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Digital-analogue approach in pier abutment: A case report and literature review

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Abstract
This case report and literature review explores the challenges and solutions associated with the fabrication of long-span fixed partial dentures (FPDs) involving a pier abutment, where a non-rigid connector was employed. The study presents a detailed account of a 43-year-old female patient who required rehabilitation of an edentulous space using a 5-unit FPD with a non-rigid connector. The digitalization of the cast and the use of advanced scanning and designing tools for the fabrication process are discussed. The review highlights the critical factors affecting long-span bridges, including physiological tooth movement, arch position, and retentive capacity, emphasizing the importance of using non-rigid connectors to accommodate these dynamics. The discussion also covers various types of non-rigid connectors and different schools of thought regarding their application. The report concludes that the selection of the appropriate type of non-rigid connector, based on the clinical situation, is crucial for the success of the restoration, particularly when implant therapy is not feasible.

Keywords: Fixed partial denture (FPD), pier abutment, non-rigid connector

Introduction
The occlusal forces applied to a fixed partial denture (FPD) are transmitted to the supporting structures through the pontic, connectors, and retainers [1]. An FPD with the pontic rigidly fixed to the retainer provides adequate strength and stability to the prosthesis and minimizes the stresses associated with the restoration [2]. But if an edentulous space is on both sides of a tooth creating a pier abutment, then physiologic tooth movement, arch position of the abutment, and a disparity in the retentive capacity of the retainers can make a 5-unit FPD with rigid connector a less than definitive treatment. Conventional fixed prostheses with rigid connectors struggle to accommodate this dynamic environment, often resulting in complications such as prosthesis failure. This article focuses on the problems faced during the fabrication of long span bridges, different schools of thought on pier abutment, clinical and laboratory steps in the fabrication of the non-rigid connectors also explained.

Case History
A 43-year-old female patient reported to the Department of Prosthodontics in with a chief complaint of missing teeth and difficulty in chewing in the right upper back tooth region for six months. Past dental history revealed that the patient had undergone uneventful extraction of the grossly carious tooth in right maxillary first premolar and first molar four months back. On intraoral examination, there was missing maxillary left second molar (27). There was missing right maxillary second premolar (15) and second molar (17) with first molar (16) acting as a pier abutment (Fig 1).
Patient was educated with different treatment options. With the patient's consent, the treatment option selected was to rehabilitate the edentulous space using nonrigid connector on the pier abutment. The material of choice selected was porcelain fused metal.

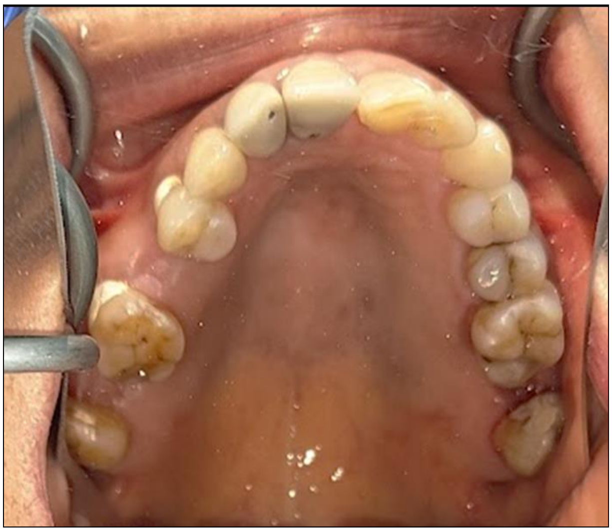

Fig 1: Pretreatment view intraoral view of the maxillary arch

Step 1: Tooth preparation & Gingival retraction
The tooth preparation was done on tooth 14, 16, 18 with equigingival margins and shoulder finish line incorporated. (# 000) Non impregnated gingival retraction cord (Sure Cord ®) was packed into the gingival sulcus followed by removal after adequate gingival displacement had been achieved. (Fig 2)

Fig 2: Tooth preparation of 14, 16, 18

Step 2: Impression making & Cast Preparation
Final impression was made using elastomeric impression material (GC Flexceed Putty & Light body Kit) with two-stage putty wash technique. Master cast was poured with Type IV Gypsum Products (Kalabhai Kalrock Diestone). After the material completely set, Cast retrieved and die cutting was done and the die pins were placed. Master cast was mounted on an articulator using interocclusal record.

Step 3: Digitalization of the record
The Prepared cast was scanned using the laboratory desktop scanner (Ceramill Map 400 Scanner, Amann Girrbach America, Inc.). The virtual / digital surveying was done. Then the wax pattern with the non-rigid connector was designed using the Ceramill mind Software. The male part (key) of the non-rigid connector was attached to the distal portion of 16 and the female part (Keyway) of the non-rigid connector was attached to the mesial portion of the 17. (Fig 3) The resin pattern (Liqucreate Wax Castable) was printed using the 3D printer (Fig 4) and then light cured for 3 min. The resin pattern trial was done.

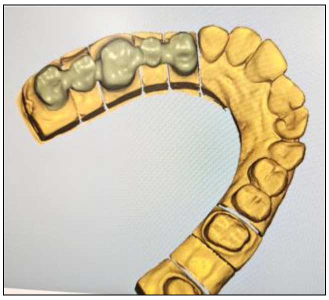

Fig 3: Digital designing of the non-rigid connectors

Fig 4: Castable resin pattern printed

Step 4: Casting & Ceramic buildup
The pattern is invested, and the casting was done. The casting retrieved was cleaned and pickled. Any part of the key-way portion of the attachment that protrudes above the occlusal surface were carefully cut off. Then the ceramic layering was done with shade selection A2. Anterior segment with male portion (key tenon) and posterior segment with female portion (Key-way mortise) were assembled in the working cast. (Fig 5, 6, 7).

Fig 5: Castable resin pattern on the cast

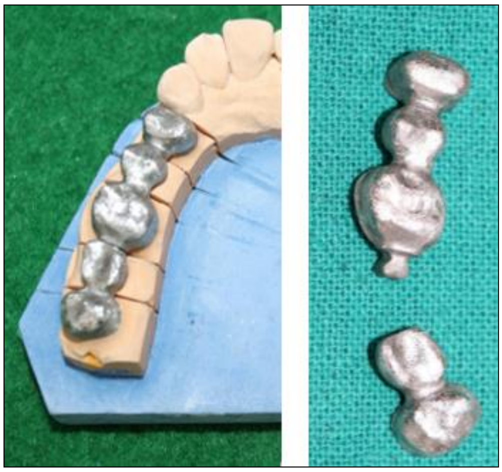

Fig 6: Invested castable resin pattern

Fig 7: Metal Copings with non-rigid connector

Step 5: Cementation & Patient instructions

The 5 - Unit FPD was cemented using the type I luting Glass Ionomer Cement. Then the excess cement is removed, and the occlusion was verified using articulating paper. The patient was advised to maintain good oral hygiene and hygiene aids such as mouth wash and inter-dental brush as required.

Fig 8: Intraoral view Prosthesis insitu

Discussion

The use of the rigid connectors between the pontic & retainers is the preferred method for fabrication in the most fixed partial dentures. However, it's not feasible to use the rigid connectors in all clinical situations. For long span bridges with the pier abutment, there are many factors to be considered [3].

Factors affecting the long span bridges

i) Physiological tooth movement

Movement of the healthy teeth is not usually visible to eyes. So, it is easily overlooked. But studies show buccolingual movement of the teeth usually varies from 56 μ to 108μ [4]. Intrusion that occurs during the mastication probably resulted from the periodontal membrane's ability to recoil because of the repeated application of occlusal forces [5]. This will impact the seating of the retainers and connectors over the abutment but a providing a stress breaker minimizes mesio-distal torquing of abutments and permits them to move independently.

ii) Arch position

Chayes [6] *et al*. found that the difference between the movements of canine and second molar is nearly 40 degrees. These micromovements of measurable magnitude and in the divergent directions can create stress in the long span bridges. These stresses are then transferred to the abutment leading to the compromise in support.

Pier abutment acts as fulcrum in the cases of long span bridge. The greater length of the bridge, independent movement of the abutment teeth, stresses on the abutment teeth and the retainers can reach destructive level in the 5-unit bridge [7]. But splitting the long span 5 unit into 2 small unit bridge helps in breaking the accumulating stress.

iii) Retentive capacity

The excessive force transmitted to the terminal retainers because of the middle abutment's fulcrum like position can cause the weaker retainer to loosen. This results in the failure due to marginal leakage and caries. There are limits to increase a retainer's capacity to withstand this displacing force. Some sort of solution must be used to neutralise the destructive effects of these forces [8].

To compensate for all the problems faced in long span bridges with a lone standing tooth to be used as an abutment i.e., pier abutment, a non -rigid connector is indicated. The etymology of the word "pier" is from medieval Latin "pera" that means "to support" [9]. The principle behind the use of non-rigid connector is equalization of occlusal forces and stress distribution. The non-rigid connector is a broken - stress mechanical solution of retainer and pontic instead of the usual rigid soldered connection [10].

Digital approach

The anterior and middle abutment preparations must have parallel insertion paths as would the abutment preparations for the usual three unit fixed partial denture. The distal abutment preparation need not to be in the same path of insertion as the other two preparations, but the distal abutment that accommodates the key-way must share a common path of insertion [11].

The digitalization of the casts and digital/virtual surveying was done to ensure there is single path of insertion in the anterior segment (3 unit) and in the posterior segment (2 unit). Any undercuts are blocked out digitally. The castable resin pattern trial was checked in the patient's mouth to ensure the single path of insertion, parallelism maintained for the coping inserts. then the conventional casting and ceramic buildup is done.

Types of non - rigid connectors: According to literature there are four types of nonrigid connectors [12] such as

- Tenon-Mortise type connectors.
- Cross-pin and Wing type connector.
- Split type connector.
- Loop type connector.

The most widely used type is Tenon-Mortise type where accurate position of the Mortise is technique sensitive as it must establish the parallelism for accurate path of withdrawal of a distal retainer. According to the clinical situations, the selection of the non - rigid connectors is chosen. Selection of the right type of connector makes the difference between success and failure of the restoration [13].

Different school of thoughts on non-rigid connectors

Markley [14] suggested placement on one of the terminal abutments and not at the pier abutment and stated that broken-stress measures serve as "safety valves" against the tremendous leverage forces created by the rigid attachment to two or more teeth.

Adams [15] suggested that placing the connector at the distal side of pier and if required adding one more at the distal side of the anterior retainer and stated that the long span bridge with a pier becomes two short span bridges and when a nonrigid connector is used with the pier will work out successfully.

Gill [16] suggested that each tooth must function both as an individual and as a part of a collective unit which makes each tooth an important factor in the function of the entire mouth and suggested is placing it at one side or both sides of the pier.

Carl E Misch [17] recommended that in conventional fixed prostheses, the "male" portion of a nonrigid attachment usually is located on the mesial aspect of the posterior pontic, whereas the "female" portion is in the distal aspect of the natural pier abutment tooth. This prevents mesial drift from unseating the attachment.

Shillingburg *et al.* [18] suggested placing the connector at the distal aspect of pier abutment. The long axis of the posterior teeth usually inclines slightly in a mesial direction, vertically applied occlusal forces produce further movement in this direction. This nullify the fulcrum effect and the patrix/male of the attachment would be seated firmly in place when pressure is applied distally to the pier.

M.B. Moulding G.A. Holland W.D. Sulik [19] conducted photo elastic stress analysis of supporting alveolar bone as modified by nonrigid connectors and concluded that pattern of stress is dependent on incorporation and location of a nonrigid connector. It is independent of the orientation of the nonrigid connector at the distal aspect of the pier abutment and the placement of a nonrigid connector at the mesial surface of the pier is least desirable.

Misch [20] suggested that bone and soft tissue consideration is important when planning for a long-span bridge. With bone available on either side of the pier abutment two implants can be one of the treatment options where stress breaker is not indicated. Because a natural teeth inclines where the implant never.

Oruc *et al.* [21] observed that the stress distribution and values of an FPD and pier abutment are affected by the presence and location of an NRC. Distal region of pier abutment is considered the area of minimum stress concentration

The load and stress, fulcrum-like situation associated with the pier abutment are avoided in case of implant treatment. However, implants can only be placed after complete medical, clinical, and radiological evaluation.

Table 1: Indications & Contraindications

Indications [22]	Contraindications [23]
The existence of pier abutment which promotes a fulcrum-like situation that can cause the weakest of the terminal abutments to fail and may cause the intrusion of a pier abutment	If the abutment presents significant mobility.
The existence of the malaligned abutment, where parallel preparation might result in devitalisation.	If the span between the abutments is longer than one tooth, because the stresses transferred to the abutment tooth under soldered retainer would be destructive.
In the mandibular arch, FPD consisting of anterior and posterior segments, a non-rigid connector is indicated as the mandible flexes mediolaterally during opening and closing strokes [23].	If the posterior retainer and pontic are opposed by a removable partial denture or an edentulous ridge while the two anterior retainers are opposed by natural dentition [24].

Conclusion

According to the clinical situations, the selection of the non - rigid connectors is chosen. Selection of the right type of connector makes the difference between success and failure of the restoration. Thus, in cases where implant therapy is not feasible, and the long span fixed bridge is indicated. Non - rigid connectors acts as safety valves and provide better choice of treatment in case of lone standing abutment. Non-rigid connectors transfer less stress to abutments also allowing physiologic tooth movement.

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