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Original article

Clinical And Radiological Comparative Evaluation Of Custom Made Zirconia Versus Titanium Dental Implants: An In Vivo Study

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ABSTRACT

AIM:To evaluate the osseointegration of custom made zirconia implants in comparison to titanium in-vivo conditions .**MATERIALS AND METHODS**:. This study was approved by the ethical committee of Government dental college and research institute, Bangalore. For the study purpose, sample size of 15 patients with bilaterally missing lower first molar reporting to the dept. of prosthodontics,gdcri,Bangalore were included and commercially available yttria stabilized zirconia blocks (Amanngirrback Germany) were used for fabricating custom made zirconia implants which were used as test implants and commercially available titanium implants (osstem system) were used as controlA split mouth design was developed with zirconia as a test specimen on one side and titanium implant as a control on the other. The implant site allocation was done randomly using sealed envelopes containing randomization codes and missing bilateral first molar was considered for implant placement. Custom made zirconia implants were made by copymilling the corresponding titanium implant, size of which was determined using radiographic analysis and bone mapping .After implant placement both groups were evaluated for bone loss ,plaque index and probing depth in 6,12,24 months. Data was collected and statistically analysed.
RESULTS: There was no statistically significant difference between the groups ($p>0.05$)
CONCLUSION: Within the limits of study, it is suggested that Zirconia implants display features of osseointegration and soft tissue changes similar to those of Titanium implants. These results are promising in using Zirconia implants for dental applications in the future. Further long term studies are recommended with larger sample size for predictable survival and success rates of Zirconia

Introduction

INTRODUCTION:

Treatment with fixed prostheses supported by endosseous implants has improved the quality of life of the edentulous patient.[1] During the past three decades, many different materials and shapes have been proposed for dental implants. It is generally accepted that implants should be made of stable, nontoxic, and bioactive materials, so that the surrounding tissues can form an interfacial bond with the implants.[2] Titanium or its alloys has become a gold standard as a base for tooth reconstruction in dental implantology, because of its mechanical strength, chemical stability and excellent biocompatibility.[3] The esthetic outcome of restorations supported by titanium implants might be compromised if the dark color of the implant shines through a thin peri-implant mucosa or if the implant head becomes visible following soft tissue recession. Furthermore, some authors

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see a potential health hazard in titanium particles or possible corrosive products.[4] Increased concentrations of titanium have been detected in tissues close to implant surfaces[5] and in regional lymph nodes.[6] Although the clinical relevance of these findings is not yet clear, an increasing number of patients are asking for metal-free treatment options. Tooth-colored ceramics were considered early as alternative implant materials but importantbiomechanical characteristics of ceramic implants such as fracture toughness were inferior to those of titanium.[4]

Partially stabilized zirconia, which is comparable to the highest values for oxide ceramics, has been introduced as a new ceramic implant material. This ceramic has more favorable mechanical properties than the fully stabilized zirconia. In addition, zirconia possesses high fracture resistance because of its energy-absorption property during martensitic transformation of tetragonal particles to monoclinic ones. Thus zirconia may act like steel, is biocompatible and possesses mechanical stability. Moreover, this material is highly radiopaque and easily cut for abutment preparation. Thus, partially stabilized zirconia is considered an attractive endosseous dental implant material.[7]

Zirconia seems to be a suitable dental implant material because of its tooth-like color, mechanical properties, and therefore biocompatibility.Apical bone loss and gingival recession associated with implants often uncover portions of the metal implant, revealing a bluish discoloration of the overlying gingiva. The use of zirconia implants avoids this complication and accedes to the request of many patients for metal-free implants. The inflammatory response and bone resorption induced by ceramic particles are less than those induced by titanium particles, suggesting the biocompatibility of ceramics.[8.9] There is less inflammatory response and better stabilization of soft tissues in contact with Zirconia. [10,11] The lower plaque retention capacity and higher affinity to osteoblasts [12,13] along with the more aesthetic tooth like color have made Zirconia a viable implant material.

The available documentation indicates that zirconia ceramics may be suitable material to be used as dental implants but currently the scientific clinical data for zirconia implants are not sufficient to recommend their routine clinical use. However they may have the potential to be a successful implant material which has to be supported by clinical investigations.

The aim of the present study is to compare and evaluate soft and hard tissue conditions of custom made zirconia implant and titanium implants with the null hypothesis being that there is no difference between the zirconia and titanium implant and an alternate hypothesis stating that zirconia Is better and can be a viable alternative to titanium implant.

Material & Methods

Patients reporting to department of prosthodontics, Government Dental College and Research institute, Bangalore for replacement of bilateral missing teeth, were screened for the past 6 months.

INCLUSION CRITERIA:

Patients in the age group of 20 to 60 yrs with bilateral missing teeth in the same arch without any gender bias were selected. Pre operative radiographs were used to quantify the amount of available bone and patients with the same residual bone height were selected.

EXCLUSION CRITERIA:

General contraindication to implant surgery, lack of opposing dentition, acute infection in the area, immunosuppression or immunodepression, active periodontitis, poor oral hygiene and motivation, irradiation in the head/ neck region, bruxism, uncontrolled diabetes, pregnant/ lactating women, substance abuse, psychiatric disorders or unrealistic expectations, participation in other clinical trials interfering with present protocol having been referred only for implant placement and unable to be followed for at least one year, requiring the use of membrane at the time of implant placement, implant sites subjectively evaluated as being characterized by soft bone quality.

Twenty five patients who reported to the department who met the inclusion criteria formed the sample out of which 15 patients were selected using simple random sampling procedure. Split mouth model was developed with custom made zirconia implant on one side as a trial specimen and titanium implant as control on the other side. In total 15 trial specimens and 15 controls formed the sample size. The implant site allocation was done randomly using sealed envelopes containing the randomization code.

The study adhered to the principles outlined in the declaration of Helsinki on clinical research involving human subjects. All patients received thorough explanations and signed written implant consent form prior to enrollment in the trial. Consent forms was made available in regional languages. Ethical clearance from the institutional ethical committee was obtained.

CLINICAL PROCEDURE:

Pre implant assessment of patient's general health, dental status, occlusion, oral hygiene was done(Fig 1). Pre operative radiographs were used to quantify the amount of available bone and locate major anatomical features(Fig 2). Diagnostic cast was made along with standardized orthopantograms with radiographic markers. Bone mapping and radiographs were used to ascertain the length and width of the implant.

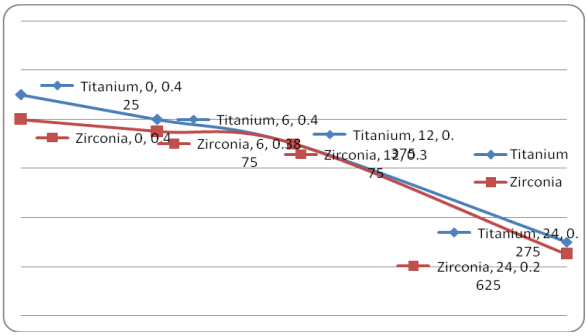
Within 10 days prior to implant placement, all patients were undergoing at least one session of oral hygiene instruction and debridement if required. All patient received single dose of prophylactic antibiotic therapy one hour prior to implant placement, 2gm of amoxicillin or 600mg clindamycin if allergic to pencillin. Patients were asked to rinse one minute prior to implant placement with 0.2% chlorhexidine mouthwash and was under local anaesthesia using lignocaine with adrenaline 1:100000.

Custom made zirconia implants were made by copymilling the corresponding titanium implant, size of which was determined using radiographic analysis and bone mapping. For copy milling ceramal unit from Ammangirback (Germany) was used (Fig 3). The unit consists of a mounting table with two arms. One arm consists of scanner and other arm of a drill attachment. Zirconia implant was milled in single piece by copying the titanium implant with attached abutment. On the scanning side corresponding titanium implant with abutment attached was mounted on the table with the mounting plates and on the corresponding side Zirconia blocks were mounted. Before milling the equipment was calibrated(Fig 4). After milling, the specimen was carefully removed from the

mounting plate and kept for sintering in the furnace for eight hours with a holding temperature upto 1200^0C(Fig 5). Zirconia implant was cleaned ultrasonically with alcohol, water steamed and autoclaved at 134^0C for 15 minutes. Single piece Zirconia implant obtained after copy milling will act as the test specimen which was compared and evaluated against the Gold Standard which is titanium acting as the control. Osteotomies were made using surgical drills after raising the flaps on both the side(Fig 6). Both zirconia and titanium implants were placed simultaneously and flaps were sutured back(Fig 7).Patients were prescribed analgesics (Ibuprofen 400mg 2 times for 5 days) and antibiotics (Amoxicillin 500mg 3 times for 5days/ Clindamycin 300mg 3 times for 5days if patients are allergic to penicillin). Patients were instructed to use chlorhexidine 0.2% mouth wash twice a day for 2 weeks, to have soft diet for 2 weeks and to avoid trauma on the surgical sites. Patients were recalled after a week for suture removal. Post implant assessment of both the group implants were constantly done(Fig 8). Radiographic evaluation was done after 6 months ,12months,24months(Fig 9).During the same time period plaque index and probing depth was also evaluated(Fig 8). Both the group implants were loaded after 3 months(Fig 10) and both the groups were constantly evaluated.

RESULTS

The bone to implant contact increased over the examination period for both Zirconia and Titanium implants. After four weeks of healing the mean bone implant contact was 47.7 % ± 9.1 for Titanium and 35.3 % ± 10.8 for Zirconia. After four weeks of healing the mean bone implant contact was 58.6 % ± 9.5 for Titanium and 45.3 % ± 15.7 for Zirconia. After twelve weeks of healing the mean bone implant contact was 82.9 % ± 10.7 for Titanium and 71.4 % ± 17.8 for Zirconia. No



PLAQUE INDEX:

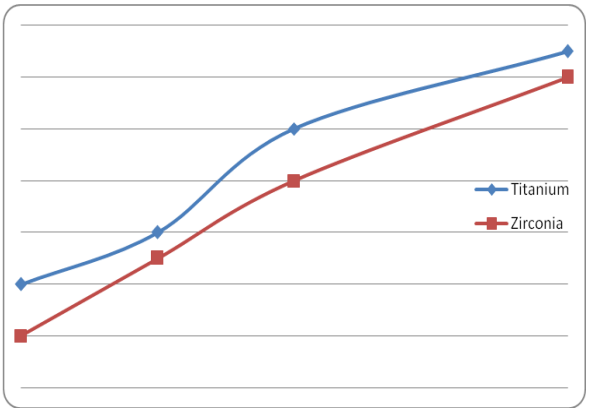
The Results in the figure shows no statistically significant difference between the groups comparing the Plaque Index.

	df	SS	MS	F-value	Pr(>F)	F crit
Group	1	0.0070	0.0070	0.274	0.607	2.866
Residuals	18	0.04625	0.0257			
Time	3	0.257	0.0856	6.58	0.0007	2.866
Group*Time	3	0.0008	0.0003	0.02	0.996	
Residuals	54					

Repeated measures two-way ANOVA test results for Plaque Index for group-1 (Titanium) versus group-2 (Zirconia).

statistically significant differences in percentage, bone implant contact, existed between surfaces of Titanium and Zirconia at different time periods of 4, 8 and 12 weeks. So it was concluded that no differences in bone apposition could be observed between the two groups after healing periods of 4,8 and 12 weeks in a rabbit model. All clinical and radiographic data were tabulated for each individual and group. Summary statistics (mean and standard deviation), were calculated for each study group. A repeated measures two-way ANOVA (Analysis of Variance) was conducted using SPSS. For each clinical measure and for the radiographic measure of evaluation, the repeated

measures ANOVA was conducted between the first group (Titanium) and second group (Zirconia).



PROBING DEPTH

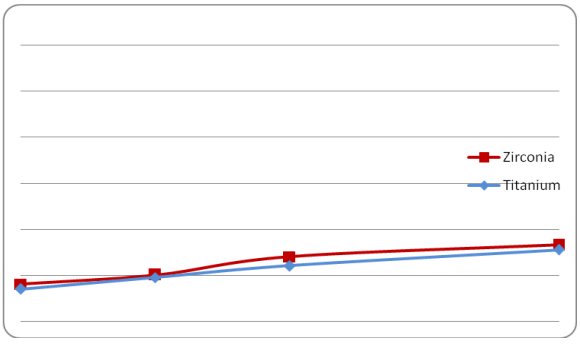
	df	SS	MS	F-value	Pr(>F)	crit
Group	1	0.0281	0.02813	0.219	0.645	2.866
Residuals	18	2.3109	0.12839			
Time	3	0.6438	0.21458	16.816	7.73e-08	2.866
Group*Time	3	0.0031	0.00104	0.082	0.97	
Residuals	54	0.6891	0.01276			

Repeated measures two-way ANOVA test results for Probing Depth for group-1 (Titanium) versus group-2 (Zirconia).

DISCUSSION

Zirconia is a bioinert nonresorbable metal oxide that offers mechanical properties which are superior over other ceramic biomaterials, e.g. high fracture toughness and bending strength. Because of its good

chemical and material stability, high strength and resilience it seems to be a suitable material for dental application. Its successful application in dentistry for fabricating endodontic posts and for crown and bridge restorations has been reported in several studies. Especially because of its tooth-like colour, zirconia was suggested to be a desirable alternative material to titanium for the fabrication



BONE LEVEL LOSS

The Results in the figure shows no statistically significant difference between the groups comparing the Bone Level loss.

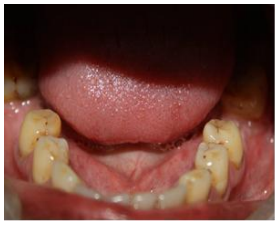
	df	SS	MS	F-value	Pr(>F)	F crit
Group	1	0.010	0.010	2.059	0.168	2.866
Residuals	18	0.088	0.0048			
Time	3	0.3424	0.11415	96.071	2e-16	2.866
Group*Time	3	0.0020	0.00068	0.571	0.636	
Residuals	54	0.0642	0.00119			

Repeated measures two-way ANOVA test results for Bone level loss for group-1 (Titanium) versus group-2 (Zirconia).

of dental implants. The results of the present study have shown that zirconia implants fabricated seem to be integrated into bone in a similar fashion as titanium.

Several studies in animal models showed successful osseointegration of zirconia dental implants under both unloaded and loaded conditions and bone-to-implant contact values similar to those of titanium. Absence of signs of marginal bone loss around implants surface indicates maintained integration

between the implant fixture and the surrounding bone. However, the finding of periimplant bone remodelling must be carefully considered because the marginal bone loss which may be detected around implants after beginning of function should



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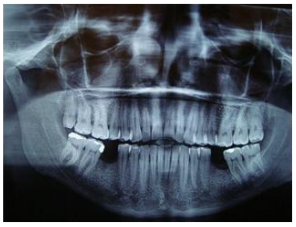

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Fig-1: Bilateral missing first molar

Fig-2: Panoramic view showing missing 36 and 46

Fig-3: Titanium implant with attached abutment

Fig-4: Mounting plates attached to theceramil unit

be distinguished from the bone loss that is affected by one or more of the following factors: (1) traumatic surgical technique; (2) excessive loading conditions; (3) location, shape, and size of the implant abutment microgap and its microbial contamination; (4) biologic width and soft tissue considerations; (5) periimplant inflammatory infiltrate; (6) implant and prosthetic components micromovements; (7) repeated screwing and unscrewing; (8) implant-neck geometry; and (9) infectious process.

According to several studies investigating criteria for implant treatment success, a marginal bone loss of 1.5mm during the first year in function and an annual bone loss not exceeding 0.2mm thereafter is considered acceptable.

The results of the study showed a mean marginal bone loss of 1.2mm in Titanium and 1.3mm in Zirconia during the first 6 months, 0.4 and 0.3mm

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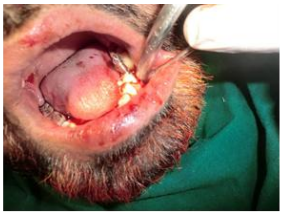

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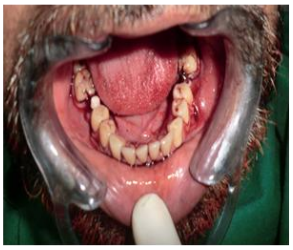


Fig-5: Single piece milled Zirconia implant

Fig-6: Titanium implant placed in 36 region

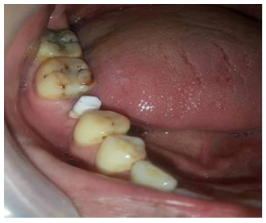
Fig-7: Corresponding single piece zirconia implant

Fig-8: Split mouth design implants

from 6 to 12 months, 0.021mm and 0.018mm from 12 to 24 months.

No significant difference in the marginal bone levels were observed between Titanium and Zirconia implants. Greater bone loss occurred during the first year of function and it is related to maturation of bone after the surgery and adaptation of bone to withstand functional forces. In this study the values of marginal bone loss were within the limits of 0.9 to 1.6 mm, loading. However one piece morphology of Zirconia considered to be acceptable for the first year of dental implants can influence marginal bone loss. In fact, it has been proposed that periimplant marginal bone loss is more extended around two-piece implants than around one-piece implants as a result of the

location of the microgap. The presence of the microgap leads to bacterial leakage and a microbial colonization of the gap at the bone level. Furthermore, it is important to consider that plaque



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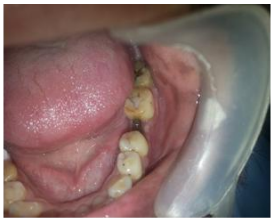

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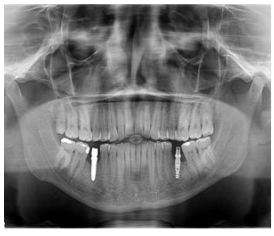

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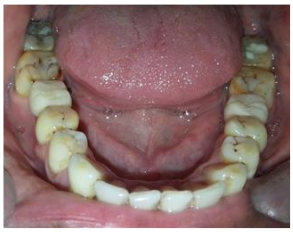

Fig-9: Zirconia implant after 2 weeks
Fig-10: Titanium implant after 2 weeks
Fig-11: Panoramic view after 3 months of implant placement
Fig-12: Implants loaded after 3 month

accumulation on implant or abutment surface induces a gingival inflammatory reaction and consequently a progressive bone loss. In particular, roughness plays an important role in the bacterial adhesion and this relationship has been demonstrated in several in vivo and in vitro studies. In this study Zirconia implants showed reduced plaque accumulation compared to Titanium implants which had higher Plaque Index. The reduced Bacterial adhesion on Zirconia implants surface promotes reformation of the biologic width and therefore the

formation of a mucosal seal that stops early marginal bone resorption.

Thus further clinical studies on Zirconia implants have to be conducted to investigate if Zirconia implants have clinical significant values compared with well established data on Titanium implants. The presently evaluated results are in accordance to findings of Titanium implants after corresponding investagtion periods and Zirconia implants after functional loading.

CONCLUSIONS:

Within the limits of study, it is concluded that Zirconia and Titanium show a comparable soft tissue and bone healing response.

The crestal bone loss of Zirconia dental implants suffers a slight reduction of 1.5mm after 2 years follow up and according to several studies when using a radiographic criteria for implant's success marginal bone loss below 0.9 to 1.6mm during the first year of function can be considered acceptable.

This peri-implant bone preservation may be associated with the absence of micro gap between the fixture and abutment since zirconia dental implants are one piece implants. Moreover Zirconia is characterized by a high bio-compatibility and it accumulates significantly fewer bacteria than titanium.

No bleeding, a minimum plaque index of 0.3 and minimal probing depth could be expected in Zirconia dental implants. The absence of mobility with the previous parameters is the key of success criteria of Zirconia dental implants, due to these characteristics, Zirconia implants may be considered as reliable as Titanium in terms of Osseo integration and biological tissue response.

The data reported in this study even if limited are encouraging so for this reason further long term clinical studies which larger sample size are

required to access the success rate and clinical outcome of Zirconia dental implants.

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