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RESEARCH ARTICLE

“TO COMPARE THE MARGINAL FIT, INTERNAL GAP AND FIRING SHRINKAGE OF METAL CERAMIC CROWN FABRICATED BY CAD-CAM AND CONVENTIONAL METHOD:AN INVITRO STUDY”

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Abstract

Purpose: The purpose of this in vitro study is to compare the marginal fit, internal gap and firing shrinkage of metal ceramic crown fabricated by cad-cam and conventional method.

Materials **And** **Methods:** A total of 30 working models, i.e. 15 models each group: conventional lost-wax; and milling were used.

Marginal discrepancy was evaluated at the framework and porcelain step through scanning under a stereomicroscope. Then, the crowns were cemented to the related die and the marginal gap was measured under a stereomicroscope and then sectioning was done and internal gap was evaluated using scanning electron microscopy (SEM). The data was analyzed using the independent t test and the one-way analysis of variance (ANOVA). The significance level was set at 0.05

Results: Among the experimental group, group 2 cad cam shows the better marginal gap in all aspects compared to group 1 conventional technique in both before and after ceramic firing. Group 1 shows the better internal fit at 4 places out of 5 that is marginal opening area was better in group 2.

Conclusion:

Within the limitation of this in vitro study, it was concluded that for all the features CAD-CAM techniques gave better results except internal gap, when compared with the conventional methods and there was a significant statistical difference between the two comparison groups.

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Introduction:-

Metal based ceramic restorations are still the most commonly used for fixed partial dentures such as crowns and bridges. In order to have suitable and successful restorations, the clinicians should be focused on both qualitative and quantitative assessments. One of the aspects of this assessment to evaluate the marginal adaptation of crown and bridge restorations¹.

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The traditional technique for fabricating the metallic crown is the lost-wax technique and using various metal alloys for casting. Conventionally, wax patterns were fabricated with waxing instruments i.e. the popular PKT instruments. Wax is chosen for making the patterns because it can be easily manipulated, precisely shaped and can also be completely eliminated from the mold by heating. The fabrication of acceptable wax patterns is the most important variable that can affect the marginal fit throughout the casting procedure².

However, in recent years, technological methods, which are more efficient, began to be used instead of conventional methods

Digital Dental Technology for fabrication of prosthesis including computer aided design/computer-assisted manufacturing (CAD/CAM) has been in development since the 1980s.

Various computer-aided designing/computer-aided manufacturing (CAD/CAM) -based systems are available for rapid production of Fixed Dental Prosthesis. In these digital systems, the dental CAD/CAM systems are generally used to improve the effectiveness of prosthesis fabrications.

The feature of dental prosthesis using digital methods are high accuracy, detailed resolution, good surface quality, and excellent mechanical properties.³

Digital methods and CAD/CAM systems have become popular, as they reduce the number of laboratory steps, have a simple fabrication procedure¹ and are cost effective. It seems that the CAD/CAM method, with its fewer steps and less human interference, could lower the number of errors and enhance the fitness of restorations⁴

Metal milling is relatively new to dentistry. There have not been sufficient studies on the accuracy of the vertical marginal fit of milled metal Co-Cr crowns considering its indications in clinical situations. Therefore, in the present study the vertical marginal fit and internal gap of milled metal Co-Cr crowns will be compared to the Co-Cr crowns fabricated by conventional casting technique

Materials And Methods:-

In-vitro study was conducted to evaluate firing shrinkage and compare the marginal fit and internal gap of metal ceramic copings fabricated by conventional and CAD-CAM techniques at the Department of Prosthodontics Crown and Bridge and Oral Implantology in Divya Jyoti College of Dental Sciences & Research, Modinagar. In association with Praj metallurgical lab for marginal gap with use of stereomicroscope and IIT BOMBAY for using SCANNING ELECTRON MICROSCOPE (SEM) for internal gap.

In this study, two groups were made:

1. Group 1 (conventional method)
2. Group 2 (CAD-CAM milled).

15 molar typodont teeth i.e. tooth number 36 were used for reduction models to make a stone replica. Two impressions were taken from each model, one for each group i.e. group 1 (conventional method) with plastic perforated tray & group 2 (CAD-CAM milled) with stainless steel perforated tray with light body polyvinyl siloxane of prepared abutment tooth. Total 30 impressions were made from each reduction model. A type IV stone was poured into the silicone putty impression to fabricate a total of 30 working models, i.e. 15 models each group.

Methodology:-

Step 1- Master model fabrication.

Step 2- Fabrication of type IV gypsum dies with sectional stainless steel custom tray using conventional elastomeric impression, which dies divided into two groups using Two step/double mix putty wash impression technique.

Step 3- Fabrication of crowns by conventional casting using free hand wax patterns for group I samples

Step 4- Fabrication of milled Co-Cr crowns after scanning of stone die models for II group

Step 5- Testing of samples for marginal gap of metal coping for both group

Step 6- Testing the samples for marginal gap after ceramic firing for both group

Step 7- cementation of crown using standardized method to respective die

Step 8- sectioning of cemented crown –die sample to measure internal gap for both group

Step 9- statistical analysis of data



Figure 1:- Typhodont (Frasaco, Lifecare Services Pvt.,ltd).

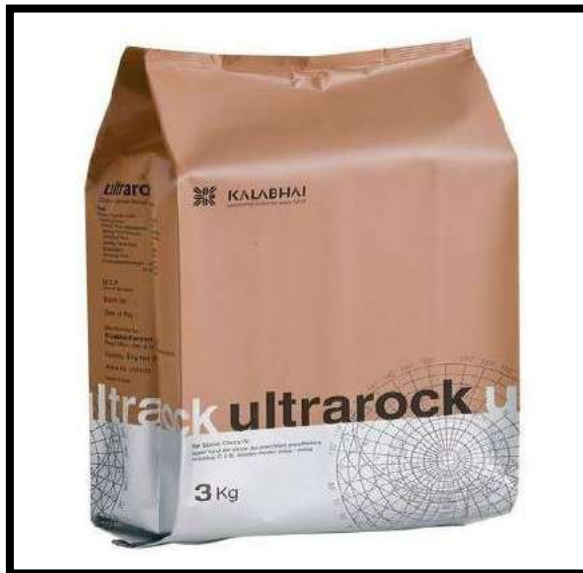


Figure 2:-Type IV die stone (Ultrarock, Kalabhai Karson Pvt Ltd).



Fig 3:- Stainless steel and plastic perforated tray.



Fig 4:- Vinyl polysiloxane impression material (zeta lus).



Fig 5:- Inlay casting wax(bego, Germany).



Fig 6:- Die spacer (DFS) with sprue wax.



Fig7:- PKT (P.K. Thomas) instrument kit.



Fig 8:- Tray Adhesive.



Fig 9:- Phosphate bonded investment material and liquid (deguyest impact).



Fig 10:- Tooth preparation in relation to 36 with chamfer finish line

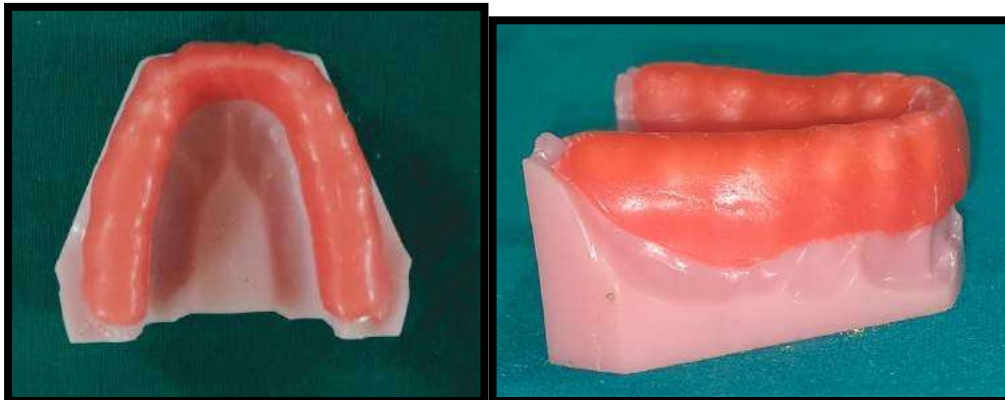


Fig 11:- Uniform wax spacer for medium body.

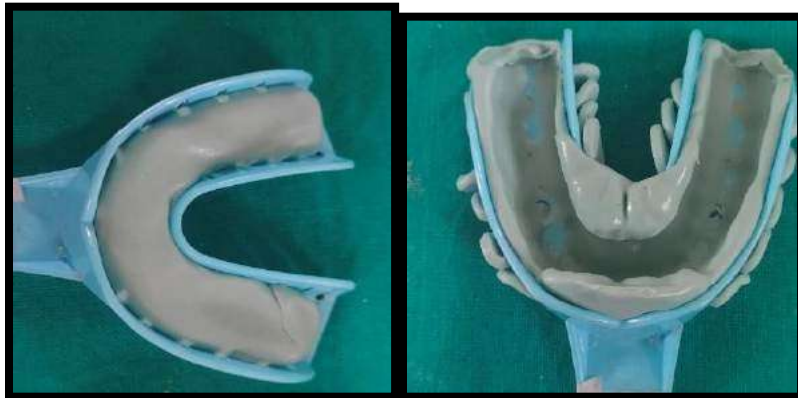


Fig 12a&b:- Heavy body impression over model placed with spacer.

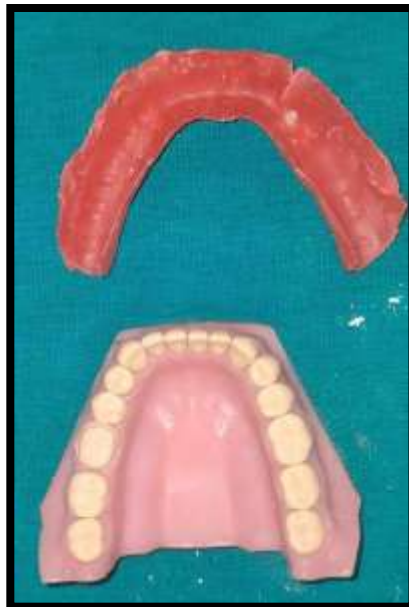


Fig.13:- Spacer is removed after heavy body impression.



Fig.14:- Medium body is loaded.



Vinyl polysiloxane impression



Fig.15:- Impression poured with die stone.



Fig 16:- Master die for Conventional Casting CAD CAM Scanning.



Fig.17:- Dental casting machine.



Fig.18:- Medit scanner t500.

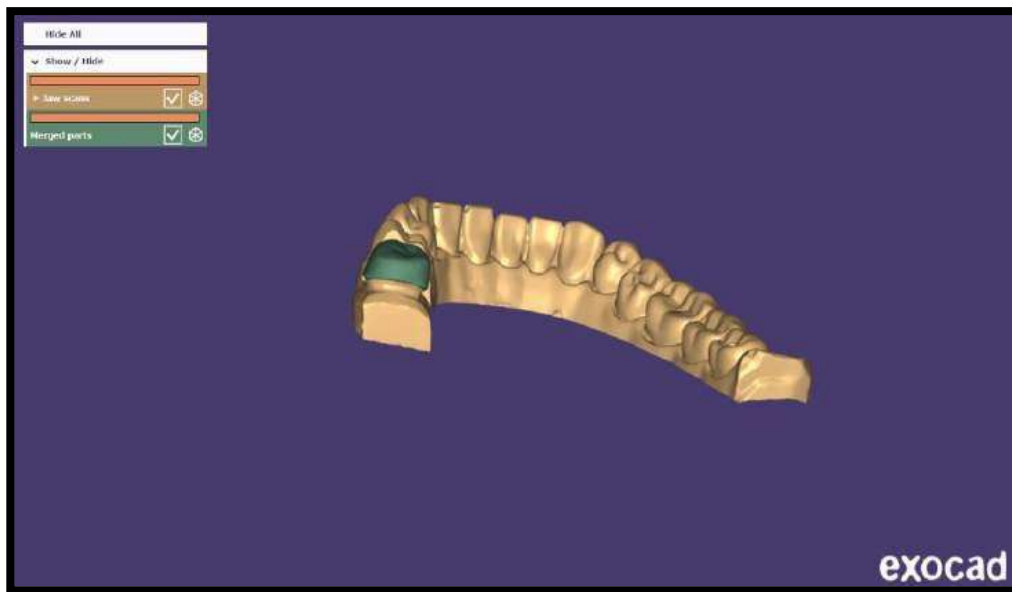


Fig 19:- Scanner scanned images of master die.

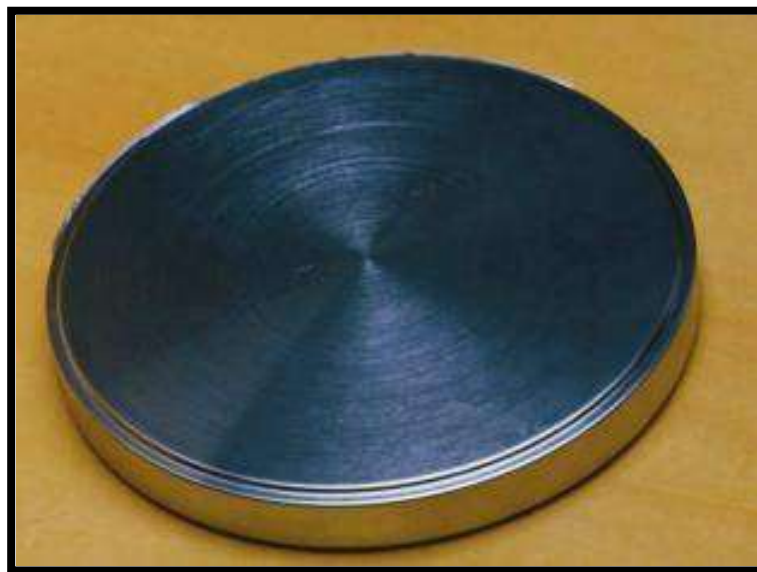


Fig.20:- Co-Cr disc.



Fig21:- ARUM-5X 450.



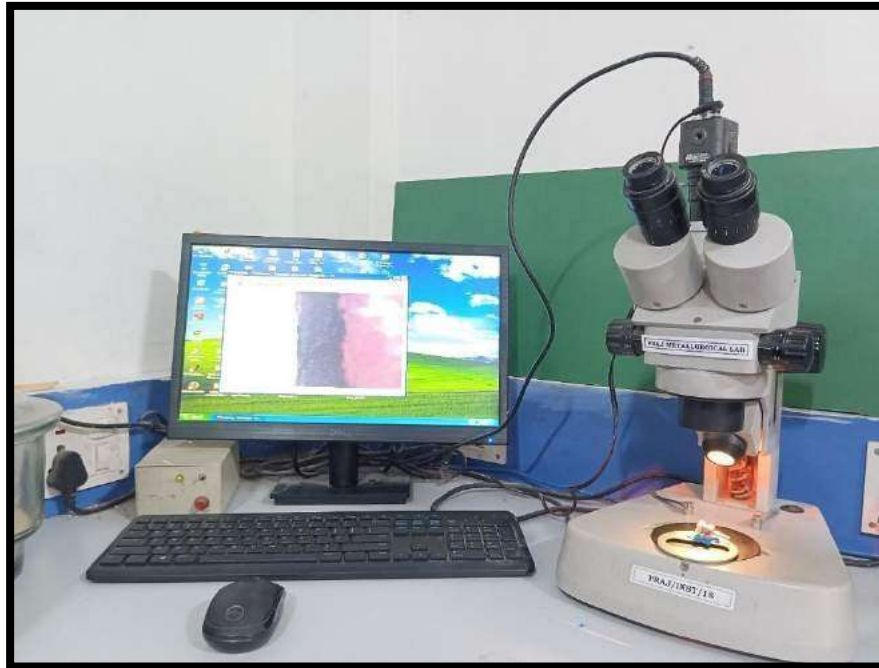


Fig.22:-Stereomicroscope.

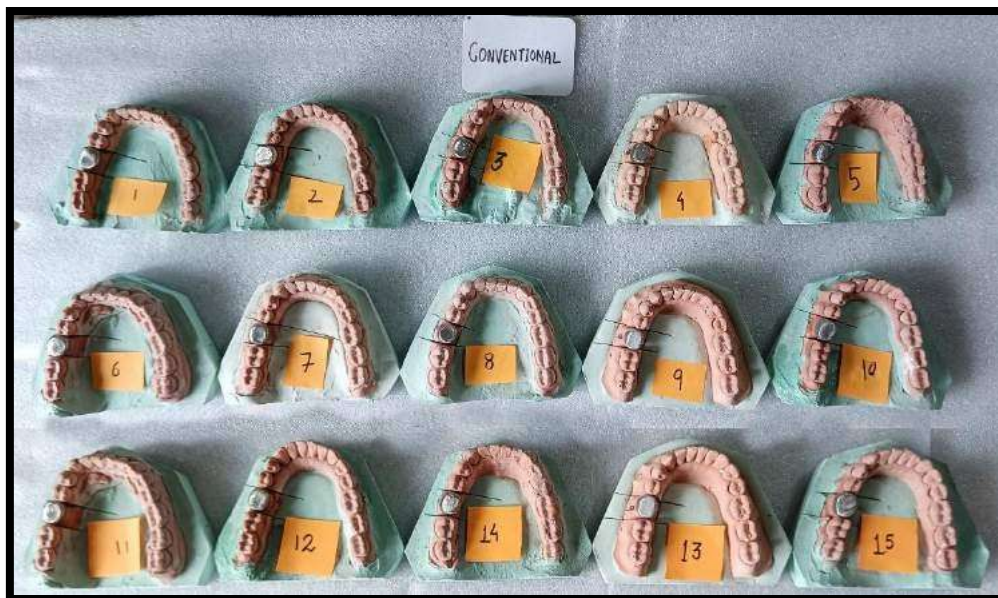


Fig 23a:- Fabrication of crown by conventional casting.



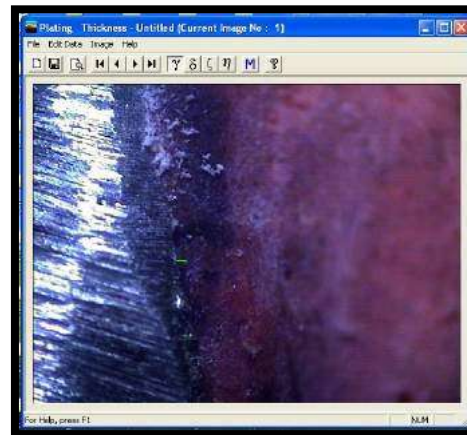
Fig.23b:- Conventional metal coping Dies(Group 1).



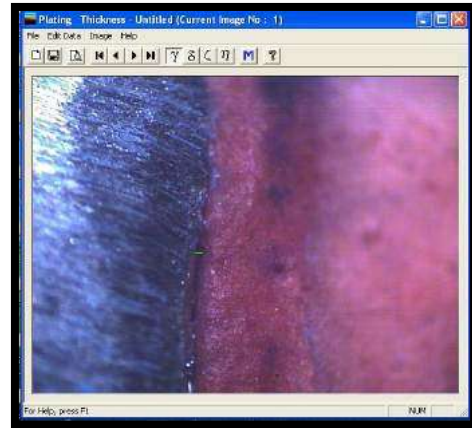
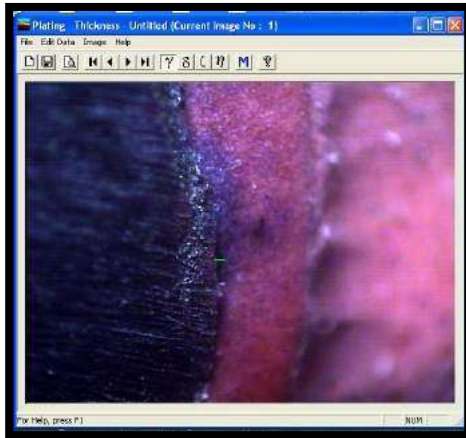
Fig.24a:- Cad cam milled metal coping.



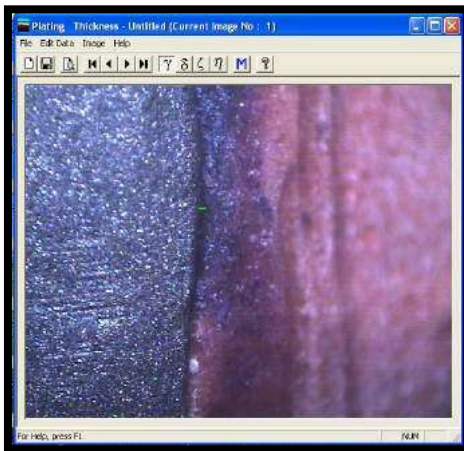
Fig.24b:- Cad cam milled metal coping Dies (group 2).



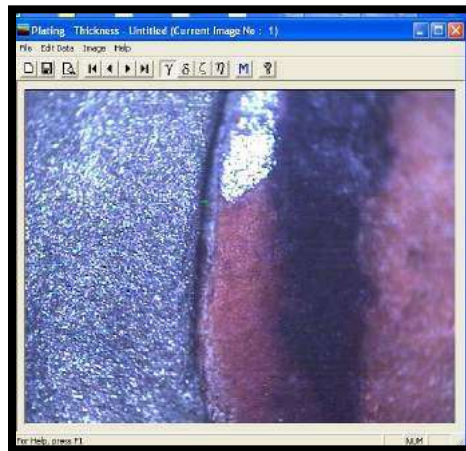
Buccalaspect
Mesialaspect



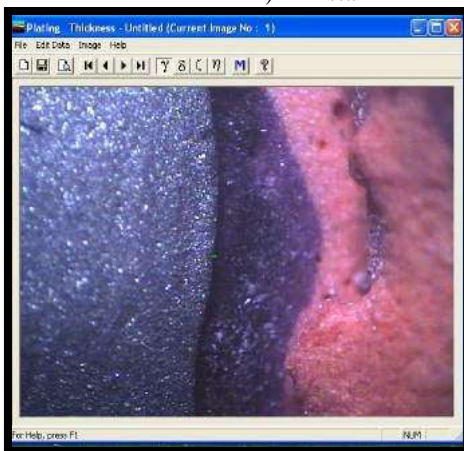
Lingual aspect Distal aspect
Fig 25a:- Stereoscopic image of conventional casting.



1) Distal



Mesial



2) Buccal

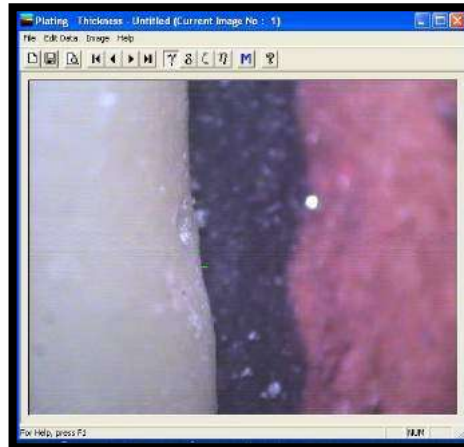


Lingual

Fig.25b:- CAD CAM Milled Crown Image.



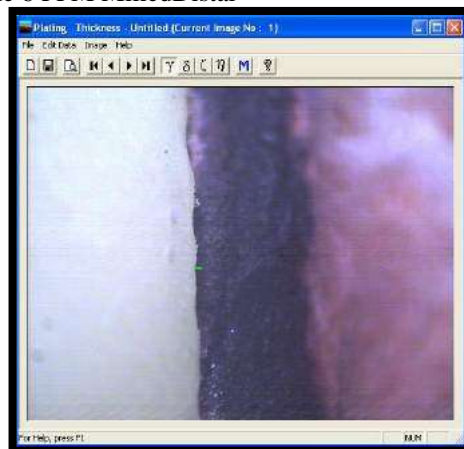
3) Sample 6 PFMMilledBuccal



Sample 6 PFM MilledDistal



4)



Sample 6 PFMMilled Lingual Sample 6

PFM Milled Mesial

Fig.26a:- CAD Cam PfmCrown.



Die spacer is removed from die before cementation



Fig.27:- Cementing with uniform 1kg load.

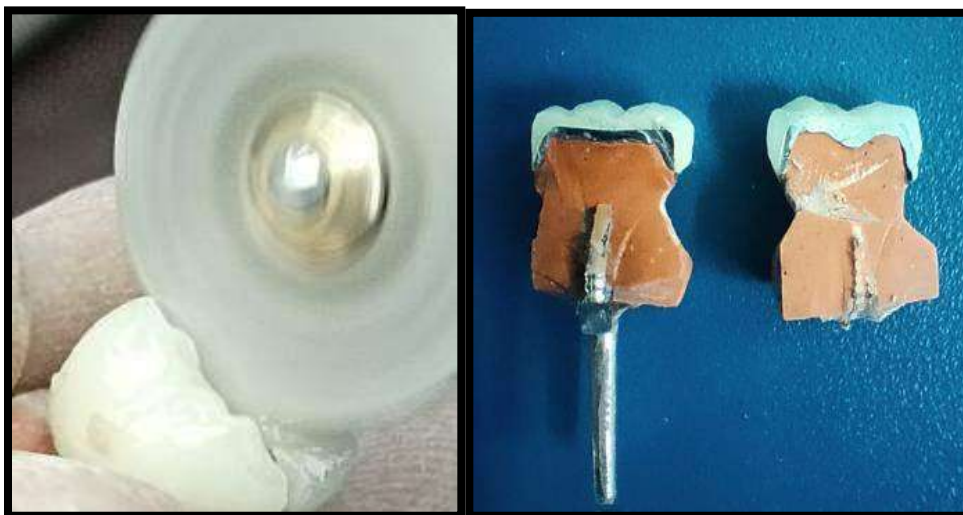


Fig.28a&b:- Manual sectioning mesio-distally for internal gap.

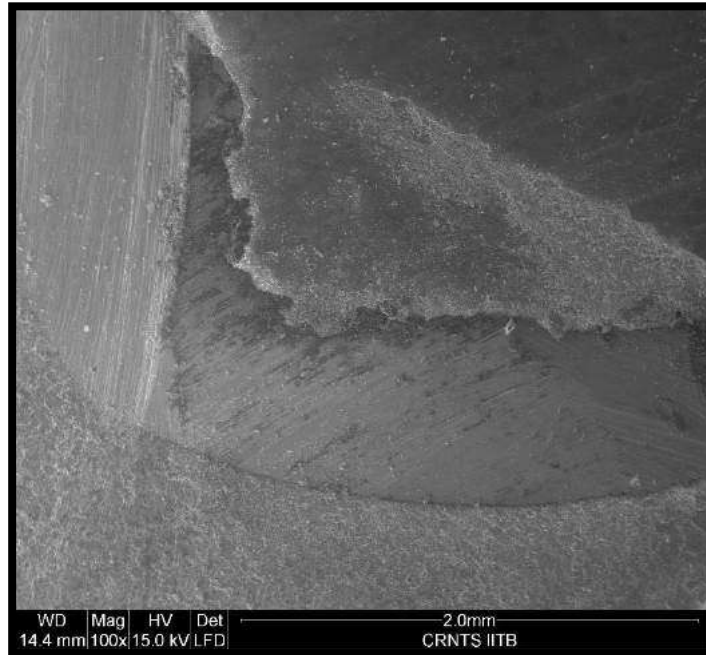


Fig.29:- SEM 100X Internal gap.



Fig.30:- SEM

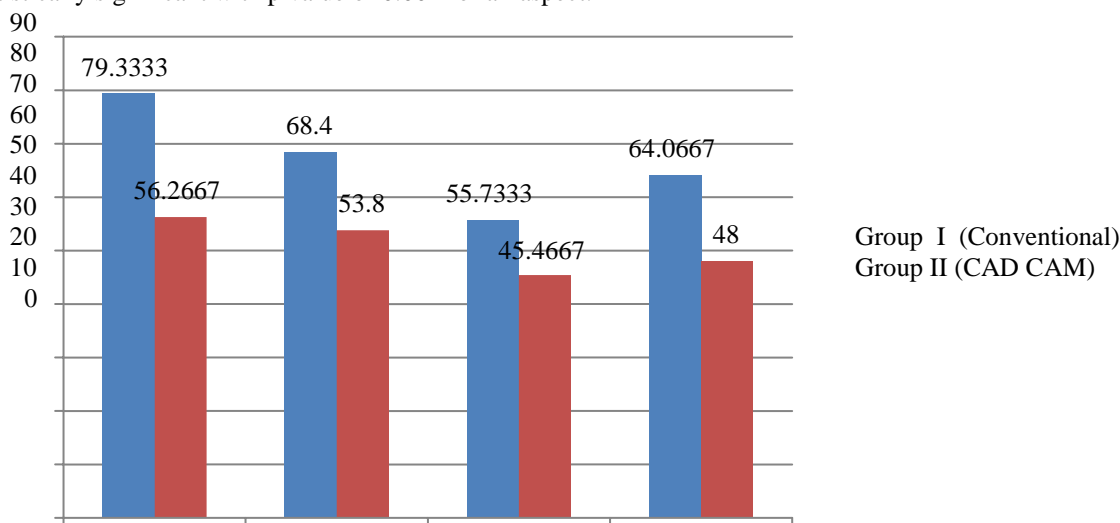
Result:-

Table No7:- Intergroup Comparison Of Marginal Gap Between Conventional And Cad Cam Based Metal Coping.

| | Groups | Mean | SD | Std Error | P value |
|--------|---------------------------|---------|----------|-----------|----------------|
| Buccal | Group I (Conventional) | 79.3333 | 12.36161 | 3.19176 | 0.001 (Sig) |
| | Group II (CAD CAM) | 56.2667 | 12.97507 | 3.35015 | |

| | | | | | |
|----------------|---------------------------|---------|----------|---------|----------------|
| Distal | Group I (Conventional) | 68.4000 | 16.80051 | 4.33787 | 0.001 (Sig) |
| | Group II (CAD CAM) | 53.8000 | 14.86222 | 3.83741 | |
| Lingual | Group I (Conventional) | 55.7333 | 13.47202 | 3.47846 | 0.001 (Sig) |
| | Group II (CAD CAM) | 45.4667 | 8.19291 | 2.11540 | |
| Mesial | Group I (Conventional) | 64.0667 | 23.95373 | 6.18483 | 0.001 (Sig) |
| | Group II (CAD CAM) | 48.0000 | 14.39742 | 3.71740 | |

The mean marginal gap on the buccal side in the conventional metal coping was 79.3333 and in the CAD CAM based metal coping was 56.2667. The mean marginal gap on the distal side in the conventional metal coping was 68.40 and in the CAD CAM based metal coping was 53.80. The mean marginal gap on the lingual side in the conventional metal coping was 55.73 and in the CAD CAM based metal coping was 45.46. The mean marginal gap on the mesial side in the conventional metal coping was 64.06 and in the CAD CAM based metal coping was 48.00. The intergroup difference of marginal gap between conventional and CAD CAM based metal coping was statistically significant with p value of 0.001 for all aspect.



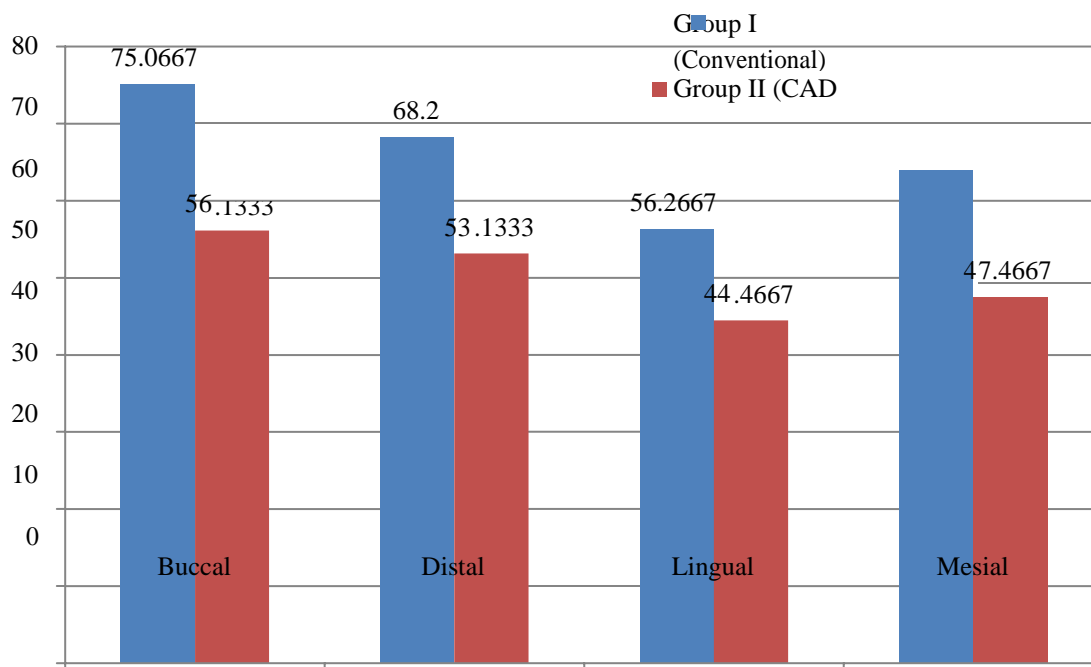
Graph 1:-Represents The Mean Of Marginal Gap Of Two Groups Conventional Casting, And Cad Cam Metal Coping Before Ceramic Firing.

Table No. 8:-Intergroup Comparison Of Marginal Gap Between Conventional And Cad Cam Based Ceramic Crown.

| | Groups | Mean | SD | Std Error | P value |
|---------------|---------------------------|---------|----------|-----------|-------------|
| Buccal | Group I (Conventional) | 75.0667 | 16.68390 | 4.30776 | 0.001 (Sig) |
| | Group II (CAD CAM) | 56.1333 | 13.08689 | 3.37902 | |
| | Group I | 68.2000 | 15.36787 | 3.96797 | |

| | | | | | |
|----------------|------------------------|---------|----------|---------|-------------|
| Distal | (Conventional) | | | | 0.001 (Sig) |
| | Group II (CAD CAM) | 53.1333 | 14.69629 | 3.79457 | |
| Lingual | Group I (Conventional) | 56.2667 | 12.27347 | 3.16900 | 0.001 (Sig) |
| | Group II (CAD CAM) | 44.4667 | 8.50938 | 2.19711 | |
| Mesial | Group I (Conventional) | 63.9333 | 22.08576 | 5.70252 | 0.001 (Sig) |
| | Group II (CAD CAM) | 47.4667 | 14.30717 | 3.69410 | |

The mean marginal gap on the buccal side in the conventional ceramic crown was 75.0667 and in the CAD CAM based ceramic crown was 56.1333. The mean marginal gap on the distal side in the conventional ceramic crown was 68.20 and in the CAD CAM based ceramic crown was 53.13. The mean marginal gap on the lingual side in the conventional ceramic crown was 56.26 and in the CAD CAM based ceramic crown was 44.46. The mean marginal gap on the mesial side in the conventional ceramic crown was 63.93 and in the CAD CAM based ceramic crown was 47.46. The intergroup difference of marginal gap between conventional and CAD CAM based ceramic crown was statistically significant with p value of 0.001 for all aspect.



Graph2:-Represents The Mean Of Marginal Gap Of Two Groups Conventional Casting, And Cad Cam After Ceramic Firing.

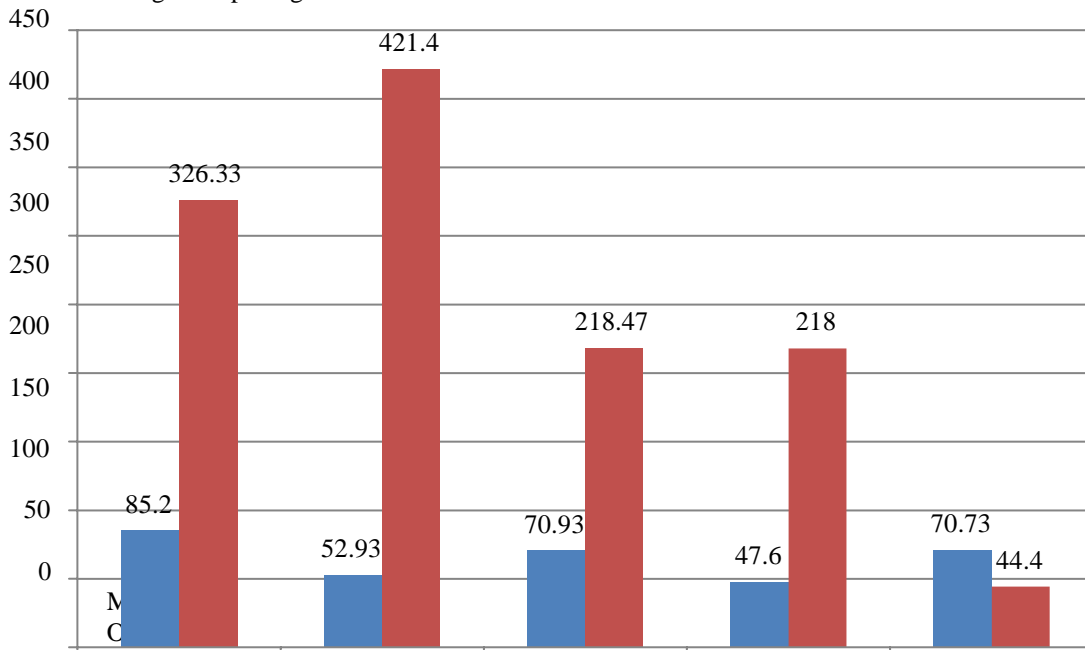
Table No11:- Intergroup Comparison Of Internal Gap Between Conventional And Cad Cam Based Ceramic Crown

| | Groups | Mean | SD | Std Error | P value |
|---------------------|------------------------|-------|---------|-----------|-------------|
| Mid Occlusal | Group I (Conventional) | 85.20 | 7.58947 | 1.95959 | 0.001 (Sig) |

| | | | | | |
|-------------------------|------------------------|--------|----------|---------|-------------|
| | Group II (CAD CAM) | 326.33 | 14.19591 | 3.66537 | |
| Cusp Tip | Group I (Conventional) | 52.93 | 5.86109 | 1.51333 | 0.001 (Sig) |
| | Group II (CAD CAM) | 421.40 | 16.41341 | 4.23792 | |
| Axial wall | Group I (Conventional) | 70.93 | 7.37241 | 1.90355 | 0.001 (Sig) |
| | Group II (CAD CAM) | 218.47 | 15.05640 | 3.88755 | |
| Chamfer Area | Group I (Conventional) | 47.60 | 4.04969 | 1.04563 | 0.001 (Sig) |
| | Group II (CAD CAM) | 218.00 | 14.63850 | 3.77964 | |
| Marginal Opening | Group I (Conventional) | 70.73 | 17.67753 | 4.56432 | 0.001 (Sig) |
| | Group II (CAD CAM) | 44.40 | 8.55904 | 2.20993 | |

The mean internal gap on the midocclusal side in the conventional ceramic crown was 85.20 and in the CAD CAM based ceramic crown was 326.33. The mean internal gap on the cusp tip side in the conventional ceramic crown was 52.93 and in the CAD CAM based ceramic crown was 421.40. The mean internal gap on the axial side in the conventional ceramic crown was 70.93 and in the CAD CAM based ceramic crown was 218.47. The mean internal gap on the chamfer side in the conventional ceramic crown was 47.60 and in the CAD CAM based ceramic crown was 218.00. The mean internal gap on the marginal opening in the conventional ceramic crown was 70.73 and in the CAD CAM based ceramic crown was 44.40. The intergroup difference of internal gap between conventional and CAD CAM based ceramic crown was statistically significant with p value of 0.001 for all aspect.

Chamfer Area Marginal Opening



Group I (Conventional) ■ Group II (CAD CAM) ■

Graph 5:- Represents The Mean Intergroup Comparison Of Internal Gap Between Conventional And Cad Cam Based Ceramic Crown.

Discussion:-

The long-term clinical success of fixed prosthesis is closely associated with the adaptation of restorations⁵. Marginal accuracy and internal fit are important parameters that determine the clinical longevity and success of restorations, including Fixed Dental Prosthesis.

Despite numerous technological advances, obtaining an effective, long-lasting marginal seal at the tooth restoration interface is still a great challenge⁶

Therefore, optimum marginal and internal adaptation should be established between the restoration and prepared tooth structure. Although the clinically acceptable marginal discrepancy value varies among authors, most agree that marginal discrepancy values of greater than 120 μm are not clinically acceptable⁵.

Currently, the introduction of different CAD/CAM systems, has led to improved quality of full coverage restorations. It is possible to fabricate wax patterns made from castable materials and omit the numerous limitations of the conventional wax up technique.⁷

The present study was conducted to comparatively evaluate the marginal and internal gaps of Co-Cr copings fabricated by Conventional casting procedures and CAD CAM milling technique. In this study, comparisons were drawn between of Co-Cr crown fabricated by conventional (lost wax technique) and CAD-CAM techniques for the following features:

1. Marginal Fit
2. Changes in marginal gap, followed by porcelain firing.
3. Internal gap

For the metal coping in this study, The highest mean marginal gap was found on the buccal side in the conventional method i.e 79.3333 and in the CAD CAM method, it was 56.2667 when intergroup comparison was done. This may be because the buccal area is large, thereby increasing the accumulation of errors during the casting and manufacture of the metal in that area.⁸

After ceramic firing, no significant difference were found in both CAD CAM milled and Conventional group. The ceramic could be responsible for alterations in marginal and internal fit. However, in all specimens, an increase in marginal openings after ceramic firing was seen, whereas this increase was not statistically significant ($p > 0.05$).

For the internal gap, The mean internal gap on the midocclusal side in the conventional ceramic crown was 85.20 and in the CAD CAM based ceramic crown was 326.33. This significant difference between the two groups can be attributed to the difference in the thickness of the die spacer as for the conventional method, the die spacer thickness was 14 μm while as a die spacer of thickness 0.5mm was used for the CAD CAM crown and there might be the accumulation of the die spacer in the surface grooves and depressions creating layers with unequal thicknesses. This also signifies the accuracy of the printing machine over the conventional hand formed wax patterns and also, it might be because of the inexperience of the operator.⁹

As a result of which, there was huge difference in the cement space created for the two methods.

The least mean internal gap value was found for the marginal opening due to the fact that there was no die spacer applied over the margins and as a result of this, this area presented the least difference.

The conventional methodology of crown fabrication has been used since long with long term results. Proper selection of material and fabrication procedures involved play a major role in compensate for dimensional changes.

In this study, attempts were made to control and standardize the steps involved. Each material was standardized according to the manufacturer's instructions in fabrication of the crowns. However, the impossibility of controlling all

the variables, combined with the propensity for human error, can result in poor marginal fit. The use of digitalization however decreases the chances for error producing better results

A study by Wei-Ting Chou, Chuan-Chung Chuang Compared the internal fit of metal crowns fabricated by traditional casting, computer numerical control milling, and three-dimensional printing and they concluded that, All three methods of metal crown fabrication, that is, traditional casting, CNC milling, and 3D printing, had values within the clinically acceptable range, but The marginal and internal fit of the crown was far superior in the CNC milling method¹⁰.

Another study on the Marginal Discrepancy of Cobalt Chromium Metal Copings Fabricated with Three Different Techniques by Ammar A. Al- sady, Eanas Ittihad J., and Amer S. Abaidy found that the minimum marginal discrepancy can be produced using Direct CAD- CAM metal milling.

S Gunsoy et al conducted a similar study comparing the marginal fit discrepancy of metal crowns following different fabrication techniques namely, Conventional lost wax method (CLW), milled wax with lost- wax method (MWLW), direct laser metal sintering (DLMS), and milled Co- Cr (MCo- Cr) and found DLMS, having the lowest value followed by MCoCr, MWLW, and CLW and The values were under MWLW, MCo- Cr, and DLMS were under the 100 µm, which can be acceptable for a good marginal fit.¹ The results of this study were consistent with their results as CAD/CAM milling (milled Co-Cr disc and milled wax pattern) yielded better marginal fit than conventional hand wax pattern.

Caroline cantieri et al did invitro studies and showed that CAD/CAM systems resulted in improved marginal fit of frameworks over the conventional lost-wax casting technique for fabrication of single-unit frameworks.¹¹

The results in this invitro study revealed that the newer technology i.e, Direct CAD-CAM milling technique produced better metal crown that had acceptable margins, and surpassed the marginal and internal gap of conventionally fabricated crowns. It is the clinician's astute ability to follow the fabrication instructions and the technique which plays a major role in the final outcome.

Conclusion:-

In this study, comparisons were drawn between of Co-Cr crown fabricated by conventional (lost wax technique) and CAD-CAM techniques for the following features:

1. Marginal Fit
2. Internal Gap
3. Changes in marginal gap, followed by porcelain firing.

Hence, it was concluded that for all the features CAD-CAM techniques gave better results except internal gap, when compared with the conventional methods and there was a significant statistical difference between the two comparison groups and the CAD-CAM technology which gave better marginal fit for the copings and less marginal gaps were seen in the copings, following the porcelain firing.

Although CAD/CAM technology has already changed dentistry, it needs some improvement in scanning procedure, data processing, manufacturing techniques and material processing to be a competitive alternative for conventional method of fabrications.

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