RESEARCH PAPER

COMPARATIVE EVALUATION OF CRESTAL BONE LEVELS AS INFLUENCED BY CHANGING CROWN TO IMPLANT RATIO ASSESSED USING DIGITAL IOPA: AN IN-VIVO-STUDY

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ABSTRACT

Introduction: The influence of the Crown-to-Implant Ratio (CIR) on peri-implant bone health and stress distribution remains a subject of debate. While some studies suggest that a higher CIR increases stress on the peri-implant bone, others report minimal clinical impact. Evaluating the effect of varying crown-to-implant ratios on crestal bone levels is essential for understanding their role in the long-term success and stability of dental implants. Thus, the aim of the study is to compare and evaluate changes in crestal bone levels associated with different crown-to-implant ratios using digital intraoral periapical (IOPA) radiographs.

Methodology: A randomized clinical study was conducted to assess the influence of crown-to-implant ratio on crestal bone levels. A total of 20 dental implants were placed in patients who fulfilled the inclusion criteria. Based on the anatomical crown-to-implant ratio, the implants were randomly allocated into two groups: Group 1 (C/I ratio > ¾) and Group 2 (C/I ratio ≤ ¾). Crestal bone levels were evaluated using digital IOPA radiographs at predetermined intervals. Statistical analysis was performed using SPSS version 26. Intragroup comparisons across different time intervals were analyzed using repeated measures ANOVA or Friedman test, followed by appropriate post hoc tests when required. Intergroup comparisons were performed using the independent t-test or Mann–Whitney U test.

Results: Both groups exhibited changes in crestal bone levels during the six-month follow-up period after implant loading. Implants with a crown-to-implant ratio of ≤¾ demonstrated comparatively lower crestal bone loss over time. However, intergroup comparison of cumulative mesial and distal bone loss showed no statistically significant difference between implants with crown-to-implant ratios >¾ and ≤¾.

Conclusion: Within the limitations of this study, implants with a crown-to-implant ratio of ≤¾ exhibited reduced crestal bone loss during the six-month follow-up period. Furthermore, digital IOPA radiography proved to be a reliable and effective method for monitoring crestal bone level changes following implant placement.

Keywords: Crown-to-implant ratio, Crestal bone loss, Dental implant, Peri-implant bone loss and osseointegration

How to cite this article: Akshit kumar, Dr. Gaurav Issar, Dr. Pallavi Sirana, Dr. Abhi Sharma, Dr. Ritwik Tyagi, Dr. P. Laxman Rao. Comparative Evaluation Of Crestal Bone Levels As Influenced By Changing Crown To Implant Ratio Assessed Using Digital Iopa: An In-Vivo-Study. Int J Drug Deliv Technol. 2026;16(76s):1615-1627. DOI: 10.25258/ijddt.16.76s.152.

INTRODUCTION

Oral health is multifaceted and involves the ability to smell, touch, taste, chew, swallow, smile, speak, and convey a variety of emotions through facial expressions with confidence and without discomfort, pain, or disease in the craniofacial region. This definition, proposed by the FDI World Dental Federation, emphasizes that oral health extends far beyond the mere absence of oral disease and is an integral component of overall health and well-being.1 The ability to perform these essential functions comfortably influences an individual's physical, psychological, and social well-being, enabling active participation in daily life. Consequently, the impact of oral health is reflected in an individual's quality of life, giving rise to the concept of Oral Health-Related Quality of Life (OHRQoL). OHRQoL

represents an individual's perception of how oral health affects their functional, emotional, and social well-being within the context of their personal goals, expectations, cultural values, and life experiences. A growing body of evidence has consistently demonstrated a strong association between good oral health and an improved overall quality of life, highlighting the importance of preserving oral health to enhance an individual's overall well-being.2

Edentulism is a debilitating and irreversible condition regarded as the final marker of disease burden in oral health. Despite a decline in its prevalence, it remains a major public health concern, significantly impairing mastication, speech, aesthetics, nutrition, and overall quality of life. Prosthetic rehabilitation is therefore essential to restore oral function and patient well-being. Among the available treatment options, implant-supported fixed prostheses have proven to be a predictable and effective solution for the long-term rehabilitation of edentulous patients.3,4

Dental implants are a predictable and effective treatment option for replacing missing teeth, offering excellent function, aesthetics, and long-term success. However, maintaining peri-implant crestal bone is essential for the longevity of implant-supported restorations. One of the biomechanical factors that may influence peri-implant bone health is the crown-to-implant ratio, which describes the relationship between the clinical crown and the implant embedded within the bone.5–7

Although higher crown-to-implant ratios have been suggested to increase stress on the crestal bone, clinical evidence remains inconclusive. Marginal bone loss, routinely assessed using radiographs, is a key indicator of implant success. Therefore, understanding the influence of crown-to-implant ratio on crestal bone levels is important for optimizing implant treatment outcomes. Hence, the present study was undertaken to compare and evaluate crestal bone levels associated with different crown-to-implant ratios using digital intraoral periapical (IOPA) radiographs.6,7 The objectives were to evaluate the crestal bone levels around implant-supported prostheses with an anatomical crown-to-implant ratio of >¾ and ≤¾ using digital intraoral periapical (IOPA) radiographs, and to compare the crestal bone levels between the two crown-to-implant ratio groups.

Methodology

An in vivo prospective clinical study was conducted among patients attending the Outpatient Department of Prosthodontics and Crown & Bridge, Institute of Dental Studies & Technologies, Modinagar, Uttar Pradesh. Ethical clearance was obtained from the Institutional Ethics Committee, and written informed consent was obtained from all participants. The sample size was calculated based on a previous study by Gomez-Polo et al.8, with a study power of 80%.

Participants aged 20–50 years with partially edentulous mandibular posterior sites and adequate alveolar bone dimensions were recruited by convenience sampling. Patients with systemic conditions contraindicating implant surgery, tobacco use, immunosuppressive drug therapy, parafunctional habits, communication difficulties, temporomandibular joint disorders, long-term edentulism with occlusal discrepancies, and other conditions affecting implant therapy were excluded.

All participants underwent comprehensive clinical, radiographic (CBCT), and routine laboratory evaluations. Based on the anatomical crown-to-implant ratio, participants were allocated into two groups: Group A (C/I ratio >¾) and Group B (C/I ratio ≤¾).

Implants were placed in the mandibular posterior region using a standardized surgical protocol with an insertion torque of 30–50N. Following a 6-week healing period, second-stage surgery was performed, and implants were restored with screw-retained porcelain-fused-to-metal (PFM) crowns using a conventional loading protocol.

Crestal bone levels were assessed using standardized digital intraoral periapical (IOPA) radiographs obtained immediately after implant placement, at 6 weeks, at prosthesis loading (8 weeks), and at 24 weeks post-loading. Mesial and distal crestal bone levels were measured to evaluate bone changes over time.

Statistical Analysis

Data were analyzed using IBM SPSS version 26. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Intergroup comparisons were performed using the Mann–Whitney U test, with a p-value < 0.05 considered statistically significant.

RESULTS

Table 1 describes the within-group comparison using repeated measures ANOVA demonstrated statistically significant changes in both mesial and distal crestal bone levels over time in Group A and Group B. In Group A, mesial and distal crestal bone levels showed a gradual increase from the postoperative stage to 6 months post-loading ($p = 0.014$ and $p = 0.025$, respectively). In contrast, Group B exhibited a significant reduction in both mesial and distal crestal bone levels over the same period ($p < 0.001$ for both). Post-hoc Bonferroni analysis revealed that the significant changes primarily occurred between the postoperative stage and the later evaluation intervals, while no significant differences were observed between the intermediate follow-up periods, indicating stabilization of crestal bone levels following prosthetic loading. (Graph 1 and 2)

Table 2 depicts the intergroup comparison using the independent t-test showed no statistically significant differences in mesial crestal bone levels between Group A and Group B at any evaluation interval. On the distal aspect, no significant differences were observed at the postoperative or second-stage surgery intervals. However, Group A demonstrated significantly greater distal crestal bone loss than Group B at the prosthetic loading stage ($p = 0.048$) and at 6 months post-loading ($p = 0.004$). (Graph 3 and 4)

Table 3 explains the cumulative crestal bone loss from the post-operative stage to 6 months post-loading was

comparable between the two groups on both mesial and distal aspects. On the mesial side, Group A demonstrated a mean cumulative bone loss of 0.10 ± 0.07 mm, while Group B showed a mean loss of 0.14 ± 0.10 mm, with no statistically significant difference between groups (p = 0.295). Similarly, on the distal side, cumulative bone loss was 0.14 ± 0.05 mm in Group A and 0.16 ± 0.07 mm in Group B, with the difference being statistically non-significant (p = 0.476). (Graph 5)

TABLE NO.1: Comparison of change in crestal bone level within each group.

Group		**Interval**	**Mean ±SD**	**p-value**
Group A	Mesial	Post-Op	1.03±0.52	**0.014***
		2nd stage	0.96±0.42	
		Prosthetic loading stage	1.02±0.45	
		6 months Post Loading	1.13±0.51	
	Distal	Post-Op	0.98±0.28	**0.025***
		2nd stage	1.01±0.28	
		Prosthetic loading stage	1.01±0.24	
		6 months Post Loading	1.12±0.27	
Group B	Mesial	Post-Op	0.99±0.34	**<0.001***
		2nd stage	0.79±0.36	
		Prosthetic loading stage	0.85±0.40	
		6 months Post Loading	0.85±0.35	
	Distal	Post-Op	0.92±0.25	**<0.001***
		2nd stage	0.79±0.31	
		Prosthetic loading stage	0.76±0.28	
		6 months Post Loading	0.76±0.22	

TABLE 2 : Intergroup comparison of crestal bone levels on mesial and distal side

		Interval			
		Post-Op	**2nd stage**	**Prosthetic loading stage**	**6 months Post Loading**
Mesial	Group A	1.03 ± 0.52	0.96 ± 0.42	1.02 ± 0.45	1.13 ± 0.51
	Group B	0.99 ± 0.34	0.79 ± 0.36	0.85 ± 0.40	0.85 ± 0.35
	p-value	0.841	0.349	0.384	0.170
Distal	Group A	0.98 ± 0.28	1.01 ± 0.28	1.01 ± 0.24	1.12 ± 0.27
	Group B	0.92 ± 0.25	0.79 ± 0.25	0.76 ± 0.28	0.76 ± 0.22
	p-value	0.620	0.116	**0.048***	**0.004***

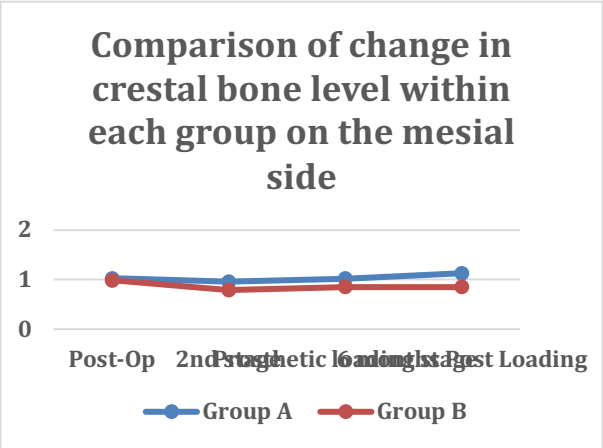
Independent t test; * indicates a significant difference at p≤0.05

Table 3: Comparison of cumulative bone loss (post-op to 6 months post-loading)

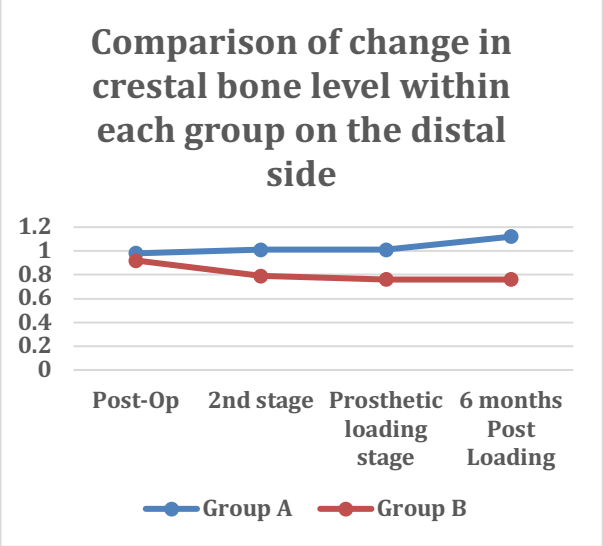
	Group A	Group B	p-value
Mesial	0.10 ±0.07	0.14 ±0.10	0.295
Distal	0.14 ±0.05	0.16 ±0.07	0.476

Independent t test; * indicates a significant difference at p≤0.05

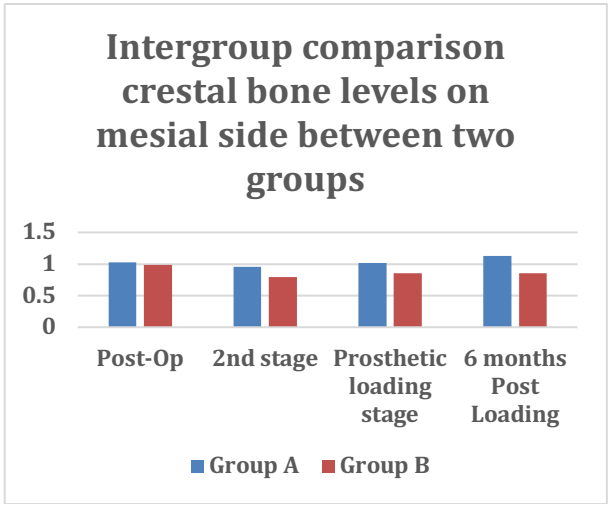
Graph 1: Comparison of change in crestal bone level within each group on the mesial side



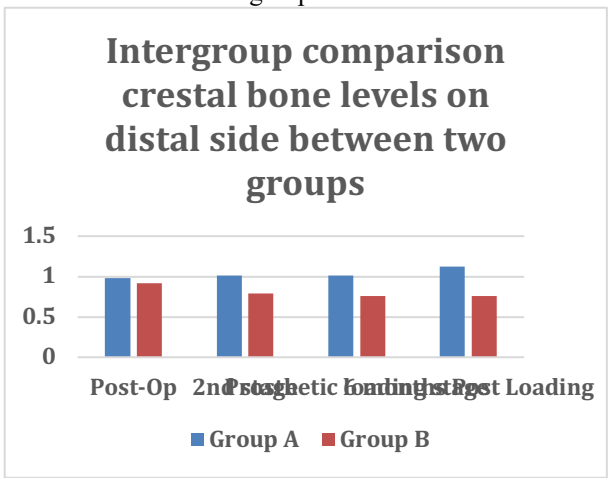
Graph 2: Comparison of change in crestal bone level within each group on the distal side



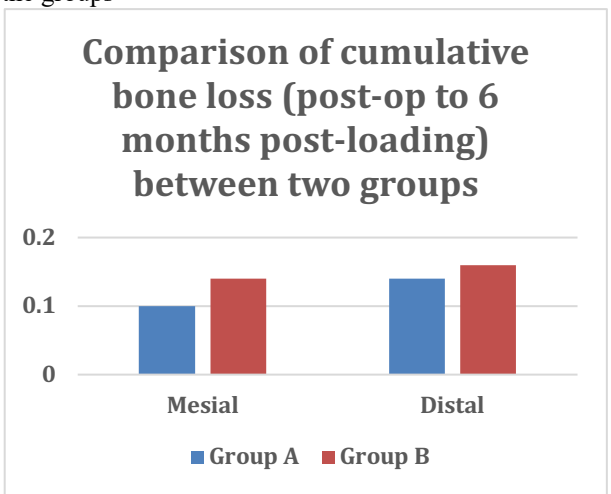
Graph 3: Inter-group comparison of change in crestal bone level within each group on the mesial side



Graph 4: Inter-group comparison of change in crestal bone level within each group on the distal side



Graph 5: Comparison of cumulative bone loss between the groups



DISCUSSION

Since the introduction of osseointegration by Per-Ingvar Brånemark, dental implants have become a predictable and widely accepted treatment modality for the rehabilitation of missing teeth. Despite their high success rates, the long-term success of implant therapy depends on several biomechanical and biological factors, among which the crown-to-implant (C/I) ratio has received considerable attention. The C/I ratio influences the distribution of occlusal forces to the supporting peri-implant bone, and an unfavorable ratio has been hypothesized to increase stress concentrations, potentially leading to crestal bone loss and compromised implant longevity. However, its clinical significance remains controversial.

In the present study, both groups exhibited crestal bone loss following implant placement. Although implants with a crown-to-implant ratio of ≤¾ demonstrated slightly greater cumulative mesial and distal bone loss than those with a ratio of >¾, the difference was not statistically significant.

Malchiodi et al.9 demonstrated significantly greater crestal bone loss with increasing crown-to-implant ratios, Rossi et al.10, Nunes et al.11, and the systematic reviews by Blanes and Ravidà et al.12 found no significant association between the crown-to-implant ratio and peri-implant bone loss. Likewise, Birdi et al.13 reported no significant correlation between the C/I ratio and crestal bone loss, suggesting that plaque control, implant design, bone quality, and appropriate occlusal load distribution may have a greater influence on peri-implant bone preservation than the crown-to-implant ratio alone.

In the present study, both groups exhibited progressive crestal bone loss from the postoperative period to 6 months post-loading. Although changes in mesial and distal bone levels within the higher C/I ratio group were not statistically significant, the overall increase in bone loss over time was significant. In the lower C/I ratio group, a significant reduction in mesial crestal bone level was observed during the follow-up period.

Intergroup comparison showed no significant difference in mesial crestal bone levels between the two groups. On the distal aspect, no significant differences were observed during the postoperative and second-stage intervals; however, the higher C/I ratio group demonstrated significantly greater distal crestal bone loss at prosthetic loading and at 6 months post-loading.

Previous studies have demonstrated that implant-supported restorations with favorable crown-to-implant ratios exhibit high long-term survival and minimal crestal bone loss. Tiwari et al. reported that restorations with a mean C/I ratio of 2:3 showed excellent long-term outcomes, highlighting the biomechanical significance of the crown-to-implant ratio.14 Similarly, Di Fiore, in a narrative review, concluded that a C/I ratio of <2.2mm was not associated with increased marginal bone loss or biological complications.6

In the present study, the mean mesial and distal bone loss was approximately 1.2 mm, which remained within clinically acceptable limits. This finding is consistent with the success criteria proposed by Albrektsson et al.15, which permit marginal bone loss of up to 1.5 mm during the first year of implant function, followed by 0.2 mm annually thereafter. Comparable marginal bone loss values have also been reported by Ghahroudi et al., further supporting the favorable clinical outcomes observed in the present study.16

Overall, the findings of the present in vivo study suggest that a lower crown-to-implant ratio did not adversely affect peri-implant crestal bone levels during the 6-month follow-up period. Although slight differences in cumulative mesial and distal bone loss were observed between the groups, these were not statistically significant. Digital intraoral periapical (IOPA) radiography proved to be a reliable and practical method for evaluating crestal bone changes around implants.

The findings should, however, be interpreted with caution owing to the relatively small sample size and short follow-up period. Further longitudinal studies with larger sample sizes and longer observation periods are warranted to better establish the influence of the crown-to-implant ratio on long-term peri-implant crestal bone stability and implant success.

Conclusion

Within the limitations of the present in vivo study, crestal bone levels around implant-supported prostheses with anatomical crown-to-implant ratios of >¾ and ≤¾ were comparable over the 6-month follow-up period. Although implants with a crown-to-implant ratio of ≤¾ exhibited relatively lower crestal bone loss, the difference between the two groups was not statistically significant. These findings suggest that the anatomical crown-to-implant ratio, within the range evaluated, may not independently influence early peri-implant crestal bone changes. Therefore, clinicians may consider crown-to-implant ratio alongside other biomechanical and biological factors during implant treatment planning rather than as an isolated determinant of implant success. Furthermore, digital intraoral periapical (IOPA) radiography proved to be a reliable and practical tool for monitoring peri-implant crestal bone levels in routine clinical practice.

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PRE-OP LEFT LATERAL

PRE-OP RIGHT LATERAL

PRE-OP FRONTAL

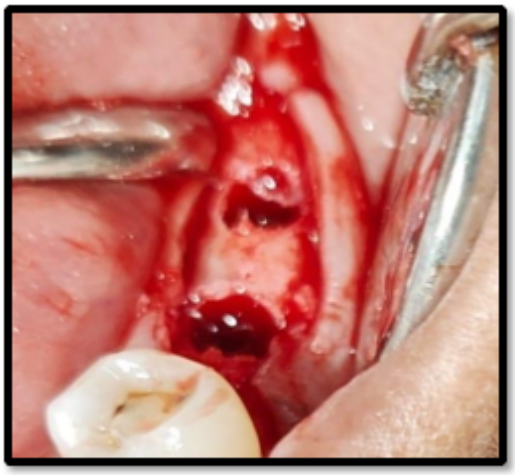
PRE-OP LOWER ARCH

PRE-OP UPPER ARCH

EDENTULOUS SITE WRT 36. 37

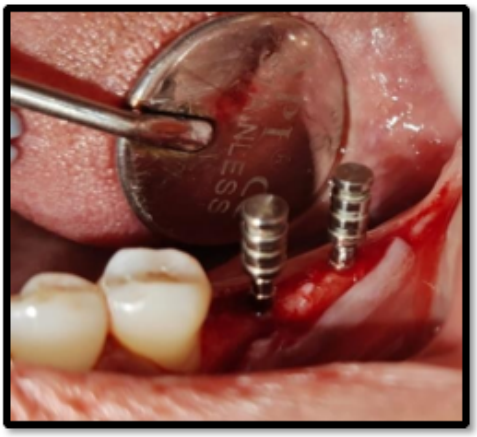
MID CRESTAL INCISION GIVEN

FULL THICKNESS FLAP RAISED



OSTEOTOMY DONE WRT 36, 37

IMPLANTS PLACED WRT 36, 37



PARALLEL PINS PLACED WRT 36, 37

IMPLANTS IOPAR WRT 36, 37

PARALLEL PINS IOPAR WRT 36, 37

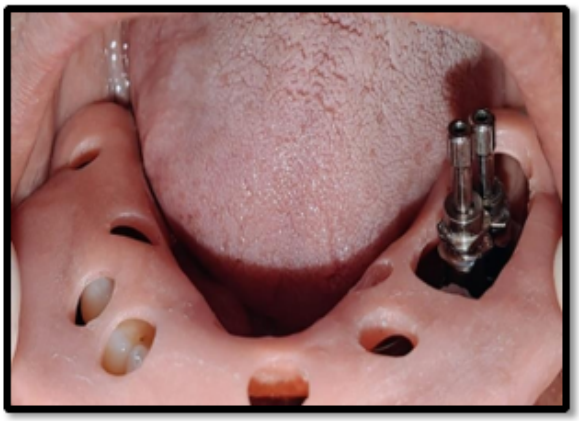
SUTURE GIVEN WRT 36, 37

GINGIVAL FORMER PLACED WRT 36, 37

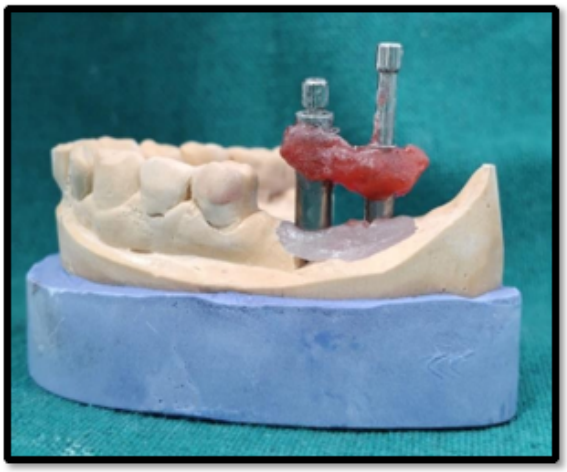
GINGIVAL FORMER IOPAR WRT 36, 37

GINGIVAL COLLAR FORMED WRT 36, 37

SPECIAL TRAY FABRICATION



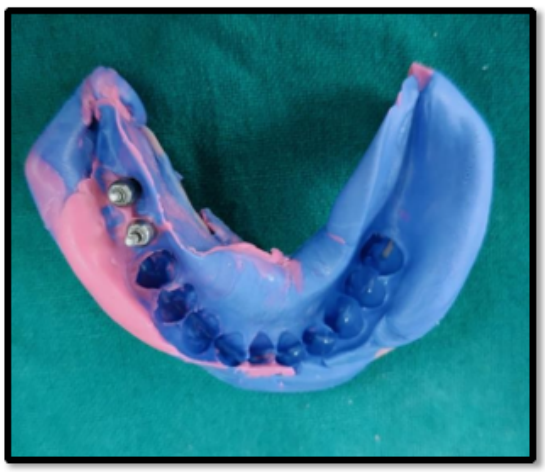
SPECIAL TRAY ADJUSTMENT DONE



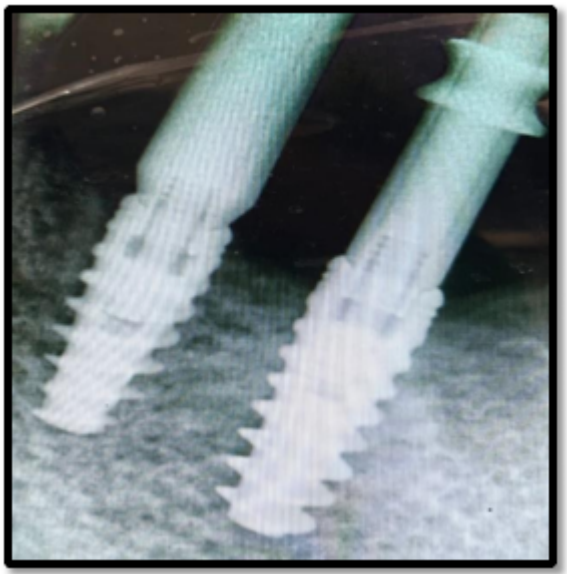
JIG TRIAL FABRICATION WRT 36, 37

IMPRESSION COPINGS IOPAR

JIG TRIAL VERIFICATION INTRA-ORALLY

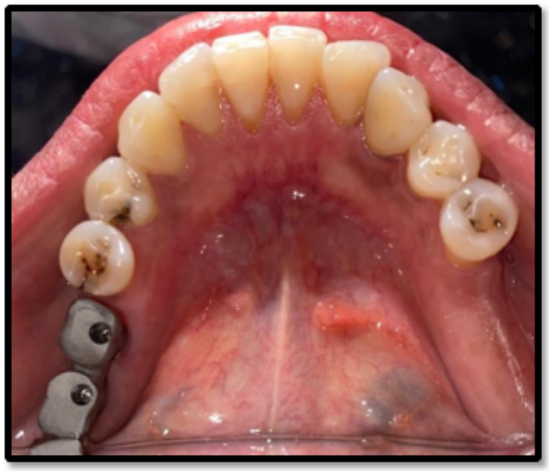


IMPLANT IMPRESSION MADE WRT 36, 37

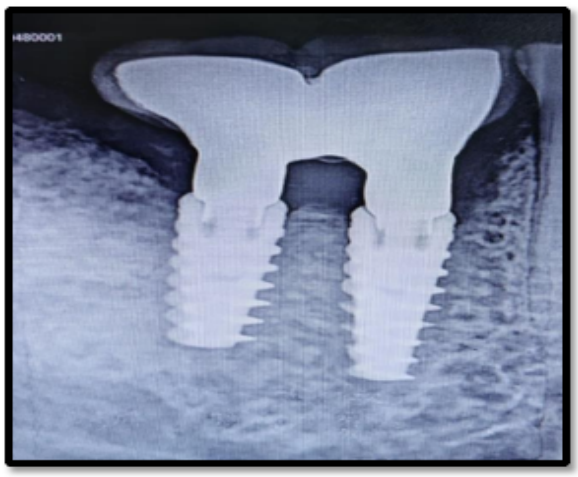


JIG TRIAL VERIFICATION IOPAR

METAL TRIAL WRT 36, 37



METAL TRIAL WRT 36, 37 INTRA-ORALLY



FINAL PROSTHESIS WRT 36. 37

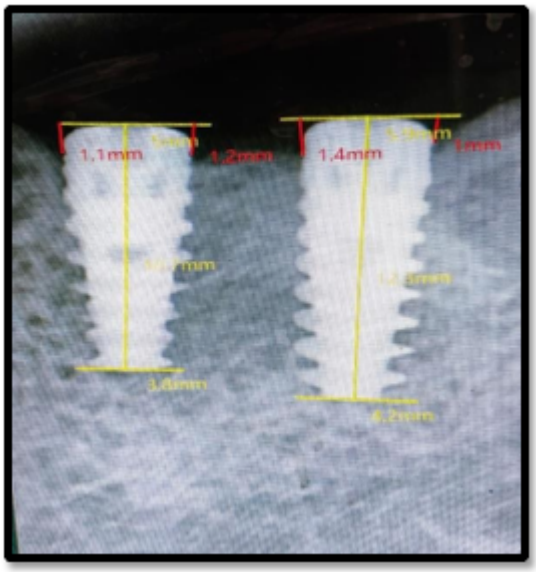
POST –OP MAXILLARY ARCH

POST-OP MANDIBULAR ARCH

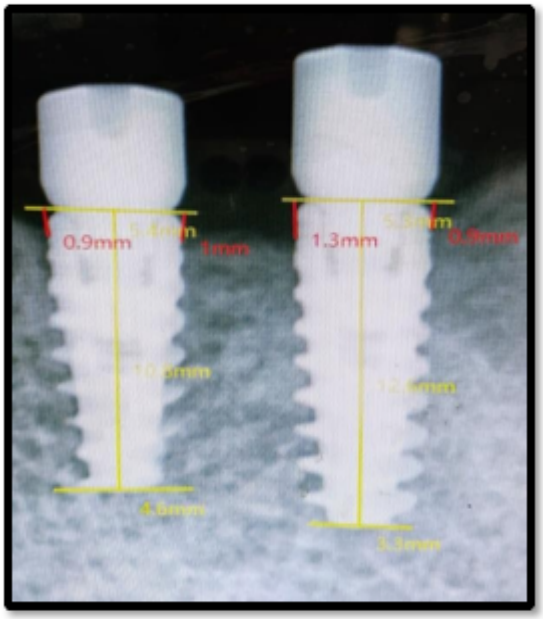
POST-OP FRONTAL

POST-OP RIGHT LATERAL

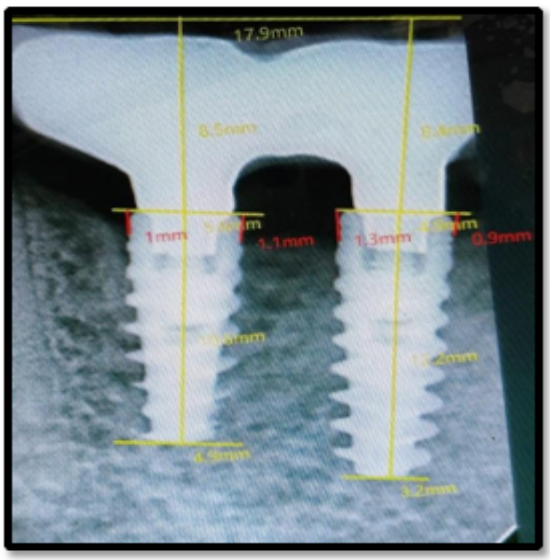
POST-OP LEFT LATERAL



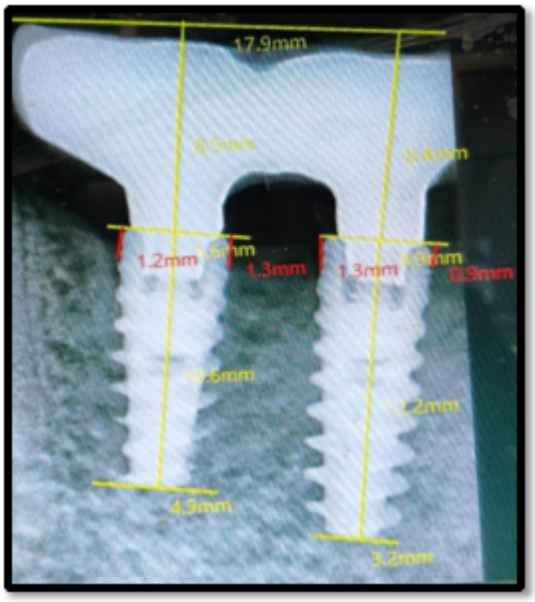
POST-OP IOPAR READINGS WRT 36, 37



POST STAGE 2 IOPAR READINGS



IOPAR AT THE TIME OF PROSTHESIS



IOPAR AFTER 6 MONTHS POST LOADING