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Radiographic Assessment of The Marginal Bone Loss Around Dental Implants for Mandibular Posteriors Restored with Screw Retained Monolithic Zirconium Vs. Screw Retained Direct Metal Laser Sintered (DMLS) Crowns: An In Vivo Study

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***Abstract*—Implant therapy has become a preferred treatment alternative for oral rehabilitation of the partially and completely edentulous patients. Marginal bone level is one of the most important factors for implant success. After the surgical insertion of implants and prosthetic loading, crestal bone undergoes remodeling and resorption process leading to marginal bone loss. Marginal bone loss is influenced by surgical, patient and prosthodontic factors, anatomical location of implant, prosthetic crowns and their retention system. This study aims at radiographic evaluation of the marginal bone loss around dental implants for mandibular posteriors restored with screw retained monolithic zirconium and screw retained DMLS crowns. Materials and method: A total of 20 patients who were already restored with screw retained monolithic zirconium and screw retained DMLS crowns in the mandibular posteriors and were willing to take part in the study were selected. Patients were randomly divided by coin toss method into 2 groups. Group A: Patients receiving screw retained DMLS crowns. Group B: Patients receiving screw retained Monolithic Zirconia crowns. Marginal bone level around each implant was measured on follow up radiographs taken at baseline, 3rd, 6th and 12th months respectively after crown placement. Results: Both groups exhibited a statistically significant increase in values over time. However, Group B consistently showed significantly higher mesial, distal and average values than Group A at all evaluated time intervals, indicating superior outcomes in Group B throughout the study duration. Conclusion: It can be concluded that the mean crestal bone levels were statistically significant, bone loss were higher in screw retained monolithic zirconia in comparison to screw retained DMLS crowns.**

***Index Terms*—DMLS crowns, Monolithic zirconium crowns, Screw retained prosthesis, Implants, Posterior mandible, Marginal bone loss.**

I. INTRODUCTION

Evolution of dental sciences in the past years has reached unimaginable heights.[1] Loss of teeth in an individual can be due to various causes, namely dental caries, periodontal disease, trauma, and/or malignancy. The replacement of lost dentition is done with removable or fixed dental prosthesis. Fixed prosthesis is the most preferred treatment option over removable prosthesis in the current scenario. A range of options in fixed prosthesis is available from fixed partial dentures to dental implants.[2] The uniqueness of treating edentulism with fixed prosthesis lies in its capability to achieve the goals of function, aesthetics, speech, and health.[1] Dental implant has come up in a big way as an acceptable alternative to the traditional prosthetic treatment of rehabilitating single or multiple missing teeth.[1] The success of implants is dependent on meticulous pre-operative treatment planning as well as careful follow-up during the healing phase to evaluate the success of osseointegration.[3] Over the past few years, guidelines such as insertion of implants with low trauma, minimal heating of the site, initial stability, etc., have been established for the purpose of successful treatment. The final outcome must also include appropriate soft and hard tissue levels.[1]
Although Osseo integrated implants are routinely used for the rehabilitation of partially or totally edentulous

patients presents long-term survival rates, some biological and technical complications may result in implant failure. Factors affecting implant failure are diverse and are related to patient systemic status, age and social habits.[4]

According to various studies the marginal bone level is one of the most important factors for implant success. After the surgical insertion of implants and prosthetic loading, crestal bone undergoes remodelling and resorption process leading to marginal bone loss. For the assessment of implant survival and success, marginal bone level change in 1st year should be less than 1.5 mm and the annual marginal bone loss should not exceed 0.2 mm after the first year of function.[3]

Different restoration materials are available for the fabrication of implant-supported single crowns. The use of ceramic materials for the fabrication of implant crowns is a possible treatment option. Porcelain-fused-to-metal (PFM) implant crowns are considered the gold standard.[5] Ceramic systems have better biocompatibility and esthetic properties but its brittleness has led to increased preference towards Zirconia-based ceramics in recent years. High-mechanical performance, durability, and resistance are the key features of Zirconia-based ceramics. The most widely used Zirconium oxide (ZrO_2) is Yttria tetragonal polycrystal (Y-TZP).[1] These restorations can be screw or cement retained to the implant, or both, through a cemented prosthesis with lingual or palatal fastening screws. Cement-retained systems are ideal where esthetics are of primary importance, as these systems can compensate for an unfavorable angulation of an implant in relation to a crown. Screw-retained systems are usually indicated for prosthesis with multiple abutments to allow the prosthesis to be removed for cleaning and possible repairs. Clinician's own preference mainly influences the selection of retention system and this also plays a major role in preservation of the marginal bone.[6]

The presence of marginal bone loss can lead to peri-implant complications, such as peri-implant inflammation, soft tissue recession, aesthetic problems, plaque accumulation, and eventually implant failure. Thus, the success of implant depends directly upon the pattern of crestal bone resorption and it is one of the major determinant factors for the post-operative success of implants. Since bone level maintenance is one of the most important factors to be considered in implant prosthodontics, the post-operative evaluation of the marginal bone is thus of great importance to a prosthodontist.[3]

Previous studies have compared the marginal bone loss among different retention systems and marginal bone loss among different prosthetic crowns but no studies have compared the combined effect of retention system and the prosthetic crowns on marginal bone loss, hence the present study aims at radiographic evaluation of the marginal bone loss around dental implants for mandibular posteriors restored with screw retained monolithic zirconium and screw retained DMLS crowns.

II. MATERIALS AND METHODOLOGY

Materials

1. X-ray machine, Aditya Medical Systems (AMS).
2. Digital (RVG) X-ray sensor, Orikam, China.
3. Nanopix software used to interpret the intra oral periapical image.

Inclusion criteria:

1. Patients within age group of 20 to 45 years.
2. There should be absence of any systemic diseases.
3. Implant restored with screw retained monolithic zirconia or with screw retained DMLS crowns in mandibular posterior region.
4. Implant width ranging from 3.5 – 4.5mm.
5. Implant length ranging from 10 – 13mm.
6. Bone quality with D2 - D3 density.
7. Adequate inter arch space.

Exclusion criteria:

1. Age less than 20 years and not more than 45 years.
2. Individuals presenting with uncontrolled systemic diseases or under medications interfering with bone metabolism.
3. Subjects using narcotics, alcohol or tobacco in any form.
4. Handicaps that would interfere with the ability to perform adequate oral hygiene.
5. Individuals who are immune compromised or on long term steroid therapy.
6. Patients having para functional habits.
7. Local factors like history of local inflammation, untreated periodontitis, mucosal diseases, local irradiation therapy, unhealed extraction sites.
8. Patient who refuses to undergo necessarily follow up.

III. METHODOLOGY

A total of 24 patients who have been restored with screw retained monolithic zirconium and screw retained DMLS crowns after delayed healing period were included for the study. These patients were randomly divided by coin toss method into 2 groups i.e.;

Group A and B:

a. Group A: Patients receiving screw retained DMLS crowns.
b. Group B: Patients receiving screw retained Monolithic Zirconia crowns.

Monitoring at regular intervals was done by taking four standardized digital intra oral periapical image using digital (RVG) X-Ray sensor from 0, 3rd, 6th and 12th month respectively after crown placement. The paralleling technique was followed.
The coronal surface of the implant was taken as the reference line, from which two perpendicular lines were dropped on to the mesial and distal aspect of implants to the first bone-to-implant contact. Compar ative measurements of mesial and distal crestal bone levels adjacent to implants were made to the nearest 0.1 mm. A minimum of 3 readings was taken for each side and the average values were used to calculate the amount of crestal bone loss. Subtracting the bone level at 0 month from the bone level at 3 months, 6 months and 12 months gave the bone loss.
The data recorded was statistically analyzed and final inference was made.

IV. SAMPLE SIZE OF ESTIMATION

Based on mean and standard deviation of the groups obtained from the pilot study conducted on 6 samples in each group, the effect size calculated was 1.96 with standard deviation of 0.56 and error probability of 0.5 and with the power of the study 90%, the total sample size calculated was 20.

$$n = \frac{2 \cdot z^2 \cdot s^2}{d^2}$$

n = sample size per arm
z = 1.96
s = 0.56 (standard deviation)
d = 0.5 (allowable error)

$n = 2*(1.96)^2*(0.56)^2$
$(0.5)^2$
n = 10 per group
2 group * 10 = 20

Total groups = 2
Total samples = 20

The sample size per group was estimated as 10.
Considering attrition rate of 10%, sample size will be 12 per group.
There was attrition rate of 10% during my study so the samples were calculated to 10 per group.

Statistical analysis
Statistical analysis was be done using SPSS version 26 software and Microsoft excel version 2016. Statistical analysis included mean standard deviation frequency and percentages.
Inferential statistics include unpaired t test, repeated measure ANOVA, paired t test and chi square test. P value of less than 0.05 is considered significant.

Sampling criteria
Purposive sampling method is used, where the patients who serve the purpose of the study or participants with implant placement on mandibular posteriors, either alternative or n^{th} person who meets the inclusion criteria will be included in the study.
Measures will be taken to maintain the homogenous baseline characteristics of the patients.

V. RESULTS

The present radiographic study was conducted to assess the marginal bone loss around dental implants for mandibular molars restored with screw retained monolithic zirconia and screw retained DMLS crowns. The study was carried out at the Department of Prosthodontics, Sri Hasanamba Dental College & Hospital, Hassan, Karnataka, India. A total of 20 patients who have been already restored with screw retained monolithic zirconium and screw retained DMLS crowns and are willing to take part were included in the study. The duration of the study was 2 years.
The crestal bone levels were measured at the baseline, 3rd month, 6th month and 12th month after implant loading.

INTRAORAL PERIAPICAL RADIOGRAPHS

Intergroup comparison

Mann–Whitney U Test was used to compare between the groups

Mesial Measurements

At baseline, the mean mesial value in Group A (0.5740 ± 0.11423) was significantly lower than that in Group B (0.8160 ± 0.14144), with a statistically significant difference (p = 0.002).

Similar statistically significant differences were observed at the 3rd month (Group A: 0.6050 ± 0.09992; Group B: 0.8360 ± 0.14144; p = 0.002), 6th month (Group A: 0.6490 ± 0.09231; Group B: 0.8770 ± 0.13242; p = 0.002), and 12th month (Group A: 0.7090 ± 0.08439; Group B: 0.9220 ± 0.12839; p = 0.002). Group B consistently demonstrated higher mesial values at all time intervals.

Distal Measurements

At baseline, Group A showed a mean distal value of 0.5890 ± 0.13536, whereas Group B showed 0.8030 ± 0.11470, with a statistically significant difference (p = 0.005).

Significant intergroup differences were also noted at the 3rd month (Group A: 0.6270 ± 0.09821; Group B: 0.8250 ± 0.10916; p = 0.003), 6th month (Group A: 0.6800 ± 0.08353; Group B: 0.8690 ± 0.10170; p = 0.002), and 12th month (Group A: 0.7390 ± 0.07460; Group B: 0.9230 ± 0.11963; p = 0.002). Group B exhibited significantly higher distal values at all observation periods.

Average Measurements

The average baseline value was significantly lower in Group A (0.5815 ± 0.09804) compared to Group B (0.8095 ± 0.10418), with a highly significant difference (p = 0.001).

Statistically significant differences persisted at the 3rd month (Group A: 0.6160 ± 0.07944; Group B: 0.8305 ± 0.10251; p = 0.002), 6th month (Group A: 0.6645 ± 0.06829; Group B: 0.8730 ± 0.09858; p = 0.001), and 12th month (Group A: 0.7240 ± 0.05582; Group B: 0.9225 ± 0.10193; p = 0.002). Across all time intervals, Group B showed significantly higher average values than Group A.

Intra group comparison

Wilcoxon Signed Ranks Test was used to compare among the group

Group A

In Group A, a statistically significant increase in average values was observed over time. The comparison between baseline and 3rd month showed a significant difference (p = 0.013). Further significant increases were noted between the 3rd and 6th months (p = 0.008) and between the 6th and 12th months (p = 0.005), indicating a progressive increase across all follow-up intervals.

Group B

Group B also demonstrated statistically significant increases in average values over time. The difference between baseline and 3rd month was significant (p = 0.005).

Significant changes were similarly observed between the 3rd and 6th months (p = 0.005) and between the 6th and 12th months (p = 0.005), showing a consistent upward trend throughout the study period.

From the statistical analysis, both groups exhibited a statistically significant increase in values over time. However, Group B consistently showed significantly higher mesial, distal, and average values than Group A at all evaluated time intervals, indicating superior outcomes in Group B throughout the study duration.

TABLE 1: COMPARSION OF MESIAL CRESTAL BONE LOSS GROUP A AND GROUP B AT VARIOUS INTERVALS USING Mann- Whitney U test

Mann-Whitney U test					
	Group	N	Mean	Std. Deviation	p
Baseline Mesial	Group A	10	0.5740	0.11423	0.002
	Group B	10	0.8160	0.14144	
Mesial 3rd	Group A	10	0.6050	0.09992	0.002
	Group B	10	0.8360	0.14144	
Mesial 6th	Group A	10	0.6490	0.09231	0.002
	Group B	10	0.8770	0.13242	
Mesial 12th	Group A	10	0.7090	0.08439	0.002
	Group B	10	0.9220	0.12839	

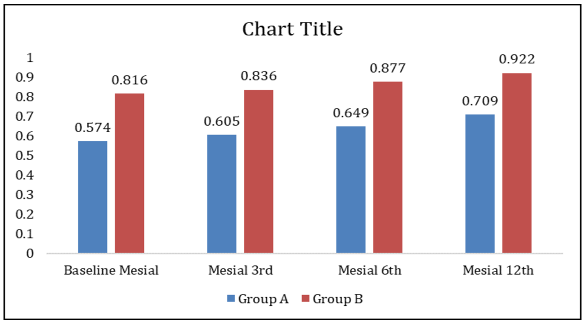

Table 2: Comparison of Distal Crestal Bone Loss Between Group A And Group B At Various Intervals Using Mann- Whitney U test

Mann-Whitney U test					
	Group	N	Mean	Std. Deviation	p
Baseline Distal	Group A	10	0.5890	0.13536	0.005
	Group B	10	0.8030	0.11470	
Distal 3rd	Group A	10	0.6270	0.09821	0.003
	Group B	10	0.8250	0.10916	
Distal 6th	Group A	10	0.6800	0.08353	0.002
	Group B	10	0.8690	0.10170	
Distal 12th	Group A	10	0.7390	0.07460	0.002
	Group B	10	0.9230	0.11963	

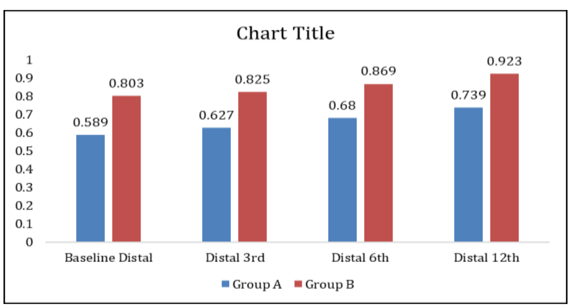

Table 3: Comparison of Average Crestal Bone Loss Between Group A And Group B At Various Intervals Using Mann- Whitney U test

Mann-Whitney U test					
	Group	N	Mean	Std. Deviation	p
AVG BL	Group A	10	0.5815	0.09804	0.001
	Group B	10	0.8095	0.10418	
AVG 3rd	Group A	10	0.6160	0.07944	0.002
	Group B	10	0.8305	0.10251	
AVG 6th	Group A	10	0.6645	0.06829	0.001
	Group B	10	0.8730	0.09858	
AVG 12th	Group A	10	0.7240	0.05582	0.002
	Group B	10	0.9225	0.10193	

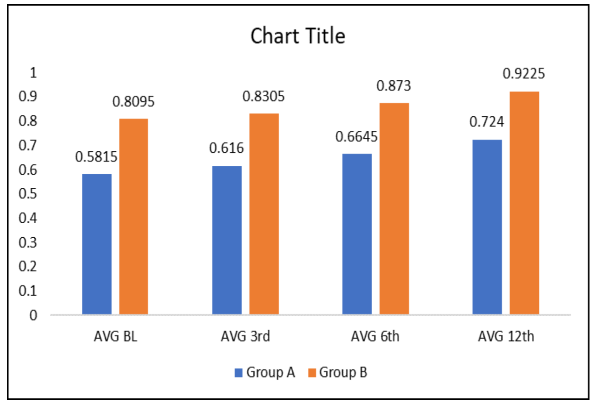

Table 4: Comparison of Average Crestal Bone Loss in Implants Restored with Screw DMLS Crowns at Various Intervals Using Wilcoxon Signed Ranks Test

Wilcoxon Signed Ranks Test			
Group A	Mean	Std. Deviation	p
AVG BL	0.5815	0.09804	0.013
AVG 3rd	0.6160	0.07944	
AVG 3rd	0.6160	0.07944	0.008
AVG 6th	0.6645	0.06829	
AVG 6th	0.6645	0.06829	0.005
AVG 12th	0.7240	0.05582	

Table 5: Comparison of Average Crestal Bone Loss in Implants Restored with Screw Retained Monolithic Zirconia Crowns at Various Intervals Using Wilcoxon Signed Ranks Test

Wilcoxon Signed Ranks Test			
Group B	Mean	Std. Deviation	p
AVG BL	0.8095	0.10418	0.005
AVG 3rd	0.8305	0.10251	
AVG 3rd	0.8305	0.10251	0.005
AVG 6th	0.8730	0.09858	
AVG 6th	0.8730	0.09858	0.005
AVG 12th	0.9225	0.10193	

Figure 1: X-ray machine, Aditya Medical Systems (AMS).

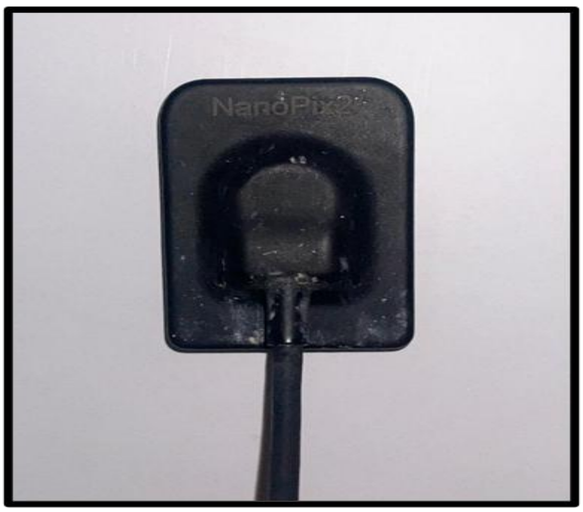

Figure 2: Digital (RVG) X-ray sensor, Orikam, China.

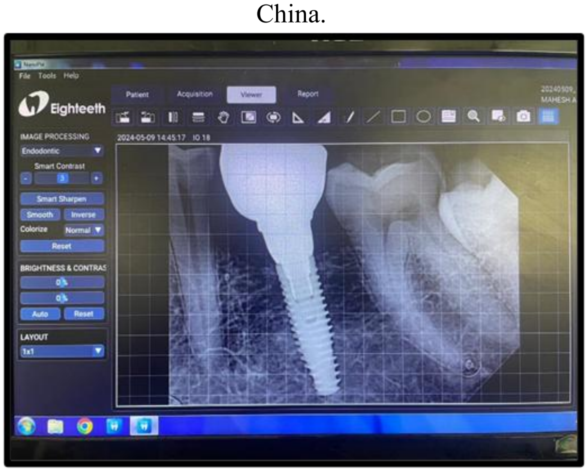

Figure 3: Nanopix software.

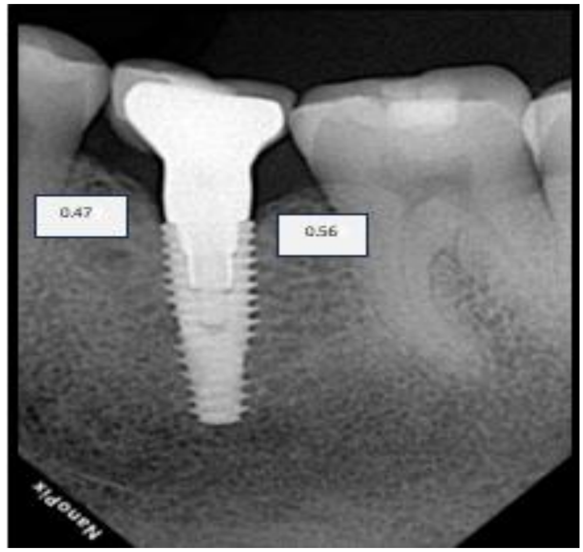

Figure 4: Group A radiograph at Baseline.

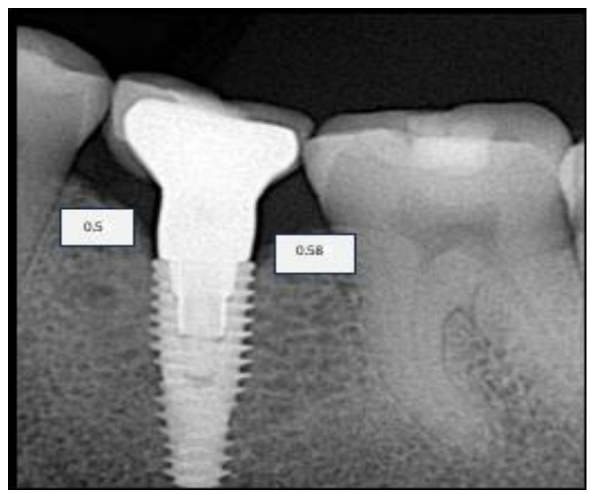

Figure 5: Group A radiograph 3rd month

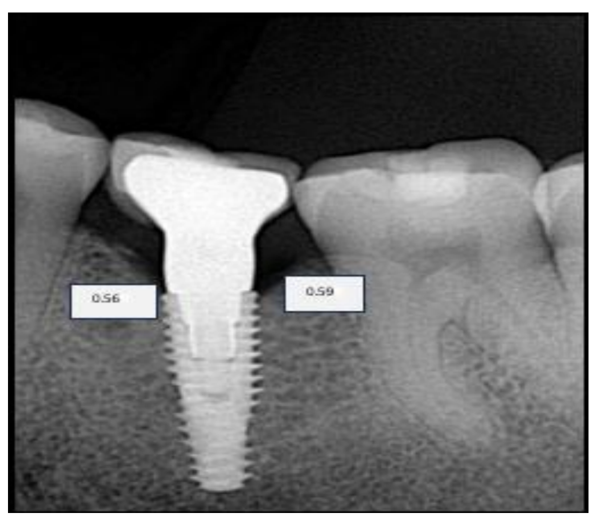

Figure 6: Group A radiograph 6th month.

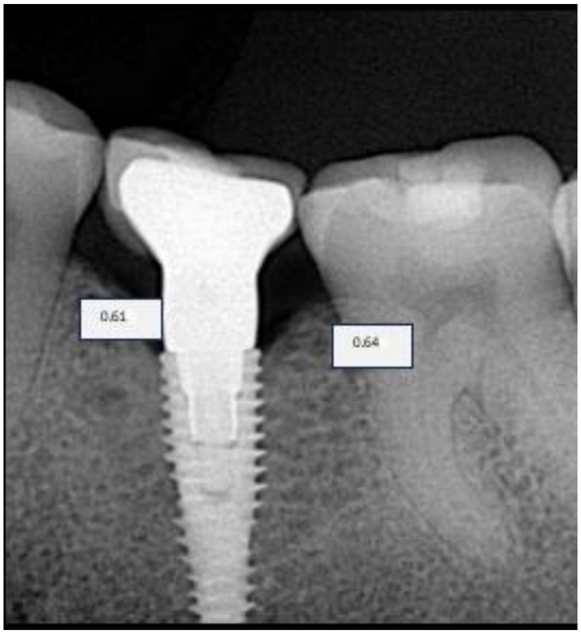

Figure 7: Group A radiograph 12th month.

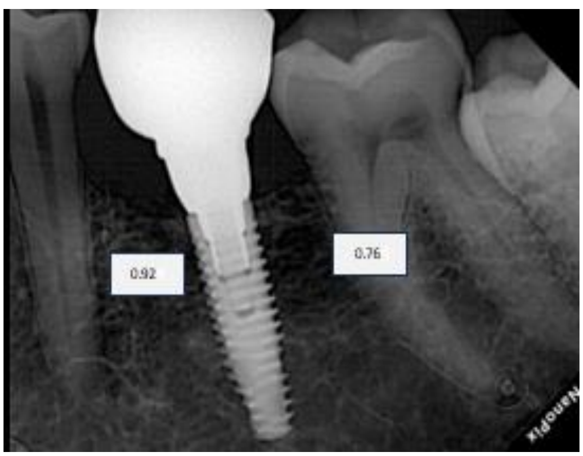

Figure 8: Group B radiograph at Baseline.

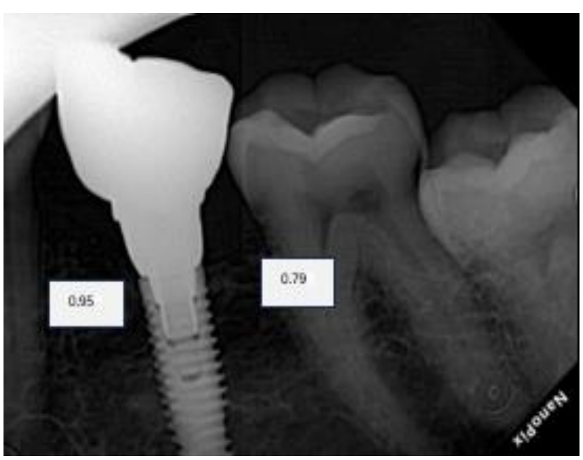

Figure 9: Group B radiograph 3rd month.

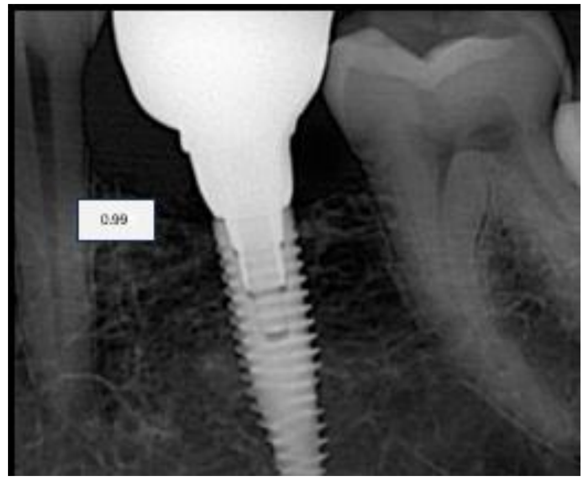

Figure 10: Group B radiograph 6th month.

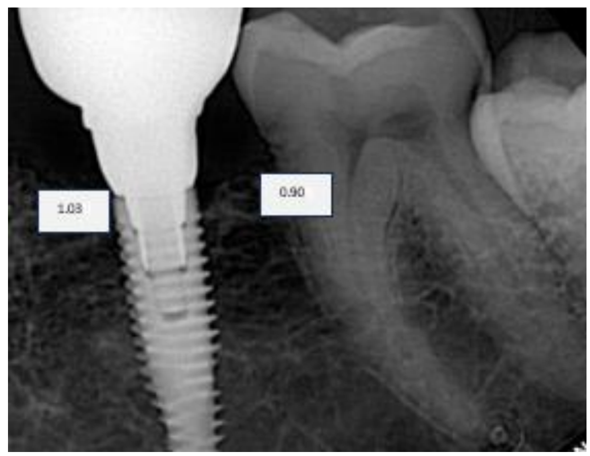

Figure 11: Group B radiograph 12th month.

VI. DISCUSSION

The use of dental implants for replacing missing teeth has become a widely recognized and predictable treatment modality with both favorable outcomes and challenges for the clinicians.[7] The primary reason to consider dental implants to replace missing teeth over the conventional removable and fixed partial denture is maintenance of alveolar bone. An endosteal implant can maintain bone width and height as long as the implant remains healthy.[2] Achievement of implant stability and maintenance of stable crestal bone levels are important factors for successful long-term function. The initial crestal remodeling seems to be related to implant design and/or to surface properties and there seems to be rather small changes in the average crestal bone level with time. Misch et al[8] in 2008 concluded that primary criteria for assessing implant quality and health are pain and mobility, with the next being uncontrolled progressive bone loss.[30] None of the patient in the study reported any pain and the implants were healthy according to the above criteria. Bone level maintenance is one of the most important factors to be considered for the success of dental implants. Long term studies have shown that crestal bone loss occurs during first year in function. According to the established criteria for the evaluation of success of dental implants, marginal bone loss should be less than 1.5mm. Smith and Zarb[9] in 1989 suggested that one of the criteria for implant success was less than 0.2 mm of alveolar bone loss per year after the one year of restoration. However, the active bone loss phase during the first month of implant placement has not been studied extensively. Dereci O et al[10] in 2022 conducted a study comparing the marginal bone loss (MBL) and periodontal health of single-crown dental implants positioned mesially and interdentally to the edentulous area. It was concluded that when compared to single-crown dental implants positioned mesially to the edentulous region, interdentally positioned single-crown dental implants exhibited reduced distal MBL and poor periodontal health.

Initial marginal bone loss may be influenced by a number of parameters such as surgical trauma, occlusal overload, peri-implantitis, microgap, biologic width and implant crest module,[11] and flapless or flapped procedures. Various other factors influence bone loss at later stages which includes prosthodontic factors such as accuracy of impression, laboratory decisions, temporization, restorative materials, their retention system, poorly designed restorations.[12] Marginal bone loss is a critical indicator of implant success, and its assessment provides insight into the biological and biomechanical response of peri-implant tissues to different restorative materials.

Restorative materials and the retention systems used for implant prosthesis significantly contributes for the marginal bone loss around the dental implants. Papavasiliou et al[13] in 1997 investigated the effect of the osseointegration degree to stress distribution and found higher crestal stresses than apical stresses under all conditions. The study found stress concentration at the implant neck due to the rigid connection between implant and bone. A consistent observation from all models was concentration of maximum stresses at the porcelain surface at the loading points. For this reason, interceptive occlusal contact in the crown should be eliminated and proper occlusal relationship should be provided. The materials selected for the occlusal surface of the implant-supported prosthesis affects the transmission of forces and the maintenance of occlusal contacts.

Solimon et al[14] in 2015 conducted a 3D FEA which concluded that soft prosthetic materials absorb more energy from the applied load and transfers less energy to the bone.

There are several studies that investigated the effects of different occlusal materials on implants and match the findings above.

Gomes et al[15] in 2011 did a three-dimensional (3D) finite element analysis (FEA) which concluded the use of different materials to fabricate the superstructure for single implant-supported prosthesis did affect the stress distribution in the supporting bone but the retention screw received less stress when a combination of porcelain fused to metal (PFM) and Monlithic zirconia was used. When the stress distribution in Monlithic zirconia structure was investigated, monlithic zirconia crown design showed the highest stress concentration. The high stress value in monlithic zirconia was the result of the force applying on the structure. When the stress distribution in framework was investigated, the stress values were different for each model. The reason of these differences may be that the elasticity modulus of monlithic zirconia was higher than PFM. For this reason, monlithic zirconia frameworks were more resistant to deformation. Structural differences in frameworks affected the stress distribution in implant structure. When the stress distribution in supporting bone was investigated, significant differences were found among monolithic zirconia crowns.

Initial crestal bone changes are expected as the bone adapts to functional forces; however, the magnitude of change appears to be influenced by the restorative material used.

Bernauer SA et al[16] in 2025 gave a literature review on the flexural strength of monolithic zirconia crowns for dental implants. It was concluded that biting force resistance of the restorative material plays a crucial role in determining stress transmission to the implant–bone interface. Monolithic zirconia exhibits extremely high flexural strength (~1200 MPa) and fracture toughness, enabling it to withstand high masticatory forces without material deformation or fracture. However, this high rigidity and very high elastic modulus (~250 GPa) result in minimal energy absorption, leading to direct transfer of occlusal forces to the implant and surrounding crestal bone. In posterior regions such as mandibular molars, where bite forces are maximal, this may contribute to increased marginal bone loss. Schettini A et al[17] in 2024 assessed mechanical properties and the microstructure of Co-Cr dental alloys manufactured by casting, milling, and 3D printing. It was concluded that DMLS restorations, typically fabricated from cobalt–chromium alloys, demonstrate high compressive strength and excellent resistance to occlusal forces with flexural strength of ~800 MPa, while possessing a relatively lower elastic modulus (~180 GPa) and a degree of microstructural resilience due to their layered additive manufacturing process. This micro-porous architecture may facilitate more favourable stress distribution and partial absorption of biting forces, reducing peak stress concentration at the crestal bone level. As a result, implants restored with DMLS crowns may exhibit improved biomechanical compatibility under functional loading, which could explain the comparatively lower marginal bone loss seen.

Thus, although both monolithic zirconia and DMLS restorations are capable of withstanding posterior bite forces well beyond physiological masticatory loads, the difference lies not in strength but in how biting forces are transmitted, with DMLS restorations offering a more stress-modulating effect on peri-implant bone.

Hameed MH et al[18] in 2018 conducted a study on marginal bone loss around cement and screw-retained fixed implant prosthesis, it was found that regardless of crowns or fixed partial dentures, screw retained prostheses demonstrated significantly higher MBL than cement retained prostheses. Potdukhe S S et al[19] in 2024 conducted a systematic review to assess the differences in technical, biological, and marginal bone level issues between screw-retained and cemented all-ceramic implant-supported crowns made on zirconia abutments at various follow-up times. At a follow-up time of three years and as well as at a follow-up period of five years, the cement retained group exhibited greater probing depth than the screw retained group, no statistically significant difference was found. Sajjanar J et al[20] in 2025 conducted a systematic study to assess the aesthetics and marginal bone loss of zirconia single implant prostheses that were screw- and cement-retained. It was concluded that screw-retained prostheses showed more marginal bone loss around implants than cement-retained ones.

The present study was undertaken to compare the crestal bone loss in dental implants rehabilitated with screw retained DMLS and screw retained monolithic zirconia. Standardized radiographs at the regular intervals (baseline, 3rd month, 6th month, and 12th month) were taken. The methodology of obtaining radiographs was standardized with the long cone paralleling technique. The patient's position was standardized with the upper arch parallel to and midsagittal plane perpendicular to the floor. For bone loss evaluation, first macro thread was taken as reference point to the crest of bone where it contacted the implant.

In the current study, bone levels individually on the mesial and distal aspects were analyzed. For both overall mesial and distal bone loss p-value was significant ($p > 0.002$). Similarly, mean overall bone loss when compared between two groups from base line to 12th month, the p-value was significant. Thus, from the statistical analysis, both groups exhibited a statistically significant increase in values over time. However, Group B consistently showed significantly higher mesial, distal, and average values than Group A at all evaluated time intervals, indicating superior outcomes in Group B throughout the study duration.

On intergroup comparison, the results of the present study demonstrated a statistically significant difference in crestal bone loss between the two groups at all evaluated time intervals, with Group B consistently showing higher mesial, distal, and average values compared to Group A. This trend was observed at baseline, 3 months, 6 months, and 12 months, indicating that the type of restorative material and fabrication technique may influence peri-implant bone response. These results were in conjunction with the study by Gomes et al[15] (2011), Solimon et al[14] (2015), Hameed MH et al[18] (2018) who concluded that soft prosthetic materials transfer less energy to the bone and absorb more energy from the applied stress. A study was conducted on the stress distribution of implant crown structures made of PFM and monolithic zirconia. In comparison to PFM, the monlithic zirconia crown design was found to have the maximum stress concentration. One possible explanation for these discrepancies is that monlithic zirconia had a higher elasticity modulus than PFM. The distribution of stress in the implant structure was impacted by structural variations in the frameworks, however, the restorative material appears to have an impact on the extent of change.

Increased crestal bone loss was observed in implants restored with screw-retained monolithic zirconia crowns may be due to the higher elastic modulus and rigidity of zirconia. Zirconia's limited shock-absorbing capacity may lead to increased transmission of occlusal forces directly to the implant–bone interface, particularly in the posterior mandibular region where masticatory loads are higher. This concentrated stress transfer may contribute to greater marginal bone remodelling over time. These findings are coinciding with Bernauer SA et al[16] (2025) who reviewed the literature on the flexural strength of monolithic zirconia implant crowns. It was determined that the restorative materials resistance to biting force is a critical factor in influencing how stress is transmitted to the implant-bone junction. Monolithic zirconia may tolerate significant masticatory forces without material deformation or breakage because of its exceptionally high flexural strength and fracture toughness. The occlusal forces are transferred directly to the implant and surrounding crestal bone due to the high stiffness and extremely high elastic modulus, which results in minimum energy absorption. This could lead to more marginal bone loss in posterior areas where biting stresses are greatest, as in mandibular molars.

In contrast, DMLS crowns, being metal-based restorations fabricated through additive manufacturing, may offer a more favourable stress distribution. The micro-porous structure and relatively lower stiffness of DMLS frameworks may aid in better dissipation of occlusal forces, thereby reducing stress concentration at the crestal bone level and resulting in comparatively lower marginal bone loss. These findings were in conjunction with the study by Schettini A et al[17] (2024) who evaluated the microstructure and mechanical characteristics of Co-Cr dental alloys produced using 3D printing, machining, and casting. It was determined that DMLS restorations, which are usually made of cobalt-chromium alloys, have a flexural strength of about 800 MPa, relatively low elastic modulus of about 180 GPa, and a degree of microstructural resilience because of their layered additive manufacturing process. They also exhibit high compressive strength and excellent resistance to occlusal forces. By partially absorbing biting pressures and promoting more advantageous stress distribution, this microporous design may lessen the concentration of peak stress at the crestal bone level. DMLS crown-restored implants may therefore show better biomechanical compatibility under functional loads, which may account for the much lesser marginal bone loss.

Both mesial and distal measurements followed a similar pattern, with Group B exhibiting significantly higher bone loss than Group A at all time intervals. This symmetrical pattern suggests that the observed bone loss was site-specific and depends on the distance between the implant and the adjacent teeth or implant for the dissipation of force. The progressive increase in both mesial and distal values over time aligns with the concept of physiological bone remodelling following implant loading.

Intragroup analysis revealed a statistically significant increase in crestal bone loss over time in both groups, indicating that marginal bone remodelling occurred irrespective of the type of crown material.

The findings of the present study were consistent with previous studies by Gomes[15] et al (2011), Solimon et al[14] (2015), Hameed MH et al[18] (2018), Dereci O et al[10] (2022), Schettini A et al[17] (2024), Bernauer SA et al[16] (2025), Sajjanar J et al[20] (2025) who concluded that use of different materials to fabricate the superstructure for single implant-supported prosthesis did affect the stress distribution in the supporting bone when porcelain fused to metal (PFM) implant crowns were compared with Monlithic zirconia crowns. When the stress distribution in Monlithic zirconia structure was investigated, monlithic zirconia crown design showed the highest stress concentration compared to PFM. Soft prosthetic materials absorb more energy from the applied load and transfers less energy to the bone.

Thus, increased crestal bone loss was observed in implants restored with monolithic zirconia crowns may be due to the higher elastic modulus and rigidity of zirconia. Monolithic zirconia offers high rigidity and very high elastic modulus resulting in minimal energy absorption, leading to direct transfer of occlusal forces to the implant and surrounding crestal bone. In posterior regions such as mandibular molars, where bite forces are maximal, this may contribute to increased marginal bone loss. DMLS restorations, typically fabricated from cobalt–chromium alloys, demonstrate high compressive strength and excellent resistance to occlusal forces with flexural strength of ~800 MPa, while possessing a relatively lower elastic modulus and a degree of microstructural resilience due to their layered additive manufacturing process. This micro-porous architecture may facilitate more favourable stress distribution and partial absorption of biting forces. Marginal bone loss around implants when retained by cement and screw-retained fixed implant prosthesis, it was found that regardless of crowns or fixed partial dentures, screw retained prostheses demonstrated significantly higher marginal bone loss than cement retained prostheses. When compared to single-crown dental implants positioned mesially to the edentulous region, interdentally positioned single-crown dental implants exhibited reduced distal marginal bone loss and poor periodontal health. The aesthetics and marginal bone loss of zirconia single implant prostheses that were screw- and cement-retained, it was concluded that screw-retained prostheses showed more marginal bone loss around implants than cement-retained ones.

However, although both groups showed progressive bone loss, the rate and magnitude were consistently higher in Group B, suggesting that monolithic zirconia restorations may exert a greater biomechanical impact on peri-implant bone during functional loading.

Nevertheless, from a biomechanical perspective, DMLS restorations may offer an advantage in terms of preserving crestal bone levels, especially in high-load bearing posterior regions. Careful occlusal planning, precise implant positioning and periodic follow-up remain essential when using rigid ceramic restorations such as monolithic zirconia.

The limitations of the present study include a small sample size and a relatively short follow-up period of one year. Long-term randomized controlled trials with larger sample sizes and evaluation of additional parameters such as occlusal force analysis and patient-reported outcomes are recommended to further substantiate these findings.

Summary

Dental implants are a predictable treatment modality for replacing missing teeth, with long-term success largely dependent on implant stability and maintenance of crestal bone levels. Marginal bone loss (MBL) is a key indicator of implant success, with acceptable limits defined as ≤1.5 mm in the first year and ≤0.2 mm annually thereafter. Early crestal bone remodeling is influenced by surgical trauma, biologic width establishment, implant design, occlusal loading, and prosthodontic factors including restorative materials and their retention systems.

Biomechanically, restorative material plays a significant role in stress transmission to peri-implant bone. Monolithic zirconia possesses high flexural strength (~1200 MPa) and a high elastic modulus (~250 GPa), making it highly rigid with minimal shock-absorbing capacity. This rigidity results in direct transmission of occlusal forces to the implant–bone interface, potentially increasing crestal bone stress and marginal bone loss, particularly in posterior regions with high masticatory loads.

In contrast, Direct Metal Laser Sintered (DMLS) cobalt–chromium restorations demonstrate high flexural strength (~800 MPa) with a relatively lower elastic modulus (~180 GPa) and their micro-porous additive-manufactured structure may allow better stress distribution and partial energy absorption, reducing peak stress concentration at the crestal bone level.

The present study was carried out to assess and compare radiographically marginal bone loss around dental implants for mandibular posteriors restored with screw retained monolithic zirconium vs. screw retained direct metal laser sintered (DMLS) crowns.

Based on the analysis of results obtained and within the limitations of this study, it can be concluded that

1. Early implant crestal bone loss during healing has seen regardless of the implant restoration types.
2. Screw retained DMLS as well as screw retained monolithic zirconia displayed crestal bone loss over the course of one year. The mean crestal bone levels were statistically significant, bone loss was higher in screw retained monolith zirconia (0.8095 ± 0.10418) in comparison to screw retained DMLS (0.5815 ± 0.09804).

3. DMLS restorations offer an advantage in terms of preserving crestal bone levels, especially in high-load bearing posterior regions.

All the post operative radiographic data were subjected to appropriate statistical analysis.

Within in the limitations of the study, both groups exhibited marginal bone loss over time, consistent with physiological remodeling after implant loading. However, intergroup comparison revealed significantly greater mesial, distal, and overall bone loss in the monolithic zirconia group at all evaluation intervals.

Despite statistical significance, the bone loss values in both groups remained within clinically acceptable limits for implant success. Therefore, both restorative materials are clinically viable. However, DMLS restorations demonstrated comparatively better preservation of crestal bone levels, suggesting a biomechanical advantage in posterior load-bearing regions.

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