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# Original Research

## Effect of implant position and attachment type on stress distribution of implant-assisted removable partial dentures

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***ABSTRACT:***
**Background:** To study the effect of implant position and type of attachment on stress distribution of implant-assisted removable partial dentures. **Materials & Methods:** A total of five implants, each measuring 10 mm in length and 4.1 mm in diameter, were placed bilaterally in proximity to the first premolar and second molar regions of a mandibular Kennedy class I model. To analyze the data, a two-way multiple analysis of variance was conducted to compare the maximum principal strain (MPS) around the implants, employing a significance threshold of 0.05. The results were analysed using SPSS software. **Results:** Significant statistical distinctions were observed concerning the impact of implant position (P = 0.001), type of attachment (P = 0.001), and the interplay between implant position and attachment type on the variables under consideration (P = 0.001). **Conclusion:** The positioning of implants significantly impacts the stress distribution of the IARPD, with anteriorly positioned implants resulting in lower MPS compared to implants placed relatively more posteriorly.
**Keywords:** Implant-assisted removable partial denture, Stress distribution, Implant position.

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### INTRODUCTION

Among modern dental treatment modalities, the restoration of partial edentulous ridges with removable partial denture is accepted as a standard treatment option. [1] However, the compromise in denture retention and stability, especially in the mandible with distal extension base, is the most common clinical drawback for many patients.[2] The difference in bearing capacities of the supporting tissues in the distal extension arch leads to the classic disadvantage of a removable partial denture, moving the denture and abutment torquing during function. [3] To overcome this inherent problem, functional impression technique has been applied to record the tissue in functional form as it reduces torque on supporting structures due to the difference in resiliency between the abutment teeth and soft tissue covered on edentulous ridges. [4,5]In the situation of partially edentulous patients, conventional clasp-retained removable partial denture (RPD) has been the treatment of choice for decades because of the noninvasive procedure and economically affordable treatment.[6] However, bilateral mandibular distal extension RPDs compared to maxillary distal extension RPDs and tooth-supported RPDs reveal limited anatomical supporting areas, which is susceptible to load transferred to underlying mucosa and residual ridge and may endanger the abutment teeth involved.[7] The use of dental implants as an ancillary component and implant-assisted removable partial dentures (IARPDs) has been encouraged by several authors.[7,8] IARPD can transform a Kennedy classification I and II into a Kennedy classification III by providing a posterior support to the prosthesis.[9] Nowadays, the placement of normal-sized implants distally to the free-end edentulous space, especially in the lower jaw to convert the Kennedy class I edentulous ridge into a pseudo class III, has been recommended as the other option to control the noncompatible resiliency between abutment teeth and soft tissue on distal extension ridges. The complementary support from dental implants placed on the edentulous ridge increases the stability and retention of the denture. In addition, it also reduces the stress loaded on supporting structures, which has resulted in decreasing traumas on those supporting tissues. [10,11]For many years, conventional RPD's have been the only option available for partially edentulous patients; however, through the advent of osseointegrated implants, treatment alternatives for patients with this profile have improved tremendously. The most outstanding merit of a fixed implant supported prosthesis over the other implant options is the psychological advantage of being a fixed versus removable over-denture prosthesis. Yet, many cases may still benefit from removable dentures, functionally and financially. In such cases, eliminating the lever movement in distal extension edentulous areas by implant incorporation could be a promising treatment plan to achieve comfort and stability. The incorporation of different resilient attachments may also improve retention and quality of force distribution and enhance the aesthetics by avoiding the buccal retentive clasps. On the other hand, implant assisted RPDs in partially edentulous patients with missing mandibular premolars and molars, opposing maxillary conventional denture can successfully prevent the occurrence of combination syndrome, by stabilizing the posterior occlusion. [12,13] Hence, this study was conducted to the effect of implant position and type of attachment on stress distribution of implant-assisted removable partial dentures.

## MATERIALS & METHODS

A total of five implants, each measuring 10 mm in length and 4.1 mm in diameter, were placed bilaterally in proximity to the first premolar and second molar regions of a mandibular Kennedy class I model. This model featured artificial dentition extending from canine to canine, aligned vertically with the occlusal plane. To accommodate locator and magnetic attachments, five IARPDs were constructed. The model's surface was equipped with strain gauges to quantify strain around the implants during loading.A unilateral vertical load of 120 N was applied to the area of the right first molar, using a crosshead speed of 10 mm/min. Measurements were taken under the subsequent conditions: premolar IARPDs with either locator or magnetic attachments, and molar IARPDs with either locator or magnetic attachments. To analyze the data, a two-way multiple analysis of variance was conducted to compare the maximum principal strain (MPS) around the implants, employing a significance threshold of 0.05. The results were analysed using SPSS software.

## RESULTS

Significant statistical distinctions were observed concerning the impact of implant position (P = 0.001), type of attachment (P = 0.001), and the interplay between implant position and attachment type on the variables under consideration (P = 0.001).Regarding the loading aspect, the stress distribution of the IARPD was notably affected by implant position (P = 0.001), although not by attachment type (P = 0.09). Conversely, on the nonloading side, both implant position (P = 0.001) and attachment type (P = 0.001) significantly influenced the stress distribution of the IARPD.

**Table 1: multiple analysis of variance for implant position, attachment type and their interaction**

| Effect | Value | P value |
|---|---|---|
| Implant position | 0.64 | 0.001 |
| Attachment type | 0.91 | 0.001 |
| Both (interaction) | 0.72 | 0.001 |

**Table 2: multiple analysis of variance (tests of between-subjects effects)**

| Source | Variable | P value |
|---|---|---|
| Implant position | Loading side (LS) | 0.001 |
| | Nonloading side (NLS) | 0.001 |
| Attachment type | LS | 0.09 |
| | NLS | 0.001 |
| Interaction between both | LS | 0.001 |
| | NLS | 0.001 |

## DISCUSSION

With regard to implant location, it was observed that distally placed implants resulted in reduced stress at the edentulous area because it transformed mandibular Kennedy class I to a more favorable arch configuration: mandibular Kennedy class III. Kennedy class III configuration's eliminated lever arm usually occurred with distal extension RPD, which reduced distal displacement of the soft tissue. Furthermore, load transfer to the abutment teeth was also reduced.[14] This is in agreement with the systematic review of Zancope et al. which explained that implant placement at the most posterior region for IARPD provided optimal stability for the prosthesis. [2] Similarly, Grossmann et al. recommended placing implants at a second molar position to enhance support and stability. [9] Hence, this study was conducted to the effect of implant position and type of attachment on stress distribution of implant-assisted removable partial dentures. In the present study, significant statistical distinctions were observed concerning the impact of implant position (P = 0.001), type of attachment (P = 0.001), and the interplay between implant position and attachment type on the variables under consideration (P = 0.001). A study by Tun Naing S et al, implant position had significant effect on the MPS of IARPD on loading and nonloading sides while attachment type only significant on nonloading side. Molar implants showed larger MPS than premolar implants with both locator and magnetic attachments during unilateral loading.The stress distribution of the IARPD is significantly affected by implant position wherein anteriorly placed implants exhibit lower MPS than relatively posteriorly placed implants.[15] Yang X et al, a complete 3-dimensional finite element model was established, which contained tooth structure, and periodontal structures. The displacement of the denture was smaller in Locator (9.38 μm vertically, 45.48 μm obliquely) and Magfit models (9.54 μm vertically, 39.45 μm obliquely) compared with non-implant RPD model (95.27 μm vertically, 155.70 μm obliquely). Compared with the two different attachments, cortical bone stress value was higher in Locator model (Locator model 10.850 MPa vertically, 43.760 MPa obliquely; Magfit model 7.100 MPa vertically, 19.260 MPa obliquely).The stress value of abutment periodontal ligamentin Magfit model (0.420 MPa vertically) was lower than that in Locator model (0.520 MPa vertically).The existence of implant could reduce maximum von Mises value of each supportive structure when Kennedy I partially edentulous mandible was restored. Comparing the structure of Magfit and Locator attachment, the contact of Magfit attachment was rigid, while Locator was resilient. Locator attachment could improve stability of the denture dramatically. Locator had stronger effect on defending horizontal movement of the denture.[16]For mucosal-level abutments, movement of the abutment tooth was lower for implants positioned distal to the abutment tooth than for those positioned medial to the abutment tooth. For elevated abutments, movement of the abutment tooth was lower for implants positioned medial to the abutment tooth than for those positioned distal to the abutment tooth.The mechanical effects on abutment teeth at the same implant position differed in relation to implant abutment height.[17]In IARPD, the morphology of the implant abutment affects movement of the abutment tooth. In particular, abutment movement was lower for H abutments than for ML abutments, for the same implant position. For ML abutments, abutment teeth moved less when the implant was positioned distal to the abutment tooth than when it was positioned medial to the abutment tooth. However, for H abutments, abutment teeth moved less when the implant was positioned medial to the abutment tooth. In ML abutments, abutment tooth movement was synchronized with denture movement. However, in H abutments, movement of abutment teeth was better suppressed by bracing when the implant abutment and abutment teeth were closer. Positioning an implant close to the abutment tooth is aesthetically desirable, as a retention arm does not need to be applied to the abutment tooth. [9]The molar IARPD showed a larger MPS around the implant than the premolar IARPD with both locator and magnetic attachments on the loading side. In the molar IARPD, the MPS was mainly concentrated on the implant and surrounding tissues of the loading side, which may have caused excessive loading on one side of the ridge. In contrast, the MPS was also distributed to the nonloading side in premolar IARPDs with both locator and magnetic attachments. This result is similar to that of Matsudate et al., [18] who demonstrated that a mesially placed implant generates a smaller MPS around the implant. The distance between the implant and abutment tooth may influence this result. Implant placement closer to the abutment tooth can decrease the stress applied to the peri-implant tissue, as the abutment tooth and implant can share the loading force and distribute it to the surrounding tissues of the implant. [14] Nevertheless, in premolar IARPDs, the implant acts as a fulcrum upon which the denture base rotates, thus generating a lateral force on the abutment tooth and implant.Mitrani et al. (2003) evaluated 10 Kennedy class I and II partially edentulous patients for 4 years. To assess the patients' satisfaction, physical, clinical, and radiographic examinations were done. In addition to satisfaction, small attachment wear and minimal radiographic peri-implant bone loss were reported.[19] One of the most challenging aspects of removable partial dentures, especially in distal extension types, is denture displacement. Based on some studies implant placement for RPDs relieves the pressure on soft tissues, and minimizes denture displacement.[19,20]

## CONCLUSION

The positioning of implants significantly impacts the stress distribution of the IARPD, with anteriorly positioned implants resulting in MPS compared to implants placed relatively more posteriorly.

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