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CASE REPORT

Digitally designed fixed dental prosthesis with stress breaking effect using non-rigid connector for pier abutment: A case report

Manu Rathee, Santhanam Divakar*, Prachi Jain, Sandeep Singh, Sujata Chahal, Sarthak Singh Tomar

Department of Prosthodontics, Post Graduate Institute of Dental Sciences, Rohtak, Haryana, India

Rigid connectors between pontic and retainer are preferred way of fabricating fixed partial dentures for many decades as they provide desirable strength, retention and stability to the prosthesis. However, it is not ideal for cases such as lone-standing abutments (pier abutment), maligned teeth where occlusal stress can extrude the restoration. This may lead to marginal leakage and secondary caries on the abutment teeth. Conversely, it is recommended to use non-rigid connectors which act as a stress breaker, where the tensile stresses are concentrated on the surrounding bone and not on the connectors. With advancement in digital technology in dentistry, the non-rigid connectors can be fabricated using additive manufacturing technology. The present case report discusses the Direct Metal Laser Sintering (DMLS) designed fixed dental prosthesis with key and keyway (Tenon and Mortise) non-rigid connector for rehabilitation of pier abutment in maxillary posterior region.

Keywords: 3D printing, direct metal laser sintering, fixed dental prosthesis, pier abutment, non-rigid connectors

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Introduction

Fixed dental prostheses (FDPs) are the most common functional restoration method employed in dental treatment to restore form, function, and aesthetics by connecting and cementing to the remaining teeth. FDPs are made up of three parts: retainer, pontic, and connectors. Connectors unite the retainer(s) and pontic, and they are described as the soul of the abutments as they bear the maximum occlusal load. Connectors are divided into two categories: rigid and non-rigid. Rigid connectors are the preferred way of manufacturing for most FPDs; however, they are not appropriate in all circumstances especially in the cases of tilted abutment, pier abutment, osseointegrated implants, mobile teeth and long span bridges [1, 2].

Pier abutment is the intermediary lone-standing abutment between the two missing edentulous spaces requiring long span bridge that poses a challenge to a prosthodontist [3]. It can be fabricated using various materials such as all metal, porcelain fused metal and all ceramic by using various techniques like conventional casting, CAD/CAM milling and recently additive manufacturing (3D printing).

Direct Metal Laser Sintering (DMLS) is an emerging innovative 3D printing technology in dentistry used for rapid prototyping and mass production of metal parts with less amount of energy [4]. This case report discussed the rehabilitation of pier abutment using DMLS designed porcelain fused metal fixed dental prosthesis with non-rigid connector (key and keyway).

* Correspondence to: S Divakar
E-mail: divakarsanthanam17@gmail.com

Case report

Case examination

A 40-year-old female reported to the department with the chief complaints of difficulty in chewing food for past 6 months due to missing upper and lower posterior teeth. History revealed that the patient had grossly decayed posterior teeth and she had undergone extraction of those teeth 6 months back. There was no significant medical history and patient was not under any medication.

On extraoral examination, patient had symmetrical face with slight sunken cheeks because of missing posterior teeth (Figure 1A). Intraoral examination revealed missing right maxillary first premolar and first molar teeth, left maxillary and mandibular first and second molar, right mandibular first and second molar (14, 16, 26, 27, 36, 37, 46, 47) (Figure 1B and 1C). Patient was advised for orthodontic correction of spacing and proclined maxillary and mandibular anterior teeth, but she denied for the treatment due to longer duration of time (Figure 1D, 1E and 1F). Radiographic examination of abutment teeth revealed root canal treatment in 15, 24, 25, 35, 45 and adequate enamel and dentin with bone support in 13, 17, 28, 38, 48.

Treatment plan

Patient was given various treatment options as follows: Removable partial denture was denied because patient wanted fixed replacement. Implant retained fixed prosthesis was denied due to cost factor and also patient did not want surgery. Hence, Conventional Fixed Dental Prosthesis with rigid connector was planned for left maxillary and mandibular and right mandibular missing teeth. For pier abutment in right maxillary missing teeth, a Direct Metal Laser Sintering (DMLS) five-unit Fixed Dental Prosthesis (FDP) with non-rigid connector (key and keyway system) was planned.

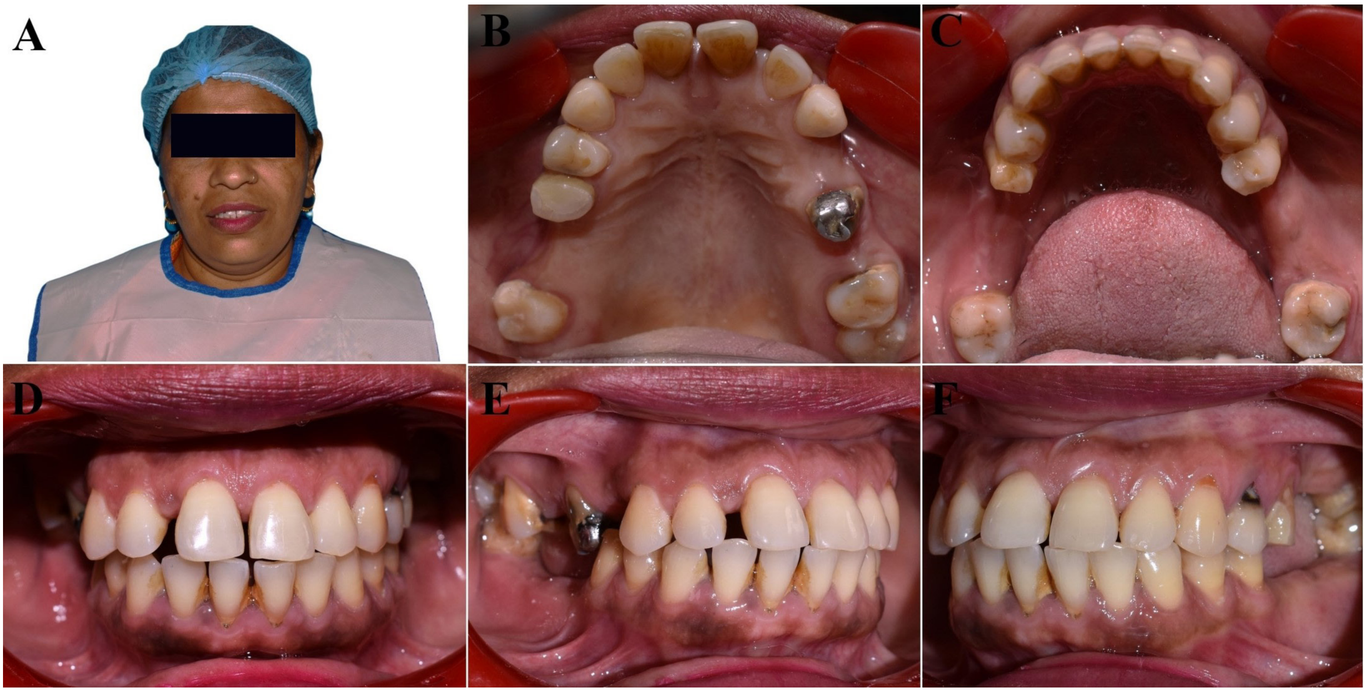

FIg. 1. Case Examination A. Pre-rehabilitative view B. Intraoral maxillary view C. Intraoral mandibular view D. Intraoral frontal view E. Intraoral left lateral view F. Intraoral right lateral view

Treatment progress

Diagnostic impression was made using irreversible hydrocolloid material (Algitex DPI, India) and the impression was poured using type III gypsum product (Ultrastone dental plaster; Kalabhai Karson Pvt Ltd.) (Figure 2A and 2B). The tooth preparation (24, 25, 28, 34, 35, 38, 45, 48) (Figure 2C) and conventional fixed partial denture fabrication was carried in the left maxillary and mandibular missing teeth and right mandibular missing teeth (Figure 2D). The prosthesis was cemented using luting Glass ionomer cement (GC Gold Label 1 - Luting & Lining GIC) (Figure 2E and 2F).

The clinical step by step procedure carried out for rehabilitation of pier abutment in right maxillary posterior region were as follows

The abutment tooth preparation was carried out for porcelain fused metal restoration using crown preparation burs in relation to right maxillary canine, second premolar and second molar with shoulder finish line at equigingival margin(Figure 3A and 3B).

The perforated rim-lock impression trays were selected and adhesive was applied. Gingival retraction was carried out using gingival retraction cord Size #000) (Sure Endo Sure Cord – Knitted Gingival Retraction Cord) (Figure 3C), and final impression was made using putty and light body addition silicone elastomeric material (3M ESPE Express Xt VPS Impression Material –Putty and Refills) (Figure 3D).

The autopolymerising composite material (Prevest Oratemp C&B Temporary Crown and Bridge Material)

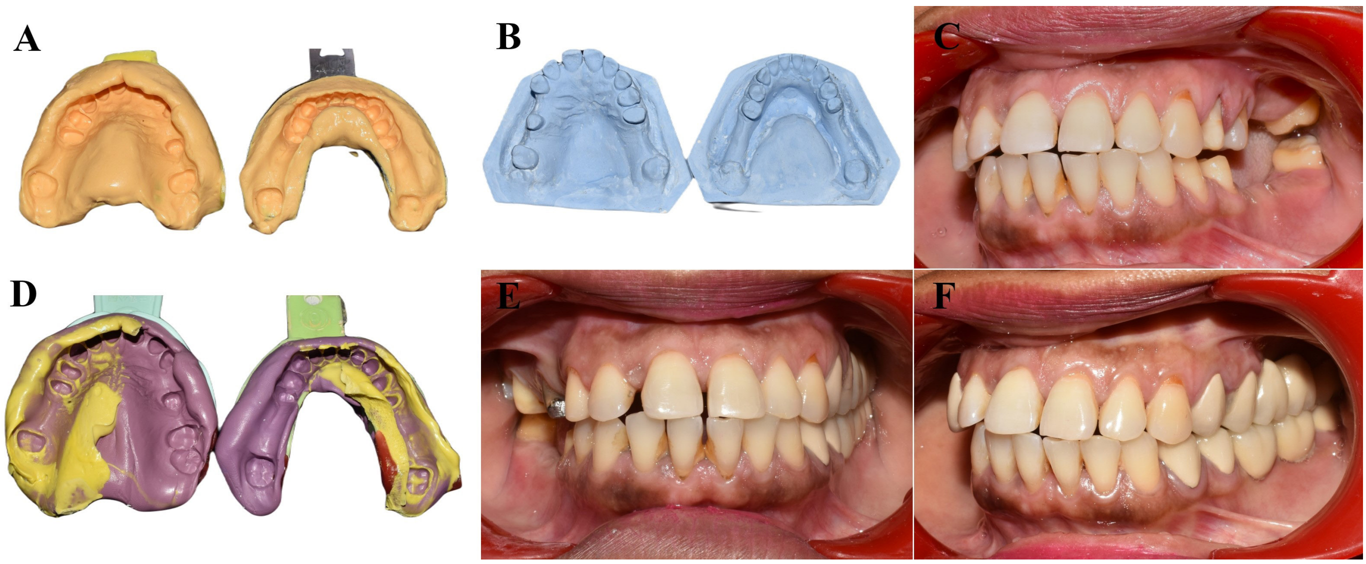

FIg. 2. Conventional Fixed Dental Prosthesis A. Diagnostic impression B. Diagnostic cast C. Conventional crown preparation in 24, 25, 28, 34, 35, 38 D. Final impression E. Post-rehabilitative frontal view F. Post-rehabilitative left lateral view

was used as a provisional restoration material and was cemented using non-eugenol temporary luting cements (3M ESPE Relyx Temp NE Non-Eugenol Temporary Cement).

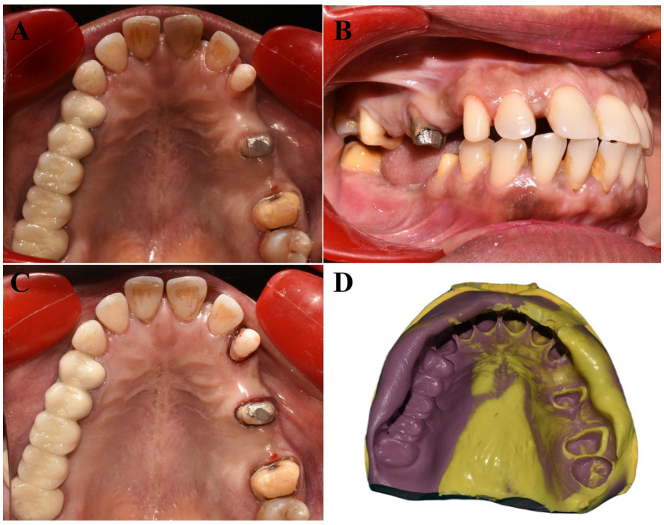

FIg. 3. Conventional crown preparation A. Intraoral occlusal view B. Right lateral view C. Gingival retraction cord (Size #000). D. Final impression

The elastomeric impression was scanned by SMART desktop scanner (open technologies FARO Europe) in the laboratory and Computer Aided Designing (CAD) of five-unit FDP with key and keyway non-rigid connector (keyway in the distal aspect of pier abutment (15) and key in the mesial aspect of distal pontic (16)) was designed using EXOCAD software (exocad GmbH, Dermstadt, Germany).The final design was imported and .STL file was generated (Figure 4A-H).

The .STL file was transferred to the DMLS unit (SLM 125; SLM Solutions, Lubeck, Germany), where the high-level focused laser beam of 200W power and 1064 nm wavelength directly fuses the Co-Cr metal powder size of 20mm to fabricate the restoration separately for anterior and posterior segments. According to the manufacturer's instructions, postprocessing heat treatments was applied (450°C for 45 min and then cooled down) and the metal copings was manually polished (Figure 5A and 5B).

The metal framework was evaluated in the patient mouth for marginal integrity and occlusal contacts by placing the anterior segment first followed by posterior segment (Figure 5C and 5D). The ceramic layering was added

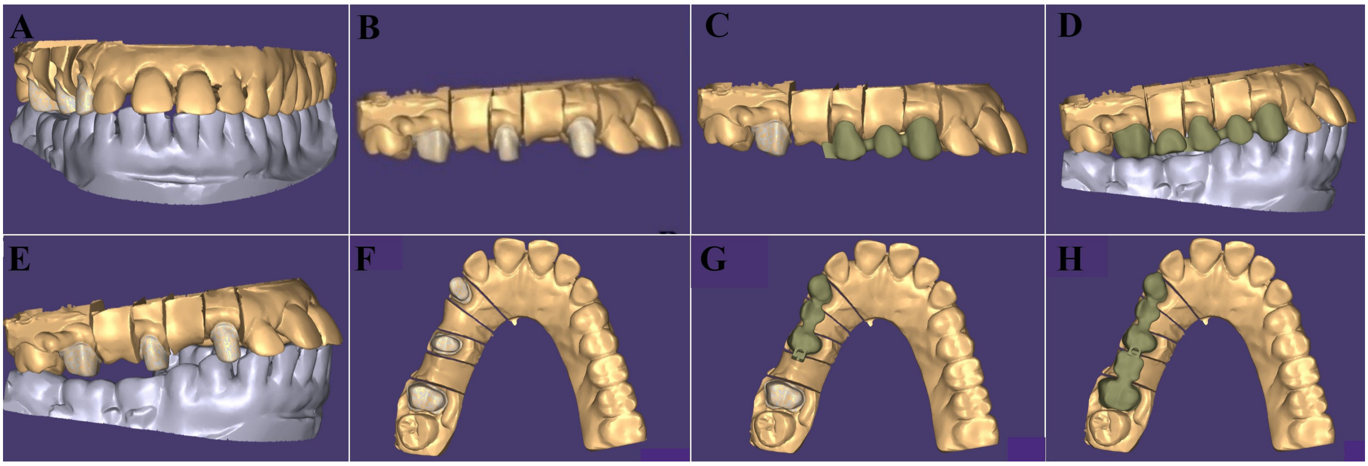

FIg. 4. CAD Designing of metal coping A, E. Exocad software with scanned cast. B, F. Maxillary view with prepared teeth. C, G. Designing of anterior segment with keyway. D, H. Designing of posterior segment with key

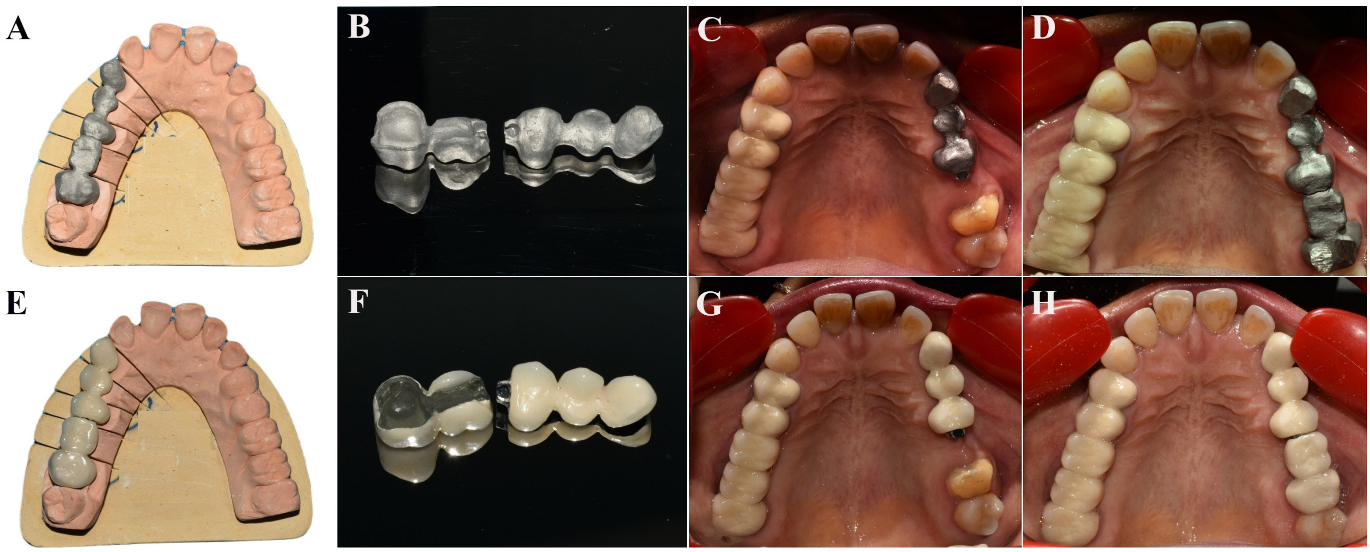

FIg. 5. A, B. DMLS printed metal coping C, D. Evaluation of metal copings. E, F. Final prosthesis with ceramic layering. G, H. Final prosthesis after cementation with type II GIC.

FIg. 6.A. Post-rehabilitative intraoral frontal view. B. Post-rehabilitative intraoral right lateral view. C. Post-rehabilitative extraoral view

in conventional manner in both the segments followed by glazing, sandblasting, finishing and polishing was carried out (Figure 5E and 5F).

The final prosthesis was evaluated for retention, stability and precise fit. The occlusal contacts were evaluated using articulating paper for maximum intercuspation and lateral interferences were adjusted using porcelain polishing kit (Figure 5G and 5H).

The prosthesis was cemented using Type I Glass ionomer cement (GIC) (GC Gold Label 1 - Luting & Lining GIC) by cementing the anterior segment first followed by posterior segment (Figure 5G and 5H). Post-rehabilitative instructions were given to the patient and advised for periodic follow-up and oral hygiene maintenance (Figure 6A-C).

Discussion

There are various biomechanical factors that cause anomalous stress concentration on FDP especially near connectors such as overload, torque, flexure and leverage. This factor plays an important role in the potential for failure in long-span FPD with rigid connectors. It is based on the lever principle I, during occlusal load at one end of the bridge, the pier abutment acts as a fulcrum and the tensile stress generated at distal retainer and abutment of the restoration which leads to dislodgement of restoration because of loss of retention [5, 6].

To avoid these situations, a non-rigid connector should be used which act as a stress breaking mechanism and dissipate much of the leverage force to the weaker attachments. Oruc et al [7] in their study analysed the stress effects of non-rigid connectors on fixed partial dentures with pier abutments by using Finite Element Analysis and concluded that maximum stress concentration was reduced while using non-rigid connector (NRC) especially at the distal aspect of the pier abutment [7]. There are various types of NRCs available in literature. They are Dovetail (key-keyway) or (Tenon Mortise) connectors, Loop connectors, Split connectors and Cross pin and wing connectors. In this case report, we used key and keyway (Tenon and Mortise) non-rigid connector on the distal aspect of maxillary right 2nd premolar (pier abutment) as it is a extracoronal attachment hence, conservative tooth preparation with physiologic axial contour and flat emergence profile can be developed [8, 9].

The conventional lost wax technique was used for more than ten decades for fabrication of porcelain fused metal FDPs. The steps in conventional method are wax pattern fabrication, casting of metal coping followed by porcelain layering above the metal coping which had various disadvantages like more time consuming for casting, costly and a very laborious manual process, inaccuracy and ill-fitting prosthesis [10].

The Additive Manufacturing (AM) has gained a lot of interest in dental field due to its wide-range capabilities for fabricating restoration. Direct metal laser sintering is the AM technology used for the production of metal-based appliances which conquer difficulties such as casting shrinkage and high hardness of Ni-Cr and Co-Cr during milling as they require less energy, less material and no active force application during fabrication. This technology also has advantages over conventional casting as it constructs prosthesis with high precision, accuracy, durability, biocompatibility, stability and render the treatment less time taking and more accessible to a larger portion of the population [10, 11].

Conclusion

It has been established that the stress breaking effect generated by non-rigid connectors integration, particularly in pier abutment conditions, helps to the prostheses long-term endurance. Digital technology has simplified and improved the way dentistry is practiced, and care is delivered especially in prosthetic field. Considering the complexity of designing non-rigid connectors, this case report has discussed the DMLS designed FDP with Tenon-Mortise non-rigid connector in the maxillary posterior region.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Conflict of interest

None to declare.

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