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International Journal of Oral Health Dentistry

Journal homepage: www.ijohd.org

Case Report

Prosthodontic management of a pier abutment using a digitally designed non-rigid connector: A clinical case report

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Abstract

A pier abutment located between two edentulous spaces presents unique biomechanical challenges during fixed prosthodontic rehabilitation. Rigid connectors in such cases may generate fulcrum effects, leading to debonding or long-term prosthesis failure. This case report highlights the prosthetic rehabilitation of a 32-year-old female patient with missing lower left teeth (35 and 37), using a five-unit metal-ceramic fixed dental prosthesis incorporating a digitally designed non-rigid connector. Tooth 36 served as the pier abutment. A precision-milled tenon-mortise connector was employed to reduce stress transmission and enhance prosthesis longevity. Therefore, this case underscores the importance of incorporating non-rigid connectors in pier abutment situations to mitigate fulcrum-induced stresses and preserve prosthesis stability. The integration of digital design and precision milling enhanced the accuracy of connector adaptation and ensured predictable biomechanical behavior. Within the limitations of a single case, the clinical outcome demonstrates that digitally fabricated non-rigid connectors can serve as a reliable alternative to conventional designs, offering improved longevity and patient comfort.

Keywords: Pier abutment, Non-rigid connector, Digital prosthodontics, Key-keyway, Stress breaker, Fixed partial denture.

Received: 12-08-2025; **Accepted:** 08-09-2025; **Available Online**: 14-10-2025

1. Introduction

Partial edentulism often presents with unique biomechanical challenges in prosthodontic rehabilitation, especially when a single natural tooth is bordered by edentulous spaces on both sides. This condition is referred to as a pier abutment and commonly occurs following the loss of the first premolar and first molar in either arch. In such cases, conventional fixed dental prostheses (FDPs) must be carefully planned to avoid long-term complications.[1]

Traditionally, rigid connectors are used to unify the retainers and pontics in FDPs. However, when a pier abutment is involved, rigid connectors may result in biomechanical failure. The pier acts as a fulcrum, and occlusal forces can lead to tensile stress on the terminal abutments. Over time, this can cause debonding, marginal leakage, or even dislodgement of the prosthesis.[2]

To address these concerns, the use of a non-rigid connector (NRC) has been advocated. NRCs act as stress breakers, allowing limited movement between segments of the prosthesis. This helps to reduce torque and distributes functional forces more evenly, thereby enhancing prosthesis longevity.[3] Among the different types of NRCs, the tenon-mortise (key-keyway) connector is the most frequently used design. In this arrangement, the keyway (female component) is placed on the distal aspect of the pier abutment, and the key (male component) on the mesial aspect of the posterior pontic. This orientation prevents dislodgement due to mesial drift and helps maintain the integrity of the prosthesis.[4]

This case report presents the clinical and laboratory management of a partially edentulous patient rehabilitated using a five-unit metal ceramic FDP incorporating a non-rigid connector on the distal aspect of a pier abutment. The

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https://doi.org/10.18231/j.ijohd.12834.1759135837

design rationale, step-by-step procedures, and clinical outcomes are described in detail.

2. Case Presentation

A 32-year-old female patient presented to the Department of Prosthodontics, with a chief complaint of missing teeth in the lower left back tooth region and associated difficulty in mastication. The patient reported that the teeth had been extracted due to caries approximately one year earlier. She expressed a desire for a fixed replacement and declined surgical implant placement. (**Figure 1**a,b)

The clinical Findings were as follows

1. Missing teeth: Mandibular left first premolar (35) and first molar (37)
2. Remaining teeth: 34, 36, 38
3. Pier abutment: Tooth 36 located between two edentulous spans served as a pier abutment
4. Occlusion: Class I molar relationship with adequate interarch clearance.

On radiographic evaluation it revealed adequate bone support with no signs of pathology.

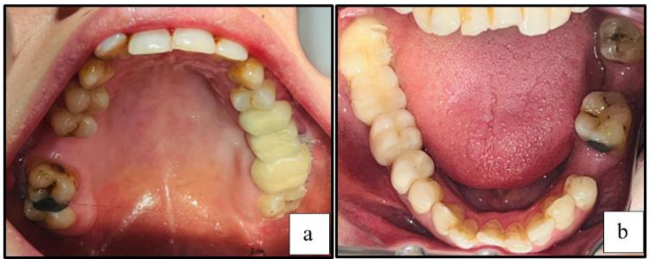

Figure 1:

3. Clinical Procedure

3.1. Diagnostic Phase

A thorough clinical and radiographic examination was performed. Diagnostic impressions were taken using irreversible hydrocolloid, and study models were poured. A diagnostic wax-up was completed to evaluate occlusal relationships and prosthetic space. The treatment plan included a five unit metal ceramic fixed dental prosthesis from teeth 34 to 38, with tooth 36 functioning as a pier abutment and a non-rigid connector integrated within the prosthesis between retainer 36 and pontic 37.

3.2. Tooth preparation

Teeth 34, 36, and 38 were prepared to receive full-coverage metal-ceramic crowns. A chamfer finish line with subgingival margin was given. Adequate occlusal and axial reductions were ensured. No special intraoral modifications were made for the non-rigid connector, as the key and keyway assembly would be completely embedded within the prosthetic pontics and not into abutment surface. (Fig 2)

Figure 2:

3.3. Provisionalization

A provisional fixed dental prosthesis extending from 34 to 38 was fabricated using a direct-indirect technique. The provisional prosthesis was cemented using a non-eugenol temporary cement, allowing for easy removal while protecting the prepared tooth surfaces. (Fig 3)

Figure 3:

3.4. Final impression and CAD Design

The final impression was made by two stage technique using putty and light body. (Fig 4)

Figure 4:

The impression was then digitalized using a extraoral lab scanner and file was stored in STL format. The STL file was imported into Exocad software for digital designing. The prosthesis was digitally segmented into two parts:-

1. Anterior segment: 34 to 36 (Fig 5a)

2. Posterior segment: 37 to 38 (Fig 5b)

A precision designed non-rigid connector (key-keyway) was incorporated at the junction between retainer 36 and pontic 37. The keyway (female component) was integrated into the distal aspect of the 36, and the key (male component) was integrated into the mesial aspect of the 37.

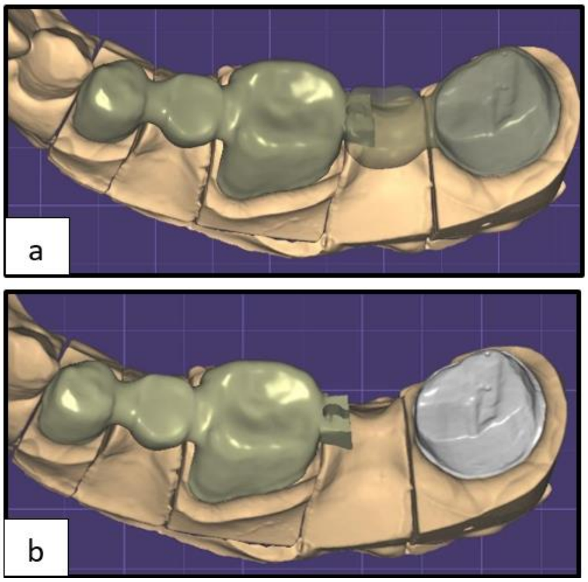

Figure 5:

3.5. Fabrication of prosthesis

The finalized CAD design was sent for Direct Metal Laser Sintering (DMLS) for fabrication in cobalt-chromium alloy. Both segments were fabricated with high precision. After cleaning and finishing, the components were verified on the master cast to ensure proper seating, Smooth engagement of the tenon-mortise connection and no binding or misalignment. (**Figure 6**a, b)

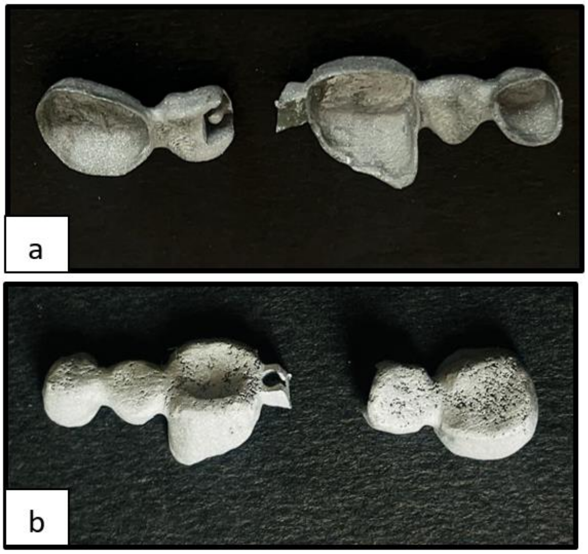

Figure 6:

3.6. Metal try-in

Intraoral metal try-in was conducted in the patient's mouth. Each segment was evaluated separately for 1) marginal integrity of 34, 36, and 38 crowns, 2) Passive fit of the non-rigid connector and 3) Stability and proper alignment of the overall framework. (**Figure 7**)

Figure 7:

3.7. Ceramic build-up and glazing

The prosthesis was then layered ceramic was applied on the frameworks, and esthetics were refined. After contouring and glazing, the segments were rechecked on the master cast for final adjustments. (**Figure 8**)

Figure 8:

3.8. Cementation Protocol of the prosthesis

The anterior segment (34–36 including keyway within the retainer) was cemented first using Type I Glass Ionomer Cement. The posterior segment (37–38 including the key) was then seated. As the patient occluded, the key component of pontic 37 engaged smoothly into the keyway within retainer 36, completing the mechanical interlock without transmitting stress to the abutment teeth. (**Figure 9** a,b)

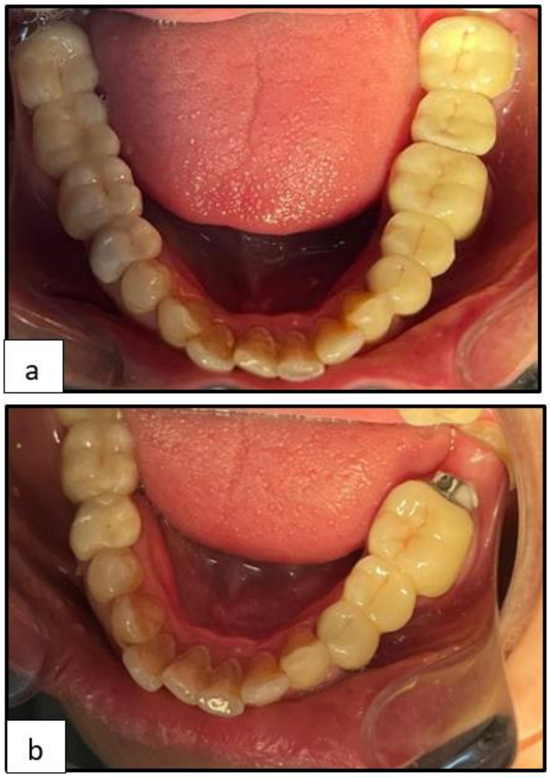

Figure 9:

3.9. Post-cementation instructions

The patient was advised to maintain meticulous oral hygiene with floss and interdental brushes, especially around the connector area. Follow-up was scheduled at 1 week, 1 month, and 3 months. No complications were reported.

4. Discussion

The presence of a pier abutment, defined as a natural tooth located between two edentulous spans, introduces a unique biomechanical challenge in fixed dental prosthesis (FDP) design. Rigidly connecting multiple retainers and pontics over a pier abutment often results in stress concentration, primarily due to physiologic tooth movements, occlusal loading patterns, and arch curvature. These forces, when left unaccommodated, may cause debonding of retainers, marginal leakage, secondary caries, or even abutment failure. This is primarily due to the fulcrum effect—the pier abutment acts as a pivot point, magnifying torque at terminal abutments during function.[1]

Traditionally, rigid connectors are the default choice in FDPs. However, their use in pier abutment scenarios is controversial. Studies have shown that under occlusal loading, the pier abutment can intrude or shift, which transmits tensile forces to the terminal abutments. The weakest retainer especially in cases with differential retentive capacity may dislodge, resulting in failure of the prosthesis.[2] Such mechanical breakdowns emphasize the need for stress modulation, rather than force locking, across the prosthesis.

To overcome this, the concept of non-rigid connectors (NRCs) was introduced. An NRC allows limited movement between different segments of the FDP, functioning as a stress breaker that redistributes functional forces across the prosthesis and to the supporting bone. The tenon-mortise (key-keyway) type is the most widely recommended and researched design, especially in cases involving pier abutments.[3] In the current case, this was achieved by incorporating a digitally designed male-female connector within the prosthesis itself between the distal aspect of retainer 36 and the mesial aspect of pontic 37 thus completely avoiding intra-abutment alteration or stress induction.

The rationale for placing the keyway on the distal surface of the pier abutment's retainer and the key on the mesial of the adjacent posterior pontic is well supported in literature. As Shillingburg et al. stated, this orientation takes advantage of the natural mesial drift of posterior teeth. When occlusal forces act on the posterior segment, the movement drives the key deeper into the keyway rather than dislodging it. This functional engagement enhances connector stability and reduces risk of decementation or prosthetic fracture.[4]

Digitally designing the NRC offers additional advantages. In this case, the prosthesis was divided into two digitally segmented parts using Exocad software, with the key-keyway junction defined precisely within the pontic bodies. This digital approach allowed:

1. Exact dimensional control (depth, angle, engagement force)
2. Elimination of casting inaccuracies
3. Predictable insertion paths
4. Enhanced fit via DMLS fabrication of cobalt-chromium frameworks

Moreover, placing the connector within the prosthesis rather than modifying abutment preparations is advantageous in multiple ways:

1. Preserves tooth structure
2. Reduces operator error
3. Enables retrievability of individual segments if needed
4. Avoids compromising abutment parallelism or crown esthetics.

Studies such as those by Kanojia et al. and Sonar et al. further reinforce the use of prosthesis-integrated NRCs, especially in long-span bridges. They concluded that stress distribution patterns and connector longevity were significantly improved when NRCs were used in pier abutment configurations, particularly when fabricated using precision digital technologies.[4,5]

However, technique sensitivity remains a limitation. The success of an NRC depends on:

1. Accurate connector positioning
2. Path of insertion control

3. Maintenance of passive fit
4. Avoidance of occlusal interference

Failure to meet these conditions may result in misalignment, premature wear of the key, or even failure of connector engagement under load. Therefore, digital workflows, as used in this case, significantly reduce the chances of error and offer reproducible results with minimal chairside adjustment.

5. Conclusion

Rehabilitating a pier abutment case with a rigid connector often leads to biomechanical failures due to the fulcrum-like effect exerted by the central abutment. In the presented case, the use of a digitally designed non-rigid connector within the prosthesis effectively addressed the challenge of stress concentration around the pier abutment. By incorporating a precision-milled key-keyway mechanism between 36 and 37, occlusal forces were redirected away from the abutments, allowing independent physiologic movement and minimizing the risk of retainer failure. Digital design and fabrication using CAD software and DMLS technology further enhanced the accuracy, passive fit, and long-term prognosis of the restoration. This approach demonstrates that prosthesis-integrated NRCs, when correctly planned and executed, are a reliable and conservative alternative to traditional rigid designs in long-span bridges involving pier abutments. Such designs not only preserve tooth structure but also contribute to the functional longevity and comfort of the prosthetic rehabilitation.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Cite this article: Raj RB, Kaur P, Rani PD, Vandana R. Prosthodontic management of a pier abutment using a digitally designed non-rigid connector: A clinical case report. *Int J Oral Health Dent*. 2025;11(3):251–255.