Effect of cyclic loading on torque loss of abutment screws

Fahad A Aziz
Post graduate student, Department of Prosthodontics and Implantology, AECS Maaruti College of Dental Sciences and Research Centre, Bangalore

Chandrasekharan Nair K
Professor and Head of the Department, Department of Prosthodontics and Implantology, AECS Maaruti College of Dental Sciences and Research Centre, Bangalore

Jayakar Shetty
Professor, Department of Prosthodontics and Implantology, AECS Maaruti College of Dental Sciences and Research Centre, Bangalore

Vahini Reddy
Professor, Department of Prosthodontics and Implantology, AECS Maaruti College of Dental Sciences and Research Centre, Bangalore

Abstract

Objective: To find out and compare the effect of cyclic loading on torque loss of abutment screws of a conventional implant supported fixed dental prosthesis (ISFDP) and an implant supported cantilevered prosthesis (ISCP)

Methodology: Four implants (two-3.5 by 10mm and two-5.0 by 10 mm) with standard abutments, embedded in acrylic blocks were used as test specimens. A three unit conventional fixed prosthesis and a three unit cantilevered prosthesis with two abutments were fabricated. Loading tests were performed by a universal testing machine. Retainers and pontics of each group were loaded at 600 N. Torque measurement was done before and after cyclic loading (50,000 cycles) using a digital torque gauge.

Results: Mean reverse torque values measured for cantilever bridge was 19.28 Ncm and 25.08 Ncm (mesial and distal abutment respectively) in comparison to 29.01 Ncm and 29.47 Ncm (mesial and distal abutment respectively) for the conventional bridge

Conclusion: Upon cyclic loading, significant abutment screw loosening occurred with the implant supported cantilever bridge. In an estimated one year period, in cantilever prosthesis, 40% torque loss was found in mesial abutment and 21% in distal abutment. In conventional bridge the mean torque loss was only 9%.

Keywords: Abutment screw, torque, implant supported cantilever

Introduction

Implant supported cantilever prosthesis is necessitated when there is inadequacy of available bone. However it is documented that 71.1% of implant supported prosthesis had event free survival where as conventional implant supported fixed dental prosthesis had 85.9% survival[1]. Most commonly reported failures of cantilever prosthesis are resorption of the peri-implant bone crest, loss of osseointegration, loosening and fracture of abutment screw, fracture of the prosthesis and fracture of implant.

Union of the abutment and implant is maintained by the compressive axial force directed through the application of torque on the abutment screw. In comparison to conventional prosthesis, the cantilever prosthesis has shown to be subjected to higher axial

Address for correspondence: Dr. Fahad A Aziz, Post graduate student, Department of Prosthodontics and Implantology, AECS Maaruti College of Dental Sciences and Research Centre, #108 Hulimavu, Tank Bund Road, BTM 6th Stage, 1st Phase, Kammanahalli, Off Bannerghatta Road, Bangalore - 560076.
e-mail: dr.fahad.aziz@gmail.com

Accepted : 24/4/2014

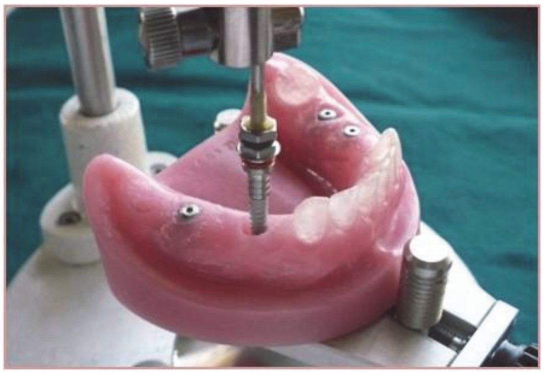

*Fig.*1 Implant placement in acrylic model using a dental surveyor

*Fig.*2 Digital torque driver

*Fig.*3 Cemented implant supported prosthesis with central access holes

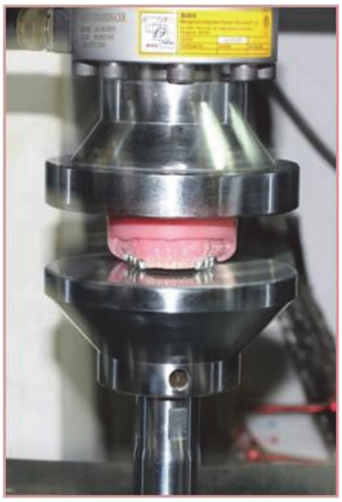

*Fig.*4 Cyclic loading using a universal testing machine

*Fig.*5 Reverse torque measurement

forces, microstains and bending moments. Abutment screw loosening has been cited as the most common cause for higher failure rates associated with cantilever prosthesis but the effect of cyclic loading on torque loss of the screws has never been quantified or compared with a conventional prosthesis design. The purpose of this study was to find out and compare the effect of cyclic loading on torque loss of abutment screws of a conventional implant supported fixed dental prosthesis and an implant supported cantilevered prosthesis.

Methodology

An acrylic dentulous model without third molar was made and the following teeth were removed- 34,35,36, 44,45,46,47. Mock osteotomy sites were prepared on the model in the place of 36,35 and 46,44 to place implants. 3.5/10 mm implants were placed in the premolar region and 5/10 mm implants were placed in the molar region. A total of four implants were placed (ADIN implant systems, Israel). The implants were placed mutually parallel using a dental surveyor (Fig1). The implants were embedded in the prepared sites and fixed with autopolymerising acrylic resin. Models were then stored in water for 24 hours.

Abutments were positioned on the implants and the abutment screws were tightened with a torque of 32 N/cm using a digital torque driver (SD Series, Eclatorq, Taiwan) - (Fig.2). A three unit cantilevered bridge for missing 34 and a conventional fixed bridge for missing 45 were fabricated. Central access holes were prepared on all the retainers (Fig.3). The prostheses were cemented on their respective implants using Tempbond.

Table 1: *Reverse torque values (N/cm) measured for the cantilever bridge specimens following cyclic loading*

Sr no.	Mesial abutment	Distal abutment
1	19.6	25.5
2	19.9	25.6
3	18.9	24.7
4	20.1	25.9
5	18.7	24.1
6	19.5	25.3
7	19.0	24.4
8	18.9	24.0
9	21.0	26.3
10	18.1	25.0
Mean	19.28 (0.81)	25.08 (0.77)

Table 2: *Reverse torque values (N/cm) measured for the conventional bridge specimens following cyclic loading*

Sr no.	Mesial abutment	Distal abutment
1	28.9	29.4
2	28.5	29.5
3	27.8	28.9
4	29.1	29.9
5	27.7	28.1
6	28.7	29.3
7	29.2	31.1
8	30.5	30.9
9	28.5	29.1
10	31.2	28.5
Mean	29.01 (0.63)	29.47 (0.95)

Table 3: *Pair wise comparison of two bridges and two abutments with reverse torque values (N/cm) scores by Tukeys multiple posthoc procedures*

Bridges and abutments	Cantilever bridge with mesial abutment	Cantilever bridge with distal abutment	Conventional bridge with mesial abutment	Conventional bridge with distal abutment
Mean	19.37	25.08	29.01	29.47
SD	0.83	0.77	1.10	0.95
Cantilever bridge with mesial abutment	-			
Cantilever bridge with distal abutment	p=0.0002*	-		
Conventional bridge with mesial abutment	p=0.0002*	p=0.0002*	-	
Conventional bridge with distal abutment	p=0.0002*	p=0.0002*	p=0.6830	-

*p<0.05

Table 4: *Comparison of two bridges types viz. conventional and cantilever and two abutments viz. mesial and distal with reverse torque values (N/cm by two way ANOVA*

Sources of variation	Degrees of freedom	Sum of squares	Mean sum of squares	F-value	p-value
Main effects					
Types of bridges	1	492.1023	492.1023	578.0560	0.00001*
Types of abutments	1	95.1722	95.1722	111.7956	0.00001*
2-way interaction effects					
Bridges x Abutments	1	68.9063	68.9063	80.9419	0.00001*
Error	36	30.6470	0.8513		
Total	39	686.8278			

*p<0.05

Cyclic loading was done using a universal testing machine (Instron, USA) - (Fig.4). The occlusal surface of the model was placed facing the lower piston, such that the upper piston could apply loading forces perpendicular to the base of the model. To simulate one year of masticatory load - 600N of occlusal load was applied for 50,000 cycles[2]. After the cyclic loading, reverse torque values were measured for each abutment using the digital torque driver (Fig.5). The same experiment was repeated with ten specimens for each of the two groups (cantilever bridge and conventional bridge).

Results

In cantilever bridges, mean reverse torque values recorded with mesial abutment was 19.28 N/cm and with distal abutment was 25.08 N/cm (Table 1)

In conventional bridges, mean reverse torque values recorded with mesial abutment was 29.01 N/cm and with distal abutment was 29.47 N/cm (Table 2)

The mean reverse torque values were significantly higher in conventional bridges when compared to those of cantilever bridges (Table 3)

The mean reverse torque values were significantly higher in distal abutment when compared to those of mesial abutment in cantilever bridges (Table 3)

The interaction effect of bridges (cantilever and conventional) and abutments (mesial and distal) on reverse torque values was found to be significant (Table 3 and 4)

Discussion

This in vitro study compared the effect of cyclic loading on the torque loss of abutment screws of a cantilever and conventional implant supported prosthesis. 40% torque loss in mesial abutment and 21% torque loss in distal abutment of the cantilevered prosthesis was found, in comparison to a mean torque loss of 9% observed on a conventional bridge.

Occlusal loading results in strain in the crown, the implant-abutment assembly, and the adjacent osseous structures[3]. The range of force applied during mastication can vary and be as high as 1200 N. In this study, a conservative protocol was selected. The forces exerted were equivalent to normal mastication in the premolar-molar region. The 500,000 cycles duration of loading is estimated to be equivalent to 9 to 10 months, a relatively short period of time 2. For both the groups occlusal contacts were applied on all three units of the prosthesis to ensure equal distribution of the forces and thus reducing the cantilever effect from the pontic. A significantly higher loss of torque was seen with mesial abutment of an implant supported pontic. This is in accordance to studies that found that distribution of masticatory forces in an implant supported FDP with cantilever extension is not uniformly distributed resulting in higher stress concentrations at implant sites adjacent to the extensions[1]. Brunski[4] describes a cantilevered prosthesis as a Class I lever with the fulcrum at the distal end of the implant adjacent to the pontic. When occlusal load is applied equally, the cantilevered extension flexes resulting in tensional forces on the retainer adjacent to it. This causes plastic deformation of the abutment screw and thus screw loosening.

Conclusions

- Cyclic loading caused loss of torque of abutment screws of conventional and cantilever bridges.
- In an estimated one year period, in cantilever prosthesis, 40% torque loss was found in mesial abutment and 21% in distal abutment. In conventional bridge the mean torque loss was only 9%.
- In implant supported cantilevered fixed prosthesis torque loss of abutment screws were more in the abutment which was placed close to the pontic.

References

1. Zurdo et al. Survival and complication rates of implant supported fixed partial dentures with cantilevers: a systemic review. Clin Oral Impl Res 2009;20:59-66
2. Setia et al. The effects of loading on the preload and dimensions of the abutment screw for a 3 unit cantilever-fixed prosthesis design. Implant Dent 2013;22:414-21
3. Rubo JH, Bianco VC, Biomechanics of cantilevered implant-supported prosthesis, Implant dentistry-the most promising discipline of dentistry, In Tech publications, 2011, pp 185-202
4. Brunski JB. Biomaterials and biomechanics in dental implant design, Int J Oral Maxillofac Implants 1988;3:85-97.