow transfer; c. Simple and produce precise result; d. Excursive movements are accurately recorded; e. Minimum chair side time during try-in and cementation phase; f. Records all dimensions of border movements at the correct vertical dimension.⁷

limitations of FGP

a. The operator should have a good knowledge of occlusion and of mandibular movements; b. The occlusal details are not similar to the ideal anatomical configuration, although the surface is functionally ideal; c. This technique cannot be used in cases with short clinical crowns; d. This technique cannot be used in cases of attrited teeth; e. Patients lacking proper neuromuscular control cannot be selected for this technique; f. In patients having disharmony in occlusion and T.M.J. dysfunction, the F.G.P. technique is destined to fail; g. good laboratory support is a basic requirement; h. Can't be used effectively for CD opposing RPD; i. Difficult in case of distal extension case.⁷

Functionally Generated Path in Fixed Partial Denture

The working side tooth contacts is evaluated to determine whether they form a mutually protected occlusion (canine guide occlusion) or unilaterally balanced (group function) occlusion, which is essential in determining the type of occlusal scheme to be produced in the final restoration. The technique to be described here is primarily for use in fabricating restorations in maxillary teeth. The preparation for the cast restoration is started by doing the occlusal reduction. Before proceeding on to the axial reduction the functional tracings are made.

The larger occlusal table that is present before axial reduction will afford greater stability to the wax tracing.

Petrolatum is applied with a cotton tipped applicator to the occlusal surface of the opposing quadrant and cavity varnish is applied to the occlusal surface of the prepared tooth to help the wax to adhere more securely. Piece of wax is cut in a square slightly larger than the occlusal surface of the teeth being restored.⁸

The square of wax is attached to a PKT No.2 waxing instrument and soften it over Bunsen burner flame. While the varnish on the occlusal surface is still tacky and the wax is soft (Fig 1). The patient is guided into a retruded closure in centric relation. Then patient is guided through all excursions, moving first into the working side (Fig 2).

From working excursion, the patient is guided back to centric relation and then into a nonworking movement (Fig

3).Have the patient return again to centric relation and then to protrusive (Fig 4).The patient should be guided through combination movements as well: working protrusive and non-working

protrusive.Finally, the patient should just “mill around” to ensure adequate clearance for the opposing cusps in function⁸

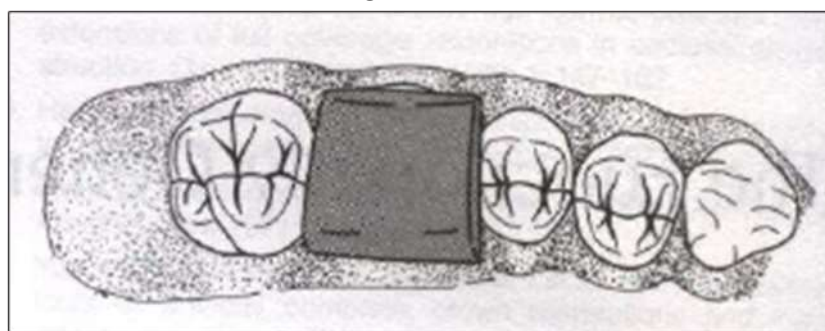


Fig 1: A square of tacky wax is positioned over the tooth being prepared

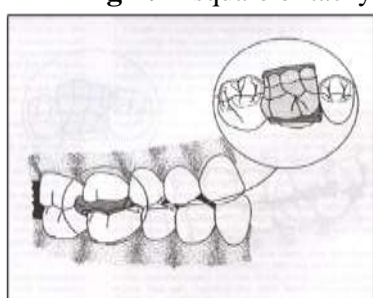


Fig 2: Working side

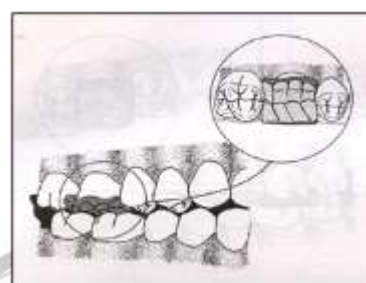


Fig 3: Non-working side

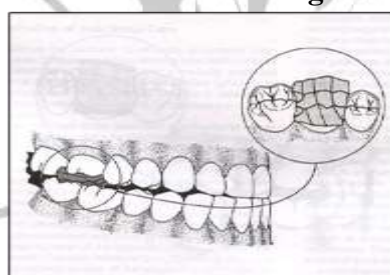


Fig 4: Protrusive

Source: Rosenstiel SF, Land MF, Fujimoto J. Contemporary fixed prosthodontics. 4th ed. St. Louis: Elsevier; 2006. p. 431-65.

Functional Core

A tray of some sort should be used to hold the stone in place in the mouth to make the functional core. Tongue blades and denture tooth cards can be employed for this purpose, but a functional index tray offers definite advantages. It is curved to fit the arch. Has undercuts to hold the stone in position. The tray

extends to the anterior teeth for added stability. The unneeded portion can be broken and discarded.

The wax is painted with a die lubricant to reduce surface tension and ensured a smooth, complete functional core. A creamy mix of mounting stone is painted on the surface of the functional wax tracing with a sable brush (Fig 5) The functional index tray is loaded with a

layer of mounting stone 6.0mm (0.25inch) thick. Position it on the occlusal surface of the quadrant so that it covers at least

one tooth on each side of the prepared tooth (Fig 6)also referred to as the functional index or counter die.⁷



Fig 5: Creating the stone core from the tacky wax FGP

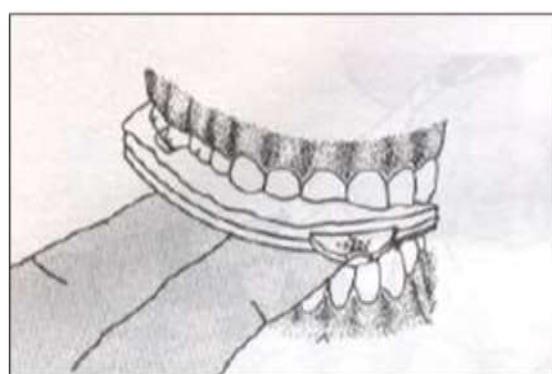


Fig 6: Tray should extend one tooth anterior and posterior tooth.

Source: Rosenstiel SF, Land MF, Fujimoto J. Contemporary fixed prosthodontics. 4th ed. St. Louis: Elsevier; 2006. p. 431-65.

The surface of the core is trimmed with a sharp laboratory knife. The rest of the tooth preparation is completed and an impression of the quadrant containing the prepared tooth is made using a custom acrylic tray made previously. It is possible to fabricate a restoration using only the functional core for an opposing model. However, it is very

helpful to have an anatomic cast against which you can occlude the wax pattern. For this an occlusal registration is made at the inter cuspal position using bite registration paste in a bite registration frame.

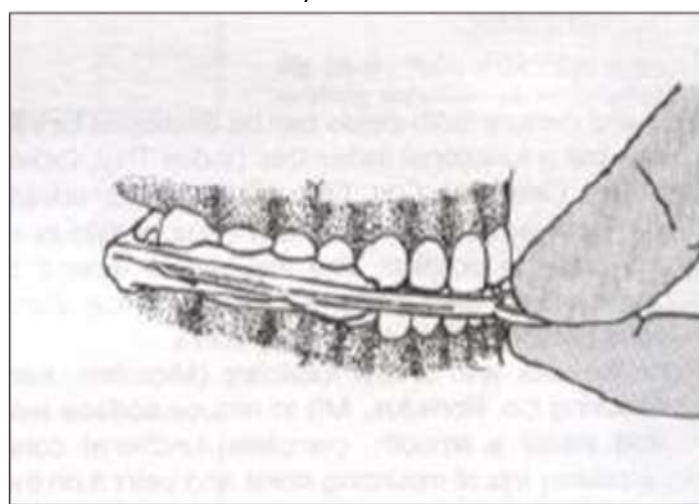


Fig 7: The bite registration frame is held while bite registration paste sets

Source: Rosenstiel SF, Land MF, Fujimoto J. Contemporary fixed prosthodontics. 4th ed. St. Louis: Elsevier; 2006. p. 431-65.

Attach the quadrant tray with the mounting stone to the lower member of an articulator with two upper members. Trim the base of the cast containing the prepared tooth also the cast will fit into the die tray. The finish line of the tooth preparation should be about 0.25 inch above the edge of the die tray

To Attach the Functional Core in Twin Stage Occluder

Now the functional core is placed on the cast in the die tray and confirmed that it still fits accurately. It is attached to the cast with the sticky wax. The incisal pin of the twin stage occluder is adjusted. The functional core is now mounted on the

upper right member of the articulator. Sawing of the die is done. Ditching is being done then Gingival finish line marked in red pencil. The die and the sections of the quadrant cast is reassembled. The mounting is ready for wax pattern fabrication. The articulator is another instrument that is made for use with the functionally generated path technique. It is extremely rigid and provides a precise alignment of cast and functional core. It also utilizes a second upper member (removable not hinged) that can be employed with the anatomic cast.⁹

A plane line hinge articulator can also be used for this purpose, but it does not permit the use of an anatomic cast.



Fig 8: Twin Stage occluder

Source: Patil PG, Nimbalkar-Patil SP, Kulkarni RS. Functionally generated pathways to develop an occlusal scheme for a removable partial denture. *J Interdiscip Dentistry* 2015; 5(1):154-57.

Wax pattern fabrication

The die is removed from the di-lok tray and the preparation is lubricated

thoroughly with die lubricant. Wax is flowed over the surface of the preparation on the die using quick, overlapping strokes of a hot no. 7 wax

spatula. Initially the occlusal portion of the wax pattern should be waxed against the anatomic cast to aid in visualizing cusp location more effectively. The wax added technique is used to position the cones of the cusp tips. Marginal ridges and cusp ridges complete the outline of the occlusal table, and then they are blended into the axial contours.

Triangular ridges are placed next. Axial contours and proximal contacts are checked before proceeding to the occlusal surface. The wax added technique is used to form the occlusal morphology.

wax pattern can be completed by waxing against the functional core.⁹

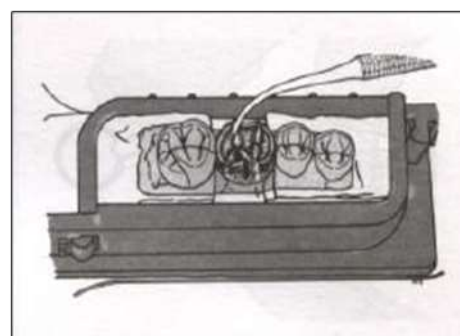
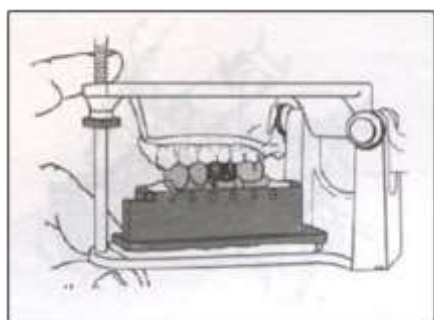


Fig 9: Axial contours and provisional contours are checked before proceeding to the occlusal surface

Fig 10: The wax-added techniques is used to form the occlusal morphology

Source: Patil PG, Nimbalkar-Patil SP, Kulkarni RS. Functionally generated pathways to develop an occlusal scheme for a removable partial denture. J Interdiscip Dentistry 2015; 5(1):154-57.

that the functional core is brought in contact with the occlusal surface of the wax pattern. The shoe polish will leave white marks on the occlusal surface of the wax pattern corresponding to the contacts in function. Any areas in white

that are not part of the of the desired centric or excursive contact pattern are carved off according to the restoration which would go to mutually protected or group function occlusion.⁹

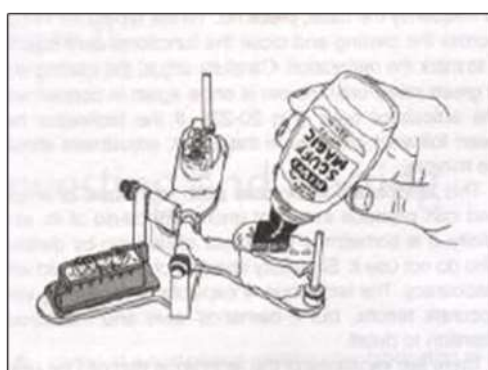


Fig 11: The functional core is painted with white liquid shoe polish.

Source: Patil PG, Nimbalkar-Patil SP, Kulkarni RS. Functionally generated pathways to develop an occlusal scheme for a removable partial denture. J Interdiscip Dentistry 2015; 5(1):154-57.

If the restoration should be in mutually protected relationship there should be no contact on the lingual incline of the buccal cusp other than the centric contacts. If on the other hand the restoration to be fabricated in group function, the lingual incline of the buccal cusp should maintain continuous contact with the functional core.

In no case should the non-working inclines have any contact with the functional core.

Functionally Generated Pathway for the Complete Dentures

The functionally generated path technique has been successfully adopted in the construction of complete denture prosthodontics. The object is to obtain the individual curves of a patient. Briefly this is attained by inserting record blocs with abrasive rims and allowing the patient to grind them together until they are in balanced articulation.

This type of record is very suitable for patients with marked translator movements of the mandible.¹⁰

Occlusal Rims

Generally, the occlusal rims for complete denture are made up of

- a. Wax
- b. Impression Compound
- c. Mixture of plaster with an abrasive such as pumice and sand.

Record Bases and Occlusal Rims

Stability of the record bases is essential for accuracy since there will be a considerable lateral and protrusive drag to friction, during the process of grinding. Ideally the denture bases are made up of heat cure acrylic resin. The occlusal rims are made up of plaster and an abrasive, such as coarse carborundum, pumice or sand. The buccolingual width should be about 1 cm, which is necessary to define the lateral and antero-posterior curves and for strength.¹⁰

Recording the Functional Path

Tentative jaw relations are first recorded with wax blocks and mounted in semi adjustable articulator. The blocks with abrasive rims are then constructed with the vertical height opened a few millimeters to allow for the closure which will result from the grinding. One method of constructing the rims is to make them of composition within 5 mm of the estimated correct height, to groove the composition for retention and then build up the plaster pumice for a further 4-5 mm.

The record bases are placed in the oral cavity. The patient is instructed to grind the blocks together with both lateral and protrusive movements but only to use the minimum pressure necessary to keep the blocks in contact. The grinding is continued until the correct vertical dimension is obtained. The occlusal surfaces of the rims now show correct balancing curves for the patient. The curves are reproduced in the denture by

mounting the casts on a plane line articulator and setting the lower zero cusp teeth to occlude with the upper block and then the upper teeth to occlude with the lower ones. The form of cusp will vary with the height of the occlusal surfaces and also with the original shape of the plaster pumice blocks whether flat or curved.¹⁰

FGP Occlusion for Single Complete Denture

Stansbury described the first functional chew-in technique (1928) for an upper complete denture opposing lower natural teeth. Compound maxillary rim trimmed buccally and lingually so that the occlusion is free in lateral excursions. Carding wax is then added to the compound rim, and the patient is instructed to perform eccentric chewing movements. Carding wax records the functional movements, while the compound in the central fossa acts as a guide to preserve vertical dimension. Stone model is poured out of wax pattern and attached to the articulator. Has 2 lower casts – anatomic cast used to teeth arrangement and functional record used to provide interference free bilateral balance teeth arrangement.

Functionally Generated Path Technique for RPD

The theory on which the FGPT is based is that “the pathways each tooth opposed to the edentulous space makes throughout all functional movements of the mandible are recorded, the artificial tooth may be positioned and formed so

that it will remain in harmonious contact with its antagonist at all times. The pathways are created by the patient in a wax occlusal rim. The patient performs all functional excursions while the opposing teeth contact the surface of the occlusal rim. The master cast was indexed with the tripod markings and surveyed, and the undercut areas were blocked out with the block out wax. The blocked-out cast was duplicated to form a refractory cast, and the wax pattern was prepared. The framework was casted in a cobalt-chromium alloy following standard laboratory procedures. Framework was finished and polished, returned to the master cast, and temporary denture base was added to the framework.

Framework was tried intraorally, the fit was verified, and it was confirmed that there was no interference by any component or the record base in centric occlusion and excursion.

Recording of the Functionally Generated Pathway

Occlusion rim was created on the base plate using hard inlay wax and visible gap was left between opposing teeth and the rim initially Softened inlay wax was added to the rim, and the framework was placed intraorally. Patient was asked to close in centric occlusion to indent the soft wax. It was ensured that all natural teeth were in contact, and the framework was removed when the wax got hardened. Wax was softened again, and the previous exercise was repeated (Fig 12a & 12b).

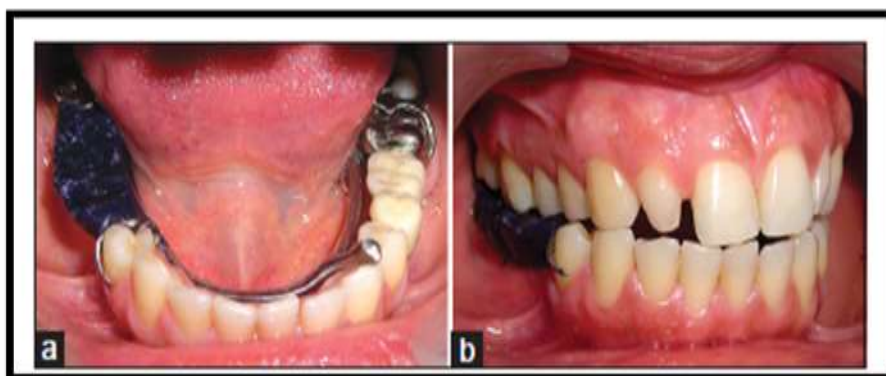


Fig:12a Try-in of partial denture framework with inlay wax attached for occlusal registration .12b obtaining functionally generated pathway record in eccentric relation.

Mounting of the Casts

The FGP record obtained was used to fabricate the stone occluding template and this record was resealed on secured onto the master cast (Fig 13a) and boxing was done with the modeling clay and the modeling wax as shown in Fig 13b. Onlay wax registration and areas for vertical stops were left exposed and it was filled with the dental stone to form occluding template (Fig 14a & 14b). Recoding the FGP eliminates the need to reproduce

the mandibular movements on the articulator and hence, mounting was done on the simple mean value articulator. The acrylic resin teeth matching the shade of the patient's natural dentition were selected (Fig 15). Waxing and carving were done after teeth arrangement and try-in was carried out in a conventional manner. The trial denture was processed using standard laboratory procedures.

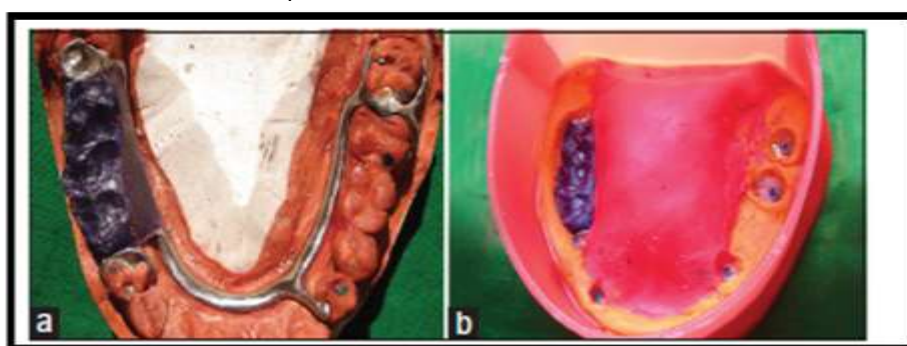


Fig :13 (a)FGP record seated on master cast (b) Modelinng clay used to block specified areas on the cast.



Fig :14 (a) Occluding template with FGP record mounted.(b) Occlusal surfaces of teeth modified to fit occluding template.

Fig :15 post operative view with RPD in occlusion

Source: Patil PG, Nimbalkar-Patil SP, Kulkarni RS. Functionally generated pathways to develop an occlusal scheme for a removable partial denture. J Interdiscip Dentistry 2015; 5(1):154-57.

Double Casting Method

Wax pattern was made with 1-mm occlusal clearance, and retentive beads of wax were placed on the prepared tooth. These beads aid in the retention of the pattern resin during functional generation of the occlusal morphology (Fig 16a & 16b). The base casting was obtained, and it was sandblasted and checked for accuracy of fit on the model and in the mouth (Fig 17a). We ensure that the base casting had adequate occlusal clearance and proper fit on the prepared teeth before generating the occlusal morphology. The occlusal morphology is generated using pattern resin following the technique described by Dawson (Fig 17b). Pattern resin was

mixed and is applied on the occlusal surface of the metal coping with retentive beads. The patient was instructed to close the mouth in Maximum inter cuspal Position and performed the left lateral, right lateral, and protrusive movements in succession, ending in the M.I.P.

With the help of an acrylic trimmer, the excess pattern resin was trimmed off. The occlusal surface was then examined for any exposure to the metal. And if this was present, the metal in the area was trimmed, pattern resin was added in that area, and the movements were performed once again and then complete the double casting(Fig:18a) and finally it is inserted in the patient mouth(Fig:18b).¹¹

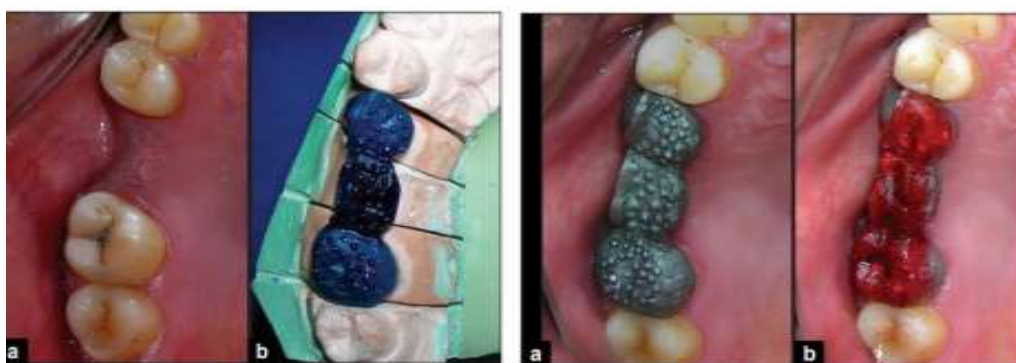


Fig:16(a) Pre treatment appearance (b) wax pattern with retentive beads

Fig:17(a)base casting(b) FGP record



Fig :18 Completed double casting (a). Double casting with functionally generated path(b)

Source: Prashanti E, Sajjan S, Reddy JM. Fabrication of fixed partial dentures using functionally generated path technique and double casting. *Indian J Dent Res* 2009; 20:492-5.

Functionally Generated Path Technique for implants

Final impressions were made, and soft tissue moulage material was added around the implant replicas (Fig:19). Single-tooth provisional crown coping were attached to the implant replicas, and acrylic resin was placed around the copings. The acrylic resin copings were milled to have parallel walls and an internal keyway to aid in the frictional attachment of the recording table.¹²

The acrylic resin copings were lubricated, and a detachable acrylic resin recording table was fabricated to fit over the milled copings (Fig:20). The recording table was extended to the mesial and distal contacts and was 12 mm wide (facial-lingually) to accommodate working and nonworking movements. The detachable recording table facilitated the addition of recording wax during the functional recording procedure. The copings and recording tables were placed onto the patient's implants. Approximately 2–3 mm of functional impression wax. The copings

and recording tables were placed onto the patient's implants. Approximately 2–3 mm of functional impression wax was added onto the occlusal surface of the recording table. The recording was made by guiding the patient's movements, beginning with guiding the patient to close into the wax in the maximal intercuspal 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. 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 (Fig:21). The recording table was removed from the patient's mouth, and the assembly was replaced on the master maxillary cast. A dental stone core was gently poured into the wax recording and then mounted to the lower member

of the articulator (Fig: 22). The final restorations were then fabricated. First custom abutments were waxed and cast in high noble alloy (Fig:23). Next, the fixed partial denture wax pattern was created opposing the stone core (Fig:24). 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. The custom abutments and the final restorations were inserted. The occlusion and excursive movements were checked using articulating paper (Fig:25).¹² To seal the margins, a small amount of resin-based cement 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:26).¹²



Fig:19 Left buccal view showing the MIP and moderate occlusal wear.

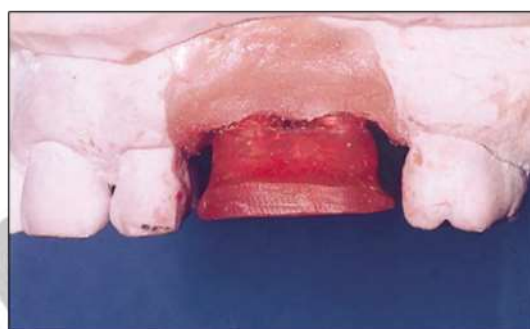


Fig:20 The detachable acrylic resin recording table is placed over the milled retaining coping.



Fig: 21 The functionally generated path wax recording is completed using the resin recording table and Korecta Wax.



Fig:22 The wax recording is replaced on the master cast, and the opposing stone core is mounted to the lower member of the articulator.



Fig: 23 The milled custom abutments are prepared for fabrication of the fixed partial denture.



Fig:24 The final, full-contour wax pattern is shown opposing the stone core.



Fig:25 The final prosthesis is inserted. The left lateral movement shows an optimal occlusal relationship with opposing dentition.



Fig:26 The prosthesis displays an intact occlusal surface and lingual setscrews.

Source: Sutton AJ, Sheets DW, Ford DE. Fabrication of a Functionally Generated, Implant-Retained Fixed Partial Denture. *J Prosthodont* 2003;12(4):260-64.

Conclusion

FGP is a concept capable of producing very accurate results and demands care and meticulous attention to detail. This technique reduces adjustment time during the final restoration. Recently FGP has also been used for the fabrication of implant-retained fixed partial dentures. The FGP technique is simple and can produce excellent results. It also demands meticulous attention and great care to detail. It is often overlooked by clinicians

Because of its simplicity and is not used more often.

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