The journal of
PROSTHETIC AND IMPLANT DENTISTRY
Official Publication of Indian Prosthodontic Society
Kerala State Branch

COMPARISON OF STRAIN GENERATED BY SHORT AND CONVENTIONAL IMPLANTS SUPPORTING DISTAL EXTENSION REMOVABLE PARTIAL OVERDENTURE– A PHOTO ELASTIC ANALYSIS

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Abstract:

PURPOSE: The aim of this study is to evaluate and compare the strains generated by short and conventional implants supporting a distal extension removable partial overdenture under axial and oblique loading.

MATERIALS AND METHODS: A mandibular photoelastic resin model was printed based on a computed tomography scan of a patient with bilaterally missing mandibular posterior teeth. Two implants were placed- short (4.3x6mm) on the right side and conventional (4.3x10mm) on the left side second molar region. A conventional Kennedy's Class I implant retained RPD was fabricated. Maximum static loads of 100 N were applied in both vertical and 45 ooblique directions in the second molar region of the denture. Ten tests were done for each group. The stress values around the implants were derived from the colored fringe patterns that were photographed after the load applications from which strain values were derived. Data were analyzed by unpaired t-test.

RESULTS: In both conventional and short implants, the strains around the neck of the implants were more on oblique loading compared to axial loading. Comparison of average compressive strain under axial and oblique loading showed no significant difference between conventional and short implants.

INTERPRETATION & CONCLUSION: 1) There is no statistically significant difference between the strains generated by conventional and short implants under vertical loading and oblique loading

2) The generated strains were more under oblique loading compared to axial loading.

Key words: conventional; short; overdenture; strain; photoelasticity

Introduction

Implants have revolutionized dental practice and have helped overcome many of the limitations encountered with conventional fixed or removable prostheses and is considered as an aesthetic and functional restoration.

Placing two implant abutments distally in the mandible has been recommended to transform a bilateral distal extension (Kennedy's Class I) RPD to a tooth and implant-supported/assisted RPD (a pseudo-Kennedy's Class III). The pseudo-Kennedy's Class III design will improve the support, stability, and retention of a distal extension RPD.

This could be seen as a cost-effective alternative compared to implant-retained fixed prosthetic options[1, 2].

Not all patients have sufficient bone height in the posterior region and are often disinclined to submit themselves to invasive surgeries prior to the placement of the implants. These include bone-grafting procedures in the region, or even nerve lateralization of the inferior alveolar nerve, which may also result in permanent paresthesia[3]. An alternative is the use of short implants[4,5].

Conventional implants are the preferred option for any prosthesis. But in compromised situations usage of short implants can be beneficial compared to surgical corrections. Investigations on the use of short implants have led to diverse results, and the choice remains controversial. This in-vitro study proposed to evaluate and compare the strains generated by short and conventional implants supporting distal extension removable partial overdenture in order to help the clinician make the right choice and achieve long-term clinical success[6].

Materials and Methods

A real-life arrangement comprising of a mandibular model was made using C-51(3222) resin and K-6 hardener employing Fused Deposition Modelling based on a computed tomographic scan of a patient with bilaterally missing mandibular posterior teeth. Soft tissue was duplicated using Gingifast- Elastic.

Fig 1: Fabricated Distal extension removable partial over denture

Fig 2: Reference points for strain comparison

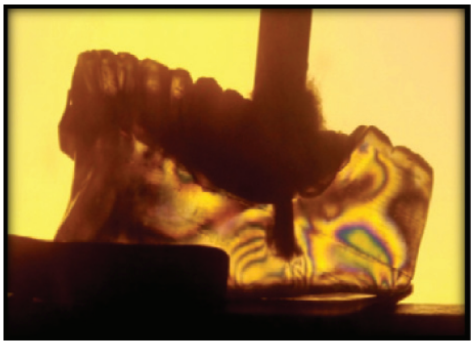


Fig 3: Strain patterns in conventional implants under axial loading

Fig 4: Strain patterns in short implants under axial loading

Fig 5: Strain patterns in conventional implants under oblique loading

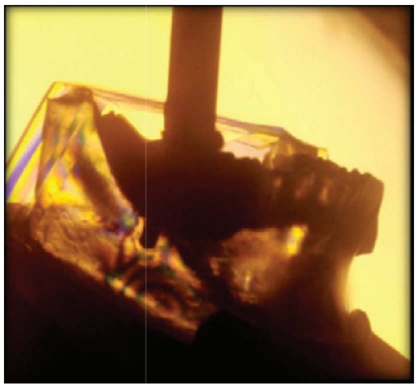


Fig 6: Strain patterns in short implants under oblique loading

One short (4.3x6mm) and one conventional (4.3x10mm) titanium tapered threaded implants (JD Evolutions) were placed on the right and left sides respectively in the second molar region of the photoelastic model with an osteotomy kit, using a standard protocol.

A conventional Kennedy's Class I RPD with a lingual bar (0.5 mm), mesial rests with canine extensions (indirect retainers) and I bar was fabricated with cobalt-chrome-molybdenum alloy (Wironit® BEGO, Bremer Goldschlägerei Wilh, Germany). The male component of the locator attachments was then picked up and secured in the denture with autopolymerizing acrylic resin. (Fig 1)

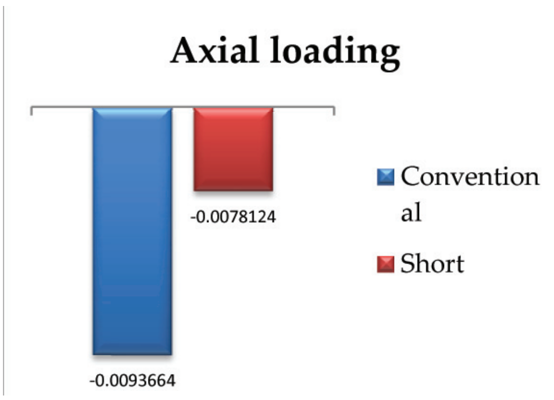
A static load of 100 N was applied in the second molar region, in both vertical and 45-degree oblique directions, using a universal testing machine (EMIC-DL 3000, Universal Test System). Ten tests were done for each group. During each load sequence, the isochromatic fringes were observed and photographed within the field of the circular polariscope with a digital camera (Canon EOS 1300D) with a resolution of 5,184 x 3,456 pixels, while the prostheses were under load for one minute. The changes in colored fringe patterns on load application were clearly captured. The fringe orders were determined by Tardy method of compensation. 5 points were considered for determining the strains;Point 1: mesial-cervical, Point 2: Mid-mesial, Point 3: Apical, Point 4: Mid-

Axial Loading	Mean	SD	T value	P value
Conventional implants	-0.0093664	0.00337358	1.86	0.068
Short implants	-0.0078124	0.00243691		

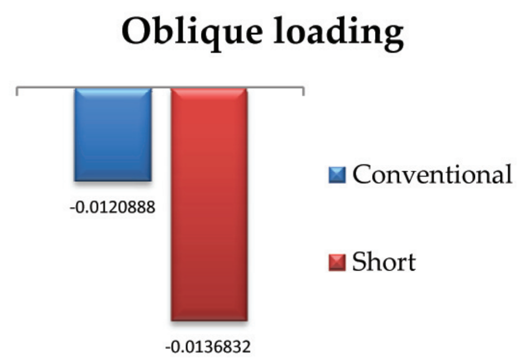
Table 1: Comparison of strain under axial loading

Oblique Loading	Mean	SD	T value	P value
Conventional implants	-0.0120888	0.00353195	-1.50	0.14
Short implants	-0.0136832	0.00396384		

Table 2: Comparison of strain under oblique loading loading



Graph 1: Comparison of strain under axial loading



Graph 2: Comparison of strain under oblique loading

distal, and Point 5: Distal-cervical. (Fig 2)

Stresses in the marked points were determined using the stress-optic law and from these stress values, amount of strain in a particular region was determined. Strain distribution data were generated for both conventional implants and short implants under both axial and oblique loading. The collected data were analyzed by unpaired t-test (student t-test)

Results

The pattern and distribution of strain were different under vertical and oblique loading.

The compressive strains generated by conventional implants under axial loading was more than short implants but it was not statistically significant (p=0.068). A marked increase in strain was noted in the apical region of conventional implants. Under oblique loading condition, short implant generated higher strain than conventional implant but the difference was not statistically significant. But a significant increase in strain was noted in the crestal region of the short implant under oblique loading. (p=0.14)

The strains generated by conventional and short implants under oblique loading was significantly higher (p=0.008, 0.001) than that of axial loading. In both cases, oblique loading showed greater strain with higher concentration in the crestal region.

Discussion

Implants in conjunction with Kennedy's class I RPD was used for the first time in the early 1970s, and since then clinical trials have indicated good implant survival rates[7]. The response of bone to applied stress has been well documented to influence the success or failure of an implant[8]. As far as implant shape is concerned, design parameters that primarily affect load transfer characteristics (the stress/strain distributions in the bone) include implant diameter and the length of the bone-implant interface.

Mandibular posterior region is found to undergo continuous resorption with time. Previous studies have correlated this resorption with reduced muscle activity[9]. The main factor to be considered is the difficulty in finding bone height and thickness in the posterior region of the mandible sufficient for placing a conventional implant to support a prosthesis without the need for lateralization of the mandibular nerve or bone graft[3]. The reason can be attributed to long-standing edentulous ridges. Short implants in this region are an interesting alternative and a therapeutical option to vertical augmentation since the treatment is faster, cheaper, and associated with less morbidity[5]. Recent studies have shown positive results for short implants even for those shorter than 7 mm in length[10].

Implants were placed in the second molar region as many investigations have mentioned that the location of an implant underneath the denture base is closer to the second molar, better the occlusal support[11,12].

The overdenture was attached to the implants using locator abutments on both sides. The locator attachments are an alternative to ball attachments, especially when the interarch distance is inadequate to avoid the denture base deformation and fracture[13]. The 100N load selected represents a load relative to a standard bite force for a patient with an RPD and was a load that the photoelastic model could repeatedly withstand without deforming[14,15].

A photoelastic analysis was done to evaluate the strains. Photoelastic models have been used successfully to indicate the differences between various prosthetic designs and the effects of compromised conditions through a comparative evaluation of stress-related outcomes[6].

There was no statistically significant difference between conventional and short implants under axial and oblique loading. The results comply with the previously published work which has shown that the behavior of conventional implants is similar to short implants[1,5, 7,10,16,17,18,23]. However, a few studies have shown that a reduction in implant length increased stress values with a significant difference[3,8,19]. This difference could be because most of the studies were done on fixed prosthesis and characteristics of implants under removable prosthesis may be variable.

In conventional implants and short implants, the strains under oblique loading were more compared to axial loading which was statistically significant. Many studies have shown that the nonaxial forces tend to cause uneven strain distribution leading to areas of higher strains and others of low strains[7]. This coincides with the findings of Barbier et al (1998) and non-parametric computerized models of loaded dental implants by Meijer et al (1996) and Lai et al (1998)[7]. Many clinical studies had agreed that more bone loss has been observed around dental implants under oblique loads than those under axial loads[20].

Conventional implants showed higher strain in the apical region under axial loading. (Fig 3) A study had compared implant supported distal extension removable prosthesis with different attachment types and shown that in the vertical application of 100 N load in resilient-resilient attachment type, stress was more in the apical region (21). In short implants, the strains in the crestal region were slightly higher compared to apical but it was not significant.(Fig 4) However, a study done by Marcele et al have shown that under axial loading short implants increased stress concentration around the implant especially in the cervical portion (23)(Table 1, Graph 1)

Both conventional and short implants showed maximum strain in the crestal region and least strain in the apical region under oblique loading.(Fig 5,6) A study had compared the stress distribution with different implant dimensions in implant-supported partial overdentures and has shown that higher stresses around the implant neck may be attributed to the fact that this area is mainly subjected to non-axial masticatory forces, which act in an oblique direction as in grinding movements, in comparison to the chopping movements, which act in an axial direction[7] (Table 2, Graph 2)

A two-dimensional finite element analysis suggested that the modulus of elasticity of the cancellous bone play a key role in good stress distribution. When a load is applied to the superstructure, the resultant stress transfers to the bone surrounding the implant. When there is a small difference in the values of the modulus of elasticity of both cortical and cancellous bone, the stress will be distributed evenly. Since a dense bone has the ability to bear the stress which is applied to it, while in the case of great difference, the stress will be concentrated on the cortical bone[22].

This study had a few limitations too. Photoelasticity requires the use of special light-polarizing materials that may not be fully representative of bone in terms of mechanical behavior[10]. The implant osseointegration and the physiological mobility of the abutment teeth were not considered. This study only looked at one IARPD design and did not consider the numerous designs that could be adopted[23]. Long-term follow-up clinical studies are also recommended to assess the results found in the present in vitro study.

The use of dental implants can be definitely recommended for treating all edentulous area. Also, alveolar bone is preserved after dental implants and a high degree of success is achieved with implants in partly edentulous jaws[24].

Conclusion

Within the limitations of this in vitro study, the following conclusions were drawn:

1. Under axial loading, there was no statistically significant difference between conventional and short implants. The strain observed in the

apical region was more in the conventional implant which was statistically significant.

2. Under oblique loading, there was no statistically significant difference between conventional and short implants. The compressive strains generated by the short implant in the crestal region were more compared to the conventional implant which was statistically significant.

3. In conventional and short implants, the strains under oblique loading were more compared to axial loading which was statistically significant.

4. Within the limitations of this in vitro study, it can be concluded that short implants may be used as an alternative to conventional implants supporting distal extension removable partial overdenture when the situation demands.

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