"Assessment of occlusal force distribution using T-scan pre-operative and post-cementation of full metal crowns fabricated by conventional and direct metal laser sintered (DMLS) technique- A split-mouth randomized clinical study"

BY

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LIST OF ABBREVIATIONS USED IN THE STUDY

ABBREVATIONS	FULL FORMS
DMLS	Direct metal laser sintering
3D	Three dimension
GIC	Glass ionomer cement
PFM	Porcelain fused to metal
T-SCAN	TekScan III
MIP	Maximal intercuspal position
RCT	Root canal treatment
Co-Cr	Cobalt chromium alloy
sec	Second
min	Minute
STL	Stereolithography
%	Percentage
µm	Micron
mm	Millimeter
S.D.	Standard Deviation

ABSTRACT

STATEMENT OF PROBLEM

A healthy and functional masticatory system depends on the physiological repair of occlusion. Surfaces of contact between occluding teeth dictate the area accessible to shearing food with each chewing cycle, and a variety of parameters, including bite force, occlusal contact area, and the number of functioning teeth, may affect masticatory efficiency. The distribution of occlusal forces may differ in individuals who have had prosthetic rehabilitation using crowns and bridges. To safeguard the stomatognathic system, these forces must be assessed and removed in order to produce a harmonic occlusal force distribution.

To demonstrate that both DMLS and traditionally produced crowns are clinically acceptable, comparative investigations on their accuracy and precision have been conducted. Shimstock foils and articulating sheets are utilised to document occlusal differences. But only qualitative evaluation is possible. By transforming qualitative data into quantitative characteristics and digitally presenting them, the T-SCAN system accurately captures and evaluates the period of time sequence and force magnitude of the occlusal interactions in order to quantify the occlusal forces.

Hence, the present study is undertaken to assess the occlusal force distribution by using T- scan pre-operative and post-cementation of metal crown fabricated by conventional and DMLS techniques - A split-mouth randomized clinical study.

AIM

Assessment of occlusal force distribution using T-scan pre-operative and post-cementation of full metal crowns fabricated by conventional and DMLS techniques.

MATERIALS AND METHODS

A total of 15 patients were considered according to inclusion criteria. Diagnostic evaluation and impression were recorded. Pre-operative T-SCAN was recorded. Teeth preparation was done by the same operator according to standard protocol and temporary crowns were cemented on the prepared bilateral endo-treated molars. On one side of the jaw, conventional metal crown was fabricated by lost salt technique and on the other side metal crown was fabricated by direct metal laser sintered (DMLS) technique. Both the crowns were fabricated by same technician. Individual crowns were temporarily cemented on the molars and T-SCAN was recorded to get comparative results for each crown. After removal of the premature contacts, both the crowns were permanently cemented on both molars and then the final T-SCAN was recorded. The resultant data were tabulated and then subjected to statistical analysis to draw conclusion from experimental data. ($p<0.05$)

RESULTS

The mean occlusal force distribution was 44.62 % (9.53) at pre-treatment and was increased at post cementation for conventional crown (fabricated by lost wax technique) and DMLS crown; 57.98 % (12.31) and 54.84 % (5.06) respectively. The occlusal force distribution at Post cementation of both crowns before correction was 46.26% (17.47) and Post cementation of both crowns after correction was 50.70%

CONCLUSION

Within the constraints of this study, it was observed that although both crowns showed clinically acceptable results, DMLS crown has proved to be better in uniformly re-distributing occlusal forces on all teeth as compared to metal crowns fabricated by conventional technique.

KEYWORDS: Metal crown; DMLS crown; T-scan; split-mouth study.

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INTRODUCTION

The human stomatognathic system consist of teeth, periodontal ligament, muscles of mastication and temporomandibular joint.[1] All of these structures need to function in harmony with each other in order to achieve functional and comfortable mastication.[1]

Occlusion is the contact of mandibular teeth with the maxillary teeth. The masticatory efficacy of an individual is highly dependent on the occlusion.[2] The total available area of occlusion, masticatory loads and the occlusal force distribution over an individual tooth and all teeth collectively are the factors that determine the functional occlusion.[3] Therefore, restoration of this occlusion becomes of utmost significance.

Frequently, patients report to the clinic with grossly decayed teeth, usually molars.[4] Restorations of these severely destructed teeth is important in order to re-establish the occlusion without which the occlusal force distribution will not be uniform and excess forces would be put on the adjacent teeth. Therefore, root canal therapy being the treatment of choice for severely decayed teeth, is necessary.[5] It is possible to maintain the space as well as preserve the natural tooth in the alveolar socket to maintain both occlusion as well as the underlying alveolar bone.

There have been many studies which either support the concept of rehabilitating the root canal treated tooth with a prosthetic crown or have concluded of maintaining the tooth with post-operative restoration without a prosthetic crown.[6,7] However, many of those studies have concluded in the favour of prosthetically rehabilitating the root canal treated tooth owing to the fact that the tooth becomes brittle and is more prone to fracture when loaded under masticatory forces.[8]

Various kinds of crowns are available depending on the type of material by which they are fabricated, the technique of fabrication, tensile strength, amount of shear stresses that can be loaded, aesthetics, etc.[9] Depending on the indications, contra-indications, advantages and disadvantages, the material and the prosthetic crown is chosen for a particular tooth. Based on material of fabrication, dental crowns could be of cobalt-chromium alloy, porcelain-fused to metal, zirconia, ceramic reinforced or polyether ether ketone (PEEK).[9,10] Based on the technique of fabrication of metal crowns, they could be either prepared with conventional lost salt technique or could be digitally milled by additive or subtractive methods. Many studies have been conducted to compare various types of dental crowns and how they perform under tensile or shear loads.[11,12] All these dental crowns have been clinically accepted and hence, the decision to choose amongst them is dependent on the clinician and the patient.

Metal crowns have been the material of choice when rehabilitation of posterior teeth is concerned owing to their durability, strength, cost efficacy as aesthetics is not the primary necessity when rehabilitating posterior teeth.[13] These crowns can be fabricated either by conventional lost wax technique or by digital i.e. direct metal laser sintering technique. Dental crowns fabricated by both these techniques have been clinically accepted and are being used in daily dental practice.[14] There are studies which are being conducted to analyse and compare digital techniques with conventional techniques in dentistry based on the functionality, aesthetics, and therefore the preference of patients as well as dentists.

The key role of dental crown irrespective of material or fabrication technique is the ability to withstand masticatory forces and to provide a uniform distribution of occlusal forces on all teeth.[15] If the dental crown is in supra-occlusion or infra-occlusion, then more occlusal forces will be loaded on the prosthetic tooth or the adjacent teeth. Therefore, to confirm the occlusion or the interferences on any prosthesis, various materials like articulating papers, Shimstock foil, bite wax are available.[16,17] These materials have been used conventionally which only demarcate the premature interferences qualitatively but are unable to quantify as to how much of the excess force is being loaded on the prosthesis.[18]

To compensate for this insufficiency, a digital technology named Tekscan (T-scan) is being utilized which not only demarcates the point of premature interference but also quantitatively depicts the excess amount of force being loaded on the prosthesis in form of percentage.[19] Due, to this quantification of occlusal force distribution, a general idea about how uniform or not the occlusal forces are being distributed on all teeth collectively is determined and successively required corrections are made on the prosthesis to achieve harmony in the stomatognathic system.[20,21]

Comparative studies have been done to evaluate occlusal discrepancy by conventional methods but literatures on T-scan are sparse. Hence, the present study was undertaken to assess the occlusal force distribution by using T- scan pre-operative and post-cementation of metal crown fabricated by conventional and DMLS techniques - A split-mouth randomized clinical study.

NEED FOR STUDY

The teeth, periodontal structures, masticatory musculature and temporomandibular joint (TMJ) constitute the masticatory complex. Restoring the occlusion physiologically is essential for an appropriate and functioning masticatory system.[5]

The relationship among the masticatory apparatus and maximal bite force—a measure of the health of the stomatognathic system—has been well-established in the literature.[6] The area accessible for shearing food during each chewing cycle is determined by the areas in contact between occluding teeth, and masticatory efficiency may be impacted by a number of factors such as biting power, occlusal contacting area, and the number of teeth in use. Occlusal force distribution may vary among patients who have undergone crown and bridge prosthetic rehabilitation.[11]

Individuals who underwent prosthetic rehabilitation with crowns and bridges may have a different distribution of occlusal stresses.[13]. Understanding masticatory mechanics, muscle activation during mastication, and the influence of physiological factors during masticatory performance is made easier with the evaluation of bite force. In order to create an ideal occlusal force distribution and protect the stomatognathic framework, these forces must be eliminated.[18,19]

The prosthesis made by using the conventional (lost wax technique) or DMLS technology are both clinically satisfactory. Studies comparing the accuracy and precision of metal crowns fabricated by conventional technique and DMLS crowns have been conducted. According to the research, there is a varied occlusal mismatch between 0.4 and 2.8 mm whether posterior dental crowns are made using the conventional lost wax method or by DMLS technology.[20,21]

To attain appropriate occlusal harmony, early occlusal discrepancies must be assessed and addressed prior to the cementation of crowns or bridges.[24] Numerous symptoms, including localised tooth discomfort, excessive wear, and altered chewing stroke patterns, may appear if these occlusal interferences are not removed during the clinical occlusal adjustment.[25] Shimstock foils and articulating sheets are utilised in clinical settings to document occlusal differences. However, while executing occlusal modifications, articulating paper marking cannot be considered the sole criterion. There are several biting forces recording systems on the market, with the T-Scan being the most sophisticated.[27]

The T-SCAN technology precisely records and assesses the force magnitude and time sequence of occlusal encounters by converting qualitative information into quantitative metrics and digitally presents them. This method can be used to correct multiple discrepancies in each dentition segment.[30]

Multiple analyses have been carried out to evaluate occlusal disparity using conventional methods, despite the paucity of information on T-scans. Thus, the purpose of this split-mouth randomised clinical study is to assess the distribution of occlusal forces using T-scan both before and after cementation of metal crowns manufactured with conventional (lost wax process) and DMLS techniques.

HYPOTHESIS

NULL HYPOTHESIS: There is no difference in the occlusal force distribution using T-scan pre-operative and post-cementation of full metal crowns fabricated by conventional and DMLS techniques.

ALTERNATIVE HYPOTHESIS: There is a difference in the occlusal force distribution using T-scan pre-operative and post-cementation of full metal crowns fabricated by conventional and DMLS techniques.

AIMS AND OBJECTIVE

AIM OF THE STUDY:

- Assessment of occlusal force distribution using T-scan pre-operative and post-cementation of full metal crowns fabricated by conventional and DMLS techniques.

OBECTIVES:

- To evaluate the occlusal force distribution by using T-scan pre-operative and post-cementation of full metal crowns fabricated by conventional technique.
- To assess the occlusal force distribution by using T-scan pre-operative and post-cementation of crowns fabricated by DMLS technique.
- To evaluate and compare the occlusal force distribution by using T-scan pre-operative and post-cementation of crowns fabricated by conventional and DMLS techniques.

REVIEW OF LITERATURE

1. An experiment by Carossa et al. (2000) examined the effects of recording strip thickness and operator-dependent factors on the assessment of the area of contact on a cast positioned on an articulator. Paper size operator knowledge, biting power, and time had a significant impact on the assessment of occlusal contact in a dental office, whereas these factors had less of an effect on the 40-μm strip. Using the 8-μm strip, the breadth of contact indicators in operators showed a substantial correlation with biting time rather than occlusion force.
2. Robert B. Kerstein conducted a research in 2001 to evaluate the utilisation of computer-analyzed and supervised occlusal changes to produce contralateral simultaneous occlusal contacts that could be measured. They came to the conclusion that by employing automated occlusal observation of a mandibular closure to guide the occlusal alterations of the contact sequence, the formation of true and measurable contralateral simultaneous occlusal contacts has become a clinical reality. The program's real-time recording and point of force trajectory features may split 0.01-second time increments to identify which tooth contacts are prolonging the closing contact series and impeding the establishment of true bilateral contact time. Adopting occlusal modifications that remove these early and prolonged occlusal interactions significantly improves the operator's ability to produce real and measurable simultaneous occlusal contacts.
3. In their 2005 study, Keng Chng Hui et al. discussed the importance of the final tooth restoration in maintaining the tooth's structural integrity and providing a durable coronal seal. Coronal microleakage may follow a root canal re-

infection. Thus, shortly after the root canal procedure is completed, a final repair should be installed.

4. In the year 2006, Zhi-gang Hu et al. assessed the occlusal equilibrium of an average occlusion at the intercuspal location using the maximal biting force. Occlusal harmony during normal occlusion was statistically analysed using centre of pressure, biting pressure percentage, and occlusal contacts. According to the study, occlusal balance may be evaluated using the T-Scan II technology. Normal individuals biting with maximal force were obstructively balanced on both sides in the intercuspal position.
5. Cláudio Wilson et al. (2006) evaluated two approaches for capturing the occlusal contacts in sustained maximum intercuspation obtained in models placed in the oral cavity as well as a semi-adjustable articulator. They did this by using an eight-micrometer carbon paper and detectors (T-Scan II). The results of the study showed that the T-Scan technology allowed for the identification of the number, sequence, and exact instant at which they occur, but it was not able to identify the exact location of the contact points on the teeth's occlusal surface. It was discovered that the width of the sensor had no bearing on the reproduction of the total number of dental contacts, and the overall total of occlusal interactions obtained in the oral cavity utilising both procedures was greater than the number obtained in the articulator, contrary to the carbon paper.
6. Muhammad N. Saad et al. conducted a research in 2007. The study's objective was to compare the number and size of occlusal indicator marks from various occlusal indicator material thicknesses under varied loads. They claimed that the marks from the broader occlusal indication were observed to be larger in size and to have a greater number of marks as compared to the thinner

Accufilm. However, when the load rose, the marks on both materials grew dramatically in size and number.

7. Jason P. Carey et al. conducted a study in 2007 to determine whether the imposed biting forces and the mark dimension obtained by articulating films are directly correlated. The study found no significant linear relationship between the articulating paper mark dimension and the applied load, which was caused by the significant heterogeneity of the mark area between different teeth and contacts that was observed at every test load. Additionally, mark regions of comparable sizes did not represent equivalent applied occlusal loads. The study's conclusions suggest that the real load content within the occlusal contact may not have been accurately estimated by the dimension of an articulating paper mark.
8. Despite the fact that the pressure-sensitive films in this kind of instrument do not produce any intraoral interaction markings, it would ultimately be great to integrate this advance in technology with marking foils. Koos B et al. (2010) examined that in reality, occlusion evaluation is restricted to using color-marking films to indicate it. In the regular clinical circumstances, the standard approaches are unable convey an accurate evaluation that represents the spread of forces within the occlusion and incorporates time resolution. This study concluded that the assessment technique is superior to the standard approaches, particularly when it pertains to force assessment per tooth.
9. In the year 2012, Sarah Qadeer et al. carried out a study to see whether there was a relationship between the dimensions of the paper marks and the amount of force applied to the same tooth. The results of the study indicate that when selecting tooth contacts for occlusal adjustment treatment, the dimension of the articulation sheet marking does not constitute a valid criterion to utilise. If

an operator thinks the largest paper mark implies the strongest contact, they almost always choose the wrong tooth to change. However, more comprehensive and fact-based results may be obtained if the selection of dental contacts for occlusal adjustments treatment is guided by a quantitative in nature, non-subjective occlusal indicator, such as computerised occlusal analysis.

10. Pyakurel U et al. used a number of methods to study appropriate occlusion in 2013. Despite the difficulty in determining the correct occlusion, T-Scan has gained popularity in dental care and is believed to be capable of repairing the occlusion. For recording the occlusion pattern, the T-Scan is a useful occlusal mapping technique, even if some studies have raised concerns about its accuracy and reproducibility. These problems are said to be resolved in future studies by persistent T-Scan I till T-Scan III.
11. In 2013, K Vijay Venkatesh et al. wrote a paper on metal crowns that were 3D printed. He claims that although laser sintering is a relatively new technique, manufacturers assert that it is simple to use, offers accurate restorations, simplifies post-processing procedures, has superior electromechanical qualities, is porosity-free in contrast to conventional castings, and is easy to carry out. However, if the outcomes are promising, further investigation into the characteristics and fit of fixed dental prostheses and laser-sintered crowns might lead to their widespread clinical use. Rapid advancements in digitalised processes will make this computerised technology more affordable going forward, and further research will make it more competitive.

12. According to a 2013 in-vitro study by Eswaran Bhaskaran et al., copings made with the DMLS technique had the smallest marginal gap when compared to cast copings made with 3D-generated resin templates and inlay casting wax. Additionally, the interior fits of the copings made using the DMLS method and the inlay casting wax pattern were both within clinically acceptable bounds; however, the internal fit of the copings made with the 3D printed resin pattern was worse. Although technique-sensitive operations are entirely eliminated by the DMLS methodology in comparison to traditional casting techniques, both approaches have produced outcomes that fall within a clinically acceptable threshold.
13. According to a 2013 paper by K. Vijay Venkatesh et al., laser sintering is the most recent development in metalworking technology. DMLS is a method of production that employs 3D CAD data to generate complex 3D components without the need for machining. The CAD program and the computer have a common data interface in the form of STL files. In an STL file, triangular facets are employed to approximate the shape of a component. Smaller facets result in higher-quality surfaces. The DMLS procedure is carried out in two different ways: powder layering and the use of the powder bed technique. Manufacturers claim that the relatively new technique of laser sintering is easy to use, produces accurate restorations, expedites post-processing procedures, is porosity-free in contrast to conventional castings, and has superior electromechanical qualities. The rapid advancement of this computerised approach will make it more cost-effective.
14. Understanding the outcomes of root canal treatment (RCT) is essential for bolstering professional judgement, especially when contrasting RCT with the extraction of natural dentition or prosthetic replacement, according to Carlos

Estrela et al. (2014). The RCT's criteria for success, consisting of painlessness, AP regression, a snug seal of the canal and coronal areas and restoring of dental function, must be evaluated on a regular basis. The longevity of an endodontically treated tooth depends on understanding the biological and structural effects of complex procedures that take place throughout each phase of a person's life. The longevity of a tooth that has undergone endodontic treatment necessitates considering the biological and mechanical effects as a whole process that takes place over a person's lifetime.

15. The objectives of the 2015 study by Eneko Solaberrieta et al. were to validate a virtual method to identify the mandibular cast into a multidimensional geographic area and to confirm the occlusal sites of contact with the matching maxillary cast on the digital articulator. In this study, three modern reverse engineering software programs were used to evaluate the key components of the digitised occlusal record. The findings indicate a mean standard variation of 0.011 mm across all occlusal surface locations and a mean divergence of 0.069 mm compared to the actual electronic occlusion technique. The primary findings of the study demonstrated that compared to the conventional physical interocclusal record, a virtual occlusion process offers a higher degree of accuracy.
16. In 2016, Tanya P. Bozhkova et al. evaluated the computerised display and assessment of occlusal contact forces using the T-SCAN III system. According to the study, the device may use a digital display to detect the occlusal pressures and contact sites while a person is chewing on an occlusion film. The T-SCAN technology is the sole reliable method for figuring out and assessing the pressure and time sequence of dental contacts through the

conversion of qualitative data through quantitative information and their digital presentation.

17. According to Rebecca L. Slayton et al. (2016), operational nonsurgical treatment for dental decay, which includes disease prevention and interventions in its initial phases, requires early evaluation for identifying people susceptible to beforehand visual signs of disease occurrence (dental decay) and person-and/or family-centered education regarding the worth of oral health and its connection to overall health. Management techniques that successfully stop the advancement of caries and allow the caries lesion to remineralise are beneficial in order to preserve tooth structure and prevent the need for future surgical procedures.
18. According to Khushbu Yadav et al.'s study in 2015, the varied microbial population of caries contains a variety of facultatively and obligately anaerobic bacteria, with S. mutans being the most frequently linked species. Dental caries in humans can present in a variety of ways, including tooth discomfort, infection, or malfunction of the stomatognathic system. In severe cases, both Ludwig angina and cavernous sinus thrombosis are fatal. As a consequence, dental problems require treatment, which is usually costly and out of reach for all communities due to a lack of time, money, and human resources. Therefore, preventive care is less expensive. Root canal therapy or restoration is recommended for teeth that have dental caries, and dietary changes and personal hygiene practices must be recommended.
19. The main advantage of DMLS or selective laser sintering (SLS) is that it produces objects without the internal defects as well as residual stresses that can affect normally fabricated metal/ceramic components. Cheng Zhu et al. conducted a study in 2017 to analyse the properties of metal prostheses

manufactured by digital technique. DMLS, also referred to as selective laser sintering (SLS), is a method that has been broadened to sinter other ceramic and polymer powders and subsequently builds up a three-dimensional element through a series of extremely fine layers, including porous metal components. According to the investigation, the microstructure, durability, and fatigue strength of the printed part are significantly impacted by the operating conditions and post-processing techniques, like heat and treatment of the surface, which ultimately lead to part failure because of voids and spaces as well as satellite objects.

20. It is debatable if occlusion serves a part in the cause of temporomandibular dysfunction (TMD), which is often treated at a very empirical level and can sometimes elicit significant emotions, according to Frank E. Cordray et al. (2017). Successful outcomes following occlusal therapy support the belief held by several dentists that occlusal differences are an important etiologic role in TMD. during the past few decades, there has been a push in dentistry to minimise the significance of occlusion in TMD and to reduce the emphasis on occlusion studies in dental education.
21. The greatest intercuspation, first contact, centre of force, and maximal biting force are all recorded by the T-Scan system. The teeth, periodontal ligaments, masticatory muscles, and TMJ comprise the masticatory system. For the masticatory system to remain healthy and effective, occlusion must be physiologically repaired. A person's dental occlusion is influenced by a number of factors, including the length of the dental arch, the shape and order of craniofacial development, the dimensions, shapes, and areas of the teeth, the order and timing of eruption, the size of the teeth, and the size of the dental arch. The importance of attaining proper physiological occlusion after

osteotomy for the intricate operation of the stomatognathic apparatus was examined by Jimoh Olubanwo Agbaje and associates in 2017. The T-Scan digital occlusion analysis device records and analyses tooth contact, force, and timings in actual time using a small, flexible, pressure-sensitive bite transducer that is positioned inside a recording sensor shaped like a dental arch. The occlusal data from the T-Scan may be evaluated visually in two or three dimensions or dynamically as a dynamic movie. The occlusal data may be used to determine the occlusal force variation, the occlusal disturbances, and the relative force for every interference.

22. Sonia K. Makhija et al. conducted an investigation in 2017 to evaluate the material recommendations made by dentists and test the theory that these recommendations are closely related to the characteristics of dental professionals and their clinical practices. These materials comprised entire metal, porcelain-fused-to-metal (PFM), multilayer zirconia, lithium disilicate, leucite-reinforced ceramic, and all-zirconia. Variables unrelated to the patient or the tooth may have an impact on crown material choices. Dentists should keep this in mind when creating an evidence-based crown material selection strategy. Despite being one of the strongest alternatives, metal crowns have a significant aesthetic drawback. Full-metal restorations are frequently regarded as the best in dentistry because of their exceptional biological compatibility and durability, as well as the possible influence of patient and clinician factors on material lifespan.

23. According to Reddy Chaithanya et al. (2018), the objective during prosthesis rehabilitation is to return occlusal contacts to their previous state. Outside of the individual's physiological limits, the stomatognathic system is subtly altered to accommodate for even minute changes in force distribution. Issues

include masticatory pain, loss of implant osseointegration, sensitivity, deteriorating periodontal health, and temporomandibular disorders (TMDs), which are caused by altered force dynamics. This highlights how important it is to precisely identify and eliminate occlusal interferences. The individual's proprioception and the clinician's interpretation of the paper marks are key factors in the conventional approach to articulating paper-driven occlusal disturbance correction. The operators' interpretations of the articulating paper marks and the patients' perceptions failed to properly restore equilibrium in the occlusal force dynamics. When these kinds of force dynamics exceed physiological limits, adverse consequences occur.

24. Lucie Zuskova et al. investigated the effects of computer-aided design/computer-aided manufacturing (CAD/CAM) processes on the overall fit of metal copings in 2019. Today, other CAD/CAM technologies are being used to build restoration types instead of the lost-wax method that Taggart first proposed in 1907. The implementation of novel and improved resources, less labour and time, greater cost effectiveness, and more consistent, high quality are some benefits of employing digital technology. It might be argued that there was minimal difference in the overall fit between DMLS copings and traditional metal crowns. Actually, both production procedures have produced outcomes that are quite well-fitting and consistent overall. Therefore, it would be highly recommended that any of the procedures under research be used in dental practice, depending on individual preferences
25. To determine how the T-Scan III system, clinician interpretation, and patient feedback connected to biting pressure at maximal intercuspal position (MIP) was the main objective of a 2019 study by Nitikarn Ruttitivapanich et al. The study discovered that, in contrast to the patient's assessment of occlusal stress

in MIP, the clinician's subjective interpretation was more precise in T-Scan III and, therefore, more clinically trustworthy. As a computerised occlusal evaluation intended for quantitative clinical use, T-Scan is regarded as the gold standard. Additionally, information derived only from the patient's perspective should be used with caution, especially in cases involving irreversible dental treatments.

26. To find occlusal contacts, Min-Young Jeong et al. conducted a research in 2020 that evaluated two computer occlusal analysis methods. They came to the conclusion that, unlike the conventional occlusal indicator, the electronic occlusal analysis method could explain both the static occlusion as well as the variation in occlusal force over time. When it comes to recognising occlusal contacts during maximal intercuspation, the T-scan approach and Accura, a contemporary computerised occlusal diagnostic technology, have comparable accuracy. Either of these digital occlusal analysis techniques, in conjunction with silicone interocclusal data and dental casts, may be useful for precise occlusal analysis in clinical settings.
27. N. Al-Nuaimi et al. conducted prospective study on the effects of coronal tooth structural degradation in 2020. According to their claims, the proportion of extractions linked to teeth that still had crown tooth structure remained nearly three times greater than that of teeth that did not. He came to the conclusion that the probability of surviving was over 94% for teeth with more than 30% of their native tooth structure and over 80% for teeth with less than 30%.
28. In 2021, Lorel E. Burns et al. conducted a systematic study and came to the conclusion that biological factors continue to have the biggest influence on RCT outcomes. Technology-based instrumentation had no discernible impact.

Research design was the primary determinant of the quality of the evidence; exclusively randomised controlled studies were deemed to have "high" grade evidence. The reported success rates show a slow improvement. By using "strict criteria," studies with a least four-year follow-up had greater weighted success rates than those with a shorter follow-up.

29. In 2021, Saranya Sreekumar et al. carried out a randomised controlled trial protocol to evaluate the effectiveness of prosthetic rehabilitation in reducing pain in edentulous patients with TMD. They also examined the effects of prosthetic status, number of affected sections, pathological movement, Kennedy classification type, and duration of edentulism on the indications and signs of temporomandibular joint dysfunction. She has concluded that there are many different factors that contribute to TMDs. Years of discussion have focused on the patient's "occlusal state." Loss of teeth or occlusal imbalance is one of the proposed dental risk factors for TMD. The type of edentulism and TMD were shown to be related in the study. The research topic was developed as a result of this researcher's prior experience and realisation that there lack many effective studies to evaluate how prosthetic rehabilitation impacts TMDs. In order to planned the study, edentulous patients were divided into many strata based on the types of edentulism.
30. In contrast with electronic occlusal indicators that can be tested, S. Qadeer evaluated the features, advantages, disadvantages, and therapeutic implications of employing static occlusal indicators during occlusal modifications in 2021. It was determined that because of the substantial amount of subjectivity inherent in their application, static occlusal markers are not adequately supported by research. However, a multitude of scientific evidence supports T-Scan's objective, accurate, and repeatable measurement methods of

comparative occlusal pressure and time. Digital occlusal indicators should be employed for objective evaluations rather than subjective interpretation using static ones in order to improve occlusal practice.

31. In 2021, Jacob Sigvardsson et al. conducted a study to assess the reliability and validity of computerised occlusal contact assessment vs more traditional methods for occlusal contact estimate. to evaluate the validity and reliability of electronic occlusal contact assessment in comparison to more conventional occlusal contact estimation techniques. The new digital tool will make using occlusion or occlusal contacts easier when it involves orthodontic strategy, choice-making, and treatment evaluation. Modern digital methods that are valid and trustworthy for measuring occlusal contacts will make studying occlusion easier and more feasible. In the long run, it will raise awareness of the significance of dental occlusion, especially in light of its links to speech, mastication, TMD, general health, and orthodontic stability.
32. In the year 2022, Cristina Fraile et al. conducted a cross-sectional study to assess the reliability of interocclusal contact data obtained using electronic devices employing intra- and extraoral electronic detection systems and the T-Scan III system, as well as conventional methods straight for participants (8-μm articulating paper). They concluded that the intraoral scanners' IOS varied significantly in terms of interocclusal distortions. In this investigation, the Trios Colour intraoral scanner yielded the best results. Clinically, the size of the occlusal contacts of restorations will be affected by the deformities observed by these writers. It may be necessary to make clinical adjustments or provide compensation during the CAD design process if the final rehabilitation is infra-occluded or supra-occluded.

33. According to Kishor Gulabivala et al.'s review study from 2022, the area of endodontics functions within a broader healthcare framework and is influenced by industrial, trend, and economic elements that might potentially impact outcomes. Root canal retreatment is mostly assessed in terms of how it varies from primary treatment because the majority of the factors influencing outcomes are same for both primary and endodontic therapy. The continuing existence of the endodontic discipline was once again endangered by new cost-economic constraints starting in the 1990s. The treatment planning procedure this time was centred on the more foreseeable choice of having to "save the tooth" or "extract and replace" it with an implant-supported crown.
34. In their narrative review published in 2022, M. Al-Ali et al. examined the treatment of teeth with significant decay. He has researched the several dental procedures available for repairing severely damaged teeth. According to him, both reversible and irreversible pulpitis should be supported by innovative pulp preservation methods. Conditions with extensive cavities should be evaluated for complete non-selective caries removal, albeit this is debatable. This will allow for pulpal management as needed, and the new materials and vital pulp therapy treatment methods should yield more consistent outcomes.
35. In 2023, Abdulhadi Warreth et al. reviewed the literature and looked into a number of treatment methods for dental caries. He has come to the conclusion that risk factor assessments and risk indicators may be used to successfully diagnose and identify caries early on. Furthermore, because they help prevent dental cavities and preserve tissue integrity, less intrusive restorative techniques must be used wherever possible. The extra expertise, resources, and information should encourage professionals to employ this tactic. Individualised care should constitute the primary focus of dental

responsibility, and the adoption of a patient-oriented therapy approach and system is crucial.

36. Research by Dr. Hareesh M.T. et al. in 2023 compared the retention of crowns manufactured with direct metal laser sintering (DMLS) and traditional casting techniques to a uniform 24-degree taper with a regulated cement spacing. The multi-stage procedure now used to manufacture cast restorations may be replaced with a superior, single-stage dental laboratory approach, even if the old casting process has improved. Advances in (CAD/CAM) have enabled a new alternative technique for making dental restorations. This dramatic shift is the result of automation introducing digital dental technology on a never-before-seen scale. Crowns created with DMLS technology showed notably better retention for this constant taper than crowns created using conventional casting methods. By maintaining the cement gap required for the effective flow of luting agents, the DMLS approach enhances retention.
37. In the year 2024, Lisa Vincent et al. conducted research on the several kinds of occlusal markers used in dentistry to determine occlusion. According to the study, the occlusal indicator should exhibit an extent of plastic deformation before any rips or distortion occur. The T-Scan system, articulating papers, foils, and silk strips were associated with varying rates of contact number decline across several applications. Occlusal contact counts were much higher in dry teeth. The choice of occlusal markers is influenced by clinical conditions, professional preference and experience, comfort, and economic factors.
38. De Souza, Maria Fernanda in the year 2024, Mauá Serapião TOLEDO et al. investigated the marking quality and thickness of several occlusal contact registration strips (OCRS) and any possible correlations between them. They

came to the conclusion that some of the factors that can lead to inappropriate occlusal contacts include bruxism, loss of vertical dimension, tooth loss, lack of tight contacts, malocclusion, occlusal interferences, substantial variations among centric relation, centric occlusion and increased tooth mobility. Stress can have a variety of detrimental effects when occlusal disharmony is associated with a physiological and operational asymmetry in the temporomandibular joints (TMJ). These include lateral occlusal loads, periodontal problems, masticatory muscle hyperfunction or poor coordination, and tooth movement and/or sensitivity.

39. Hei Chan et al. examined the longitudinal change in the dispersion of occlusal force before and after fixed replacement for molar full crowns in 2024 using T-SCAN III, a device for occlusal adjustment and prospective therapy. Three months following a fixed replacement, the patients' molar area's occlusal force distribution shifted with time, primarily indicating a rise in occlusal force. Indicating a more optimal distribution of occlusal force on both sides of the dental arch, the imbalanced occlusal force index, occlusion length, and disclusion time all tended to decrease concurrently. Clinicians may improve the calibre of occlusal examination and raise the likelihood by using the quantitative aspects of T-SCAN III to gather more accurate and objective data.
40. In their 2024 systematic review, Roberta Lekaviciute et al. investigated the relationship between occlusal pressure and the temporomandibular joint. She has come to the conclusion that different types of malocclusions have different TMJ features. The prevalence and features of TMD were also shown to be influenced by the number of tooth loss sections and the frequency of missing teeth. Furthermore, it was demonstrated that bruxism was linked to symptoms of TMD, including muscular issues, myofascial pain, arthralgia, and disc

displacement. This review of the literature goes into great detail about the relationship between malocclusion classes, bruxism, tooth loss, and TMDs. This prompts healthcare practitioners to prioritise the occlusal examination and TMJ status of their patients.

MATERIALS AND METHODOLOGY

SOURCE OF DATA:

- This split-mouth randomized clinical study was conducted in the department of Prosthodontics and Crown & Bridge,
- Precision Dental Studio, Kolhapur

METHOD OF COLLECTION OF DATA:

INCLUSION CRITERIA:

1. Subjects who are 18–54 years old.
2. Subjects who underwent bilateral posterior endodontic treatment and a post-endodontic restoration in the occlusion
3. Teeth with one walled / two walled defects
4. Opposing teeth should have sound tooth structure without any restorations

EXCLUSION CRITERIA:

1. Patients who refuse to take part in the research.
2. Patients who received post and core treatment.
3. Teeth with more than two walled defects.
4. Patients having para-functional habits like bruxism and TMDs
5. Patients having missing teeth adjacent and opposite to endodontically treated teeth.
6. Patients having peri-apical pathologies after RCT.
7. Patients having periodontally compromised teeth.

Table no. 1: List of materials used for fabrication of conventional and DMLS crowns.

Sr No.	Armamentarium	Manufacturer
1	Mouth Mirror, Probe, Explorer, Tweezer, Kidney tray, Cord packer	G.D.C, India
2	Alginate	Zhermak tropicalgin, Dentsply sirona, Germany
3	Self-cure acrylic resin	DPI-RR cold cure acrylic resin, India
4	Airotor	NSK FX Plus, Japan
5	Crown preparation bur set	MANI Inc., Japan
6	Retraction cord	Size- 00, Ultrapak Products Inc, USA
7	Haemostatic agent	Viscostat, Ultradent, USA
8	Tray adhesive	Medicept Dental Pvt Ltd, UK
9	Heavy and light body putty	Aquasil putty, Denstply Sirona, Germany Aquasil Ultra putty, Denstply Sirona, Germany
10	Die stone	Kalabhai Kalrock, Kalabhai Karson Private limited, India
11	Temporary crown and bridge material	Tempron, GC Corporation, Japan
12	PKT instrument set	Visa Stainless Steel, Germany
13	Pre-heated furnace	Miditherm, Bego, Germany
14	Induction casting machine	Fornax, Bego, Germany
15	Phosphate bond investment material	Belavest, Bego, Germany
16	Automatic mixer	Easy Mixer MX-300, Italy
17	Sandblasting unit	Duostar, Bego, Germany
18	Medit-T310 laboratory scanner	Medit Corp, South Korea
19	DMLS machine	Riton D100 DMLS 3D Printing Machine, China

Table no. 2: Armamentarium used to cement and assess the occlusal force distribution achieved by conventional metal and DMLS crowns.

Sr No.	Armamentarium	Manufacturer
1.	TekScan III	TEKSCAN, USA
2.	TekScan sensors	TEKSCAN, USA
3.	Desktop and Central processing unit	HP computer, USA
4.	Glass ionomer luting cement	Type I, VOCO Meron, Germany
5.	Freegenol temporary luting cement	Freegenol temporary pack, GC corporation, Japan)

METHODOLOGY:

A] PROCEDURE: For selection of patients for study, according to the inclusion criteria:

1. For selection of patients, routine clinical assessment followed by radiographic examination was done by paralleling technique, for all the participants. Following oral prophylaxis diagnostic impressions were recorded with alginate (Zhermak tropicalgin, Dentsply sirona, Germany).
2. The selection of patients was done according to the inclusion and exclusion criteria and patients were informed about the cementation of crowns fabricated by two different techniques and informed written consent was taken for the same in their vernacular language.
3. A single operator had performed all the clinical steps.
4. For the study, a total of 15 patients with endodontically treated bilateral maxillary/mandibular molars requiring single crown restorations were selected.
5. Diagnostic impression was recorded with alginate (Zhermak tropicalgin, Dentsply sirona, Germany) to fabricate customized perforated trays (Fig no. 1)
6. In all 15 patients, one tooth had full metal crown fabricated conventionally with lost wax technique and the other crown on contralateral side was fabricated by DMLS technique.
7. Pre-operatively, a T-scan (Teksan III, USA) was recorded for procuring baseline data before tooth preparation.

B] PREPARATION OF TEETH:

1. Standard operating procedure for tooth preparation was carried out.
2. With the aid of depth configuration bur no. 122 (Mani burs, MANI INC, Japan), depth orientation grooves were made on the tooth's occlusal, buccal, and palatal/lingual axial surfaces. Occlusal pear-shaped bur no. FG811 (Mani burs, MANI INC, Japan) was used to do the occlusal reduction.
3. Equi-gingival chamfer finish margins were provided for both restoration types for the sake of uniformity. On functional cusps, occlusal reduction will be 1.5 mm, and on non-functional cusps, it will be 1 mm.
4. Preparation of axial walls (palatal/lingual and buccal) was done using Torpedo diamond bur no. F869. (Mani burs, MANI INC, Japan)
5. Finally, the preparation was finished using finishing burs (bur no. SF201, SF101, SF265R) (Mani burs, MANI INC, Japan). (Fig no. 13)

C] IMPRESSION PROCEDURE:

1. Self-cure resin made of acrylic (DPI-RR cold cure acrylic resin, India) was used to fabricate customised perforated trays on diagnostic castings made from alginate impressions. (Fig no. 4)
2. To maintain the impression material attached to the tray, custom trays were coated with tray adhesive (Medicept, USA).
3. Gingival retraction cord (Size 00, Ultrapak Products Inc, USA) was coated with Viscostat haemostatic agent (Ultradent, USA) and placed with aid of cord packer (GDC, India) as per manufacturer's instructions for 10 minutes for adequate tissue displacement.
4. Retraction cord was removed and impression was recorded within 60 sec after removal of retraction cord.
5. Double mix two stage elastomeric impression technique was followed for impression making.
6. Impression was made by using elastomeric impression material putty consistency (Aquasil putty, Denstply Sirona, Germany) and light body consistency impression material (Aquasil ultra, Denstply Sirona, Germany) was used for recording the wash impression. (Fig no. 4)
7. Alginate (Zhermak tropicalgin, Dentsply sirona, Germany) impression was recorded for fabrication of temporary restoration (Tempron, GC International AG, Japan)
8. Temporary crowns were fabricated by indirect-direct technique and were cemented on both molars with Freegenol temporary luting cement (GC Corporation, Japan). (Fig no. 3)

D] FABRICATION OF METAL CROWNS BY CONVENTIONAL LOST WAX TECHNIQUE:

1. Impression was poured with Type IV Die Stone (Kalastone) and it was mixed as per the manufacturer instruction. Die preparation was done using Pindex system (Renfert Top Spin). Die ditching was done with round carbide bur no. 3 (Mani burs, MANI INC, Japan)
2. Die hardener (Han Dae chemical, Korea) was coated followed by die spacer (Die Master, Renfert, Germany) of 15µm thickness (gold colour) and die lubricant (Picosilk-Renfert, Germany) was painted.
3. A PKT instrument was used for the wax (BEGO, Inlay wax) build up on the labial, lingual and proximal surfaces of die.
4. Phosphate bonded investment material was used to invest, followed by casting with cobalt-chromium metal pellets (Girobong® NBS, Amann Girrbach) in the induction casting machine. (BegoFornax T-26300). (Fig no. 5)

E] FABRICATION OF METAL CROWNS BY DMLS TECHNIQUE:

1. Impression was scanned with laboratory scanner. (Medit T310) using a CAD software, the wax pattern was designed from the scanned image maintaining an internal space of 20µm and 0.5mm thickness. The data was saved as an STL file. This STL file was used to fabricate the metal crown with the help of DMLS machine (EOSINT M270, EOS Gmbh) (Fig no. 7 and 8)
2. Finishing and polishing of both crowns was done as per the manufacturers' instructions.

F] MEASUREMENT OF OCCLUSAL DISCREPANCY:

1. Occlusal discrepancy was recorded using the T-Scan (Tekscan version 10 program) gadget, that consists of a sensor that records occlusal relations, a data transfer module that is connected to a computer system, and a software application that transmits evidence to the computer and shows it on the monitor using an alternative colour coding scheme. (Fig no. 10 and 11)
2. Patient was trained to bite in centric occlusion followed by eccentric and lateral excursive movements. (Fig no. 18)
3. The sensor size was determined according to patient’s jaw size. (Fig no. 12)
4. Using the equipment to register occlusal contacts, the recording process was carried out in accordance with the manufacturer's instructions. The patient was made to sit upright on the dental chair.
5. In order to place the centre mark between the patient's maxillary central incisors, the selected recording sensor was placed between the dental arches.
6. To start the recording, the button present on the handlebar was pressed and the patient was asked to occlude with maximum intercuspation.
7. The centre mark was placed between the patient's maxillary central incisors after the selected recording sensor was placed between the dental arches.
8. The patient was asked to occlude strongly to achieve total intercuspation before the recording began by clicking a switch on the handlebar.
9. Three to five measurements of the maximum intercuspation and followed by excursive jaw movements was recorded on sensor.
10. Occlusal forces were recorded and interpreted in form of percentage during pre-operative and post-cementation of individual crowns with temporary cement. (Freegenol temporary pack, GC corporation, Japan) (Fig no. 14)

11. Recorded occlusal discrepancies found on the crowns were removed at chairside by using tungsten carbide bur no. FG-1957 (Mani INC, Japan)
12. Finishing and polishing of both metal crowns was done as per the manufacturers' instructions and bite was assessed on both sides of the jaw (Fig no. 16 and 17)
13. Both crowns were cemented with permanent GIC luting cement (Type I, Voco Meron Set & liquid, VOCO GmbH, Germany). (Fig no. 15)
14. All 30 metal crowns' occlusal force distributions were noted, assessed, and statistically examined. (Fig no. 19)

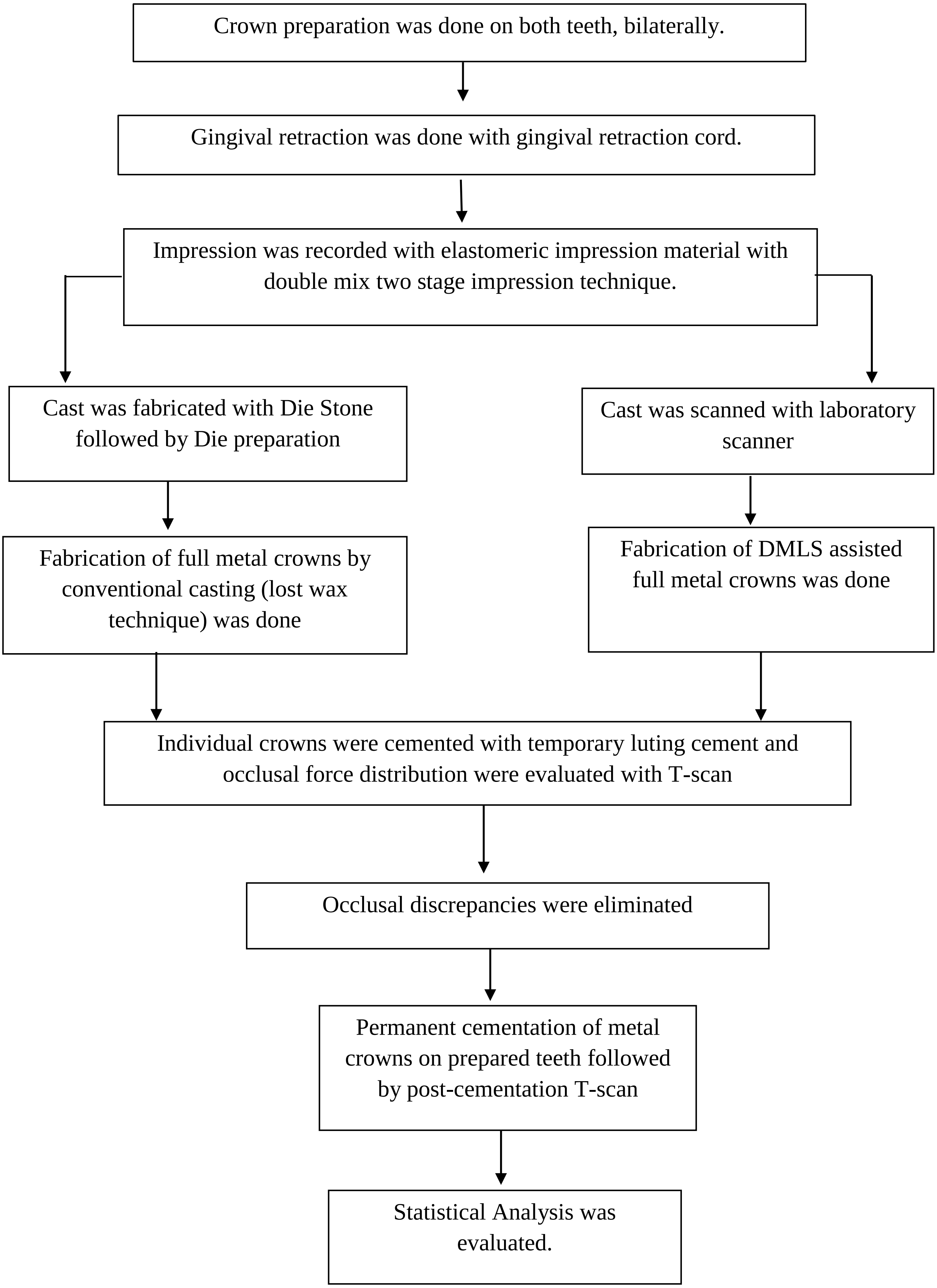

Crown preparation was done on both teeth, bilaterally.
Gingival retraction was done with gingival retraction cord.
Impression was recorded with elastomeric impression material with double mix two stage impression technique.
Cast was fabricated with Die Stone followed by Die preparation
Cast was scanned with laboratory scanner
Fabrication of full metal crowns by conventional casting (lost wax technique) was done
Fabrication of DMLS assisted full metal crowns was done
Individual crowns were cemented with temporary luting cement and occlusal force distribution were evaluated with T-scan
Occlusal discrepancies were eliminated
Permanent cementation of metal crowns on prepared teeth followed by post-cementation T-scan
Statistical Analysis was evaluated.

Fig no. 1: Armamentarium used for diagnosis, tooth preparation and mock-up

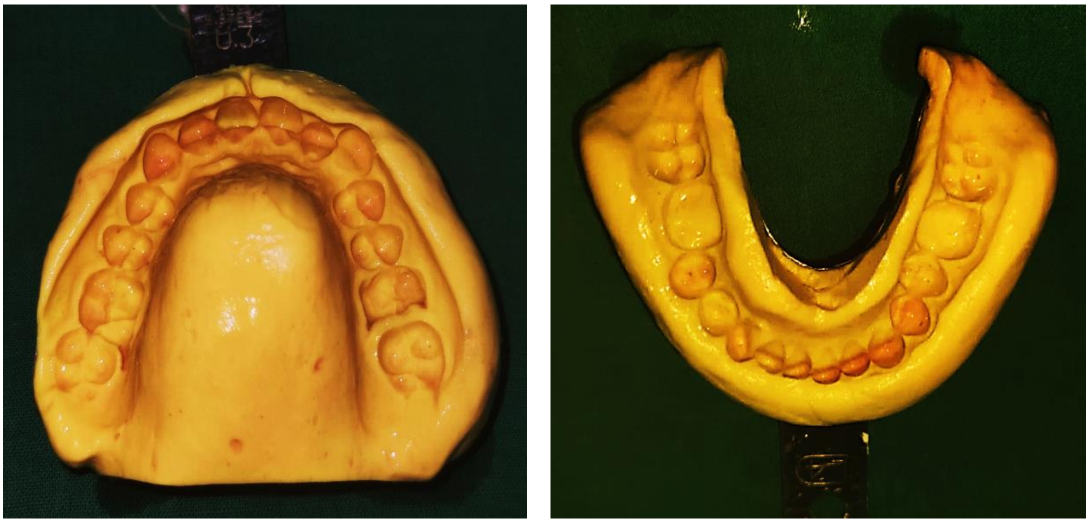


Fig no. 2: Diagnostic impression of maxillary and mandibular arches recorded with alginate

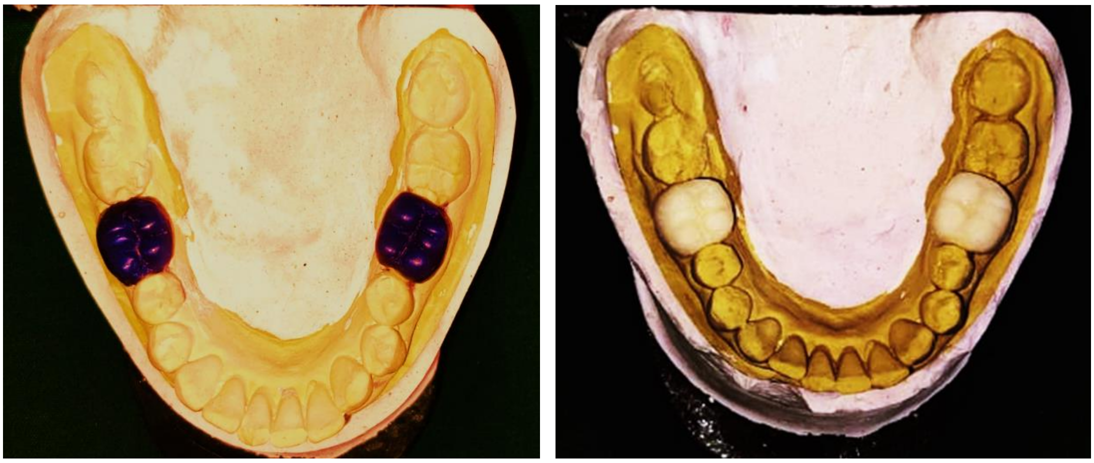


Fig no. 3: Wax mock-up and fabrication of temporary crowns

Fig no. 4: Custom tray fabrication and final impression recording with putty after tooth preparation

Fig no. 5: Armamentarium used for fabrication of conventional metal crown by lost wax technique

Fig no. 6: Bego induction casting machine

Fig no. 7: Medit T310 laboratory scanner

Fig no. 8: Riton D100 DMLS 3D printing machine

Fig no. 9: Assessment of metal crowns fabricated by both techniques.

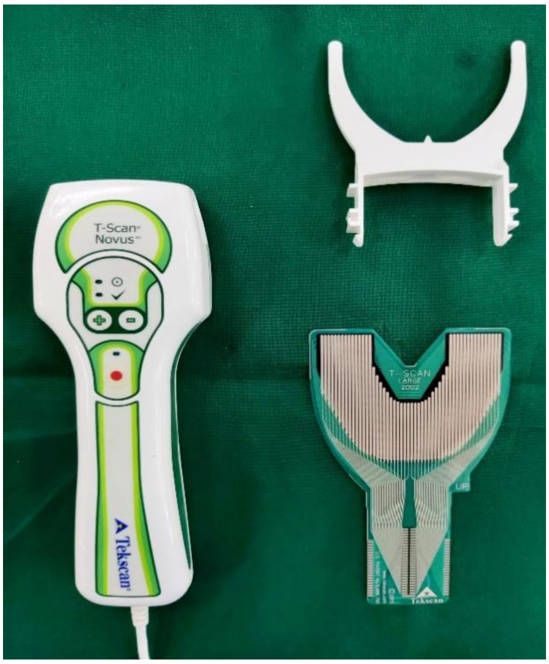


Fig no. 10: Parts of TekScan III system

Fig no. 11: TekScan III assembly with wand and sensor attached

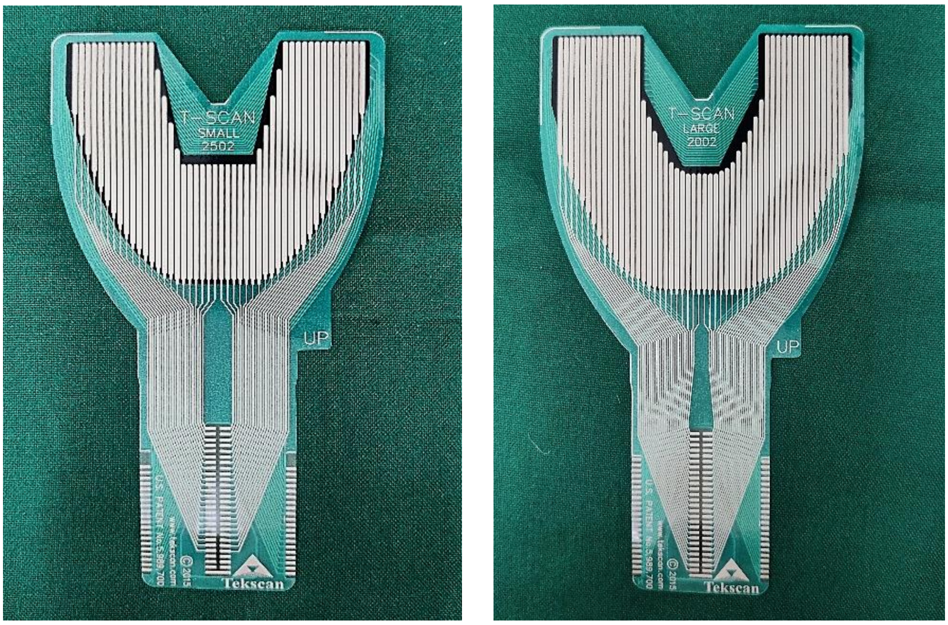


Fig no. 12: Small and large sensors of T-scan

Fig no. 13: Bilateral tooth preparation was done on endo-treated molars

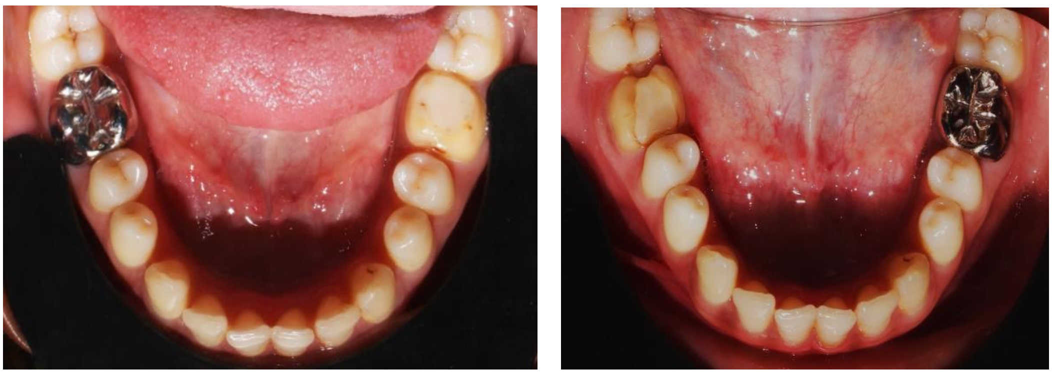


Fig no. 14: Individual crowns temporarily cemented for assessment with T-scan

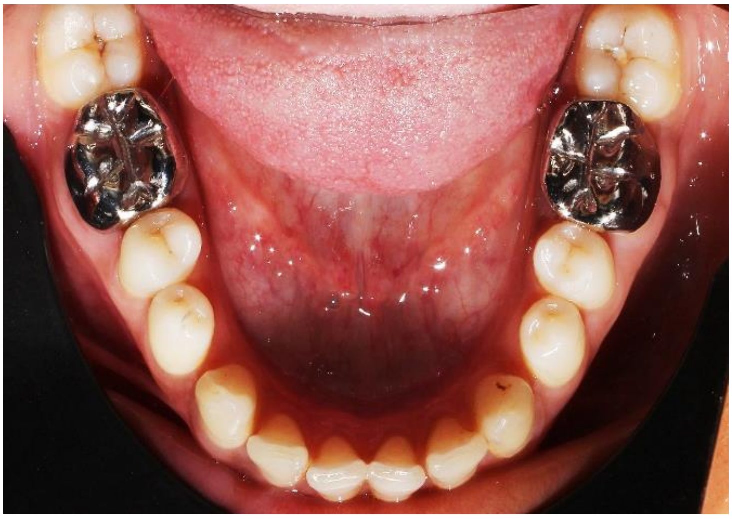


Fig no. 15: Permanent cementation done of both metal crowns

Fig no. 16: Bite assessment was done post-cementation on left side

Fig no. 17: Bite assessment was done post-cementation on right side

Fig no. 18: Recording of T-scan in patient's mouth

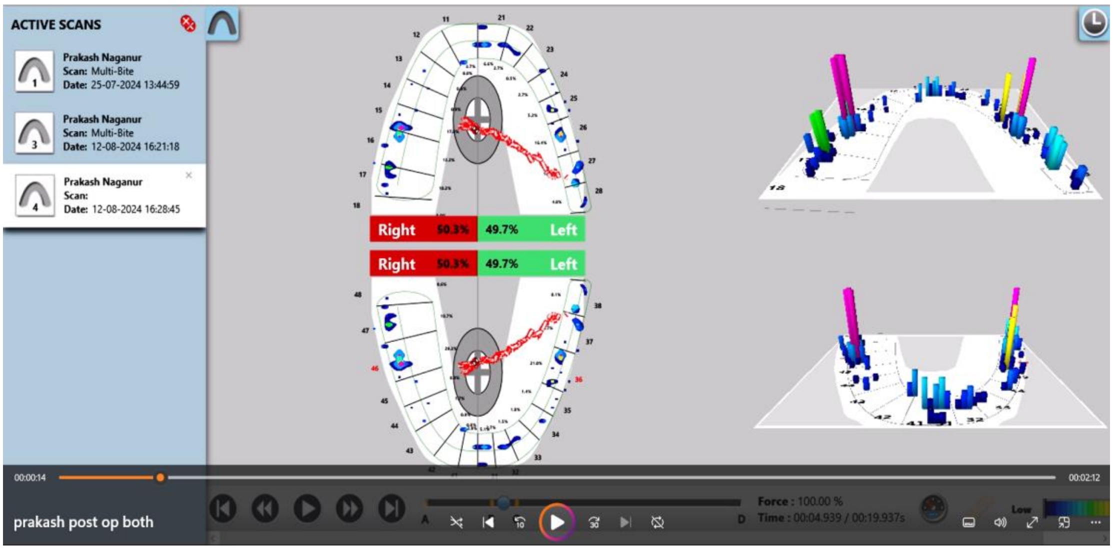


Fig no. 19: T-scan recording at display on monitor

RESULTS

The goal of the current study was to evaluate the distribution of occlusal forces utilising T-scan pre-operative and post-cementation of complete metal crowns made using the conventional (lost wax) and direct metal laser sintered (DMLS) techniques.

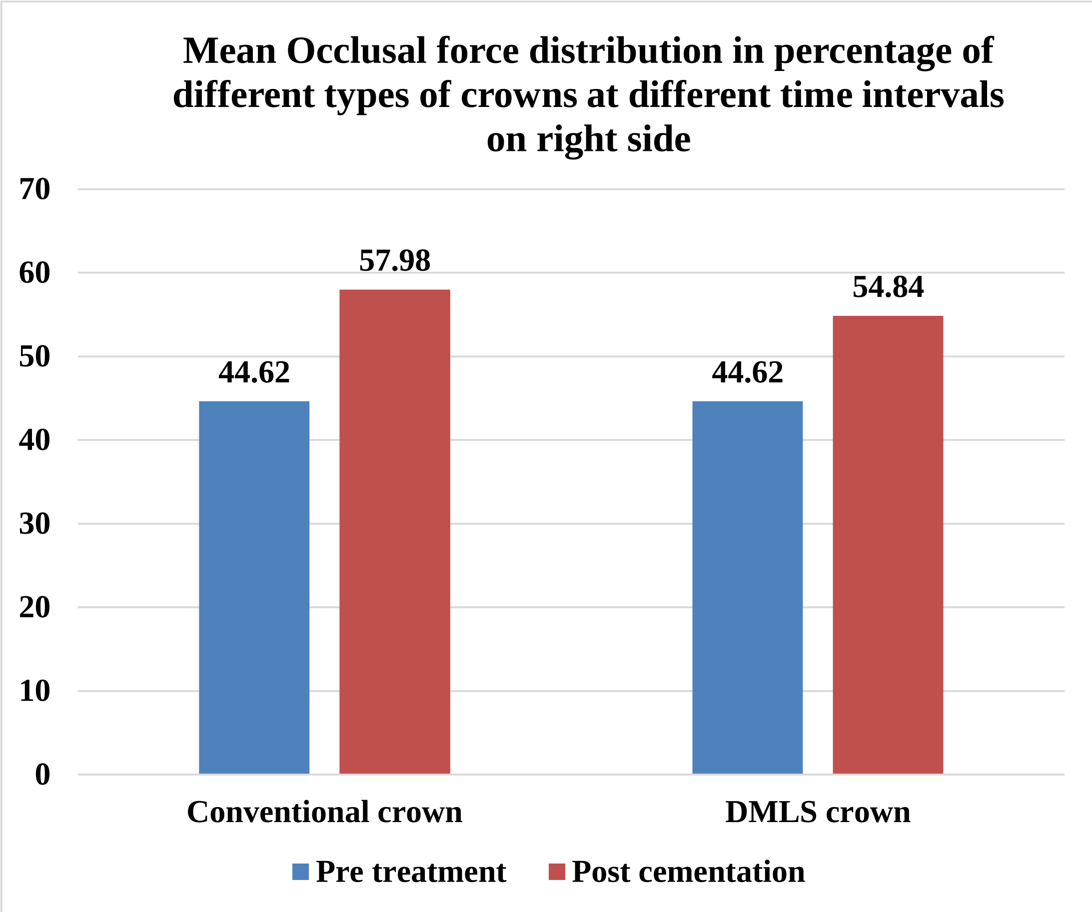
Method of statistical analysis –

- Microsoft Excel (v.2017) was implemented to enter and sort the data.
- Software from IBM Corp. called the Statistical Package for Social Sciences (SPSS) (v.26.0) was used to conduct the statistical analysis.
- The study included descriptive as well as inferential statistics for each of the different variables assessed.
- To ascertain if the data had a normal distribution, a data normality test was conducted.
- The paired t-test was used to evaluate the occlusal force spread among the two distinct crown types before and after in order to see whether there were any notable variations.
- To identify any significant differences, the occlusal force distribution among two different crown designs on the right and left sides was contrasted employing the independent samples t-test.
- 95% confidence intervals have been employed for all statistical analyses.
- In the present study, a "p" value of less than 0.05 was regarded as statistically significant.

Table no. 3 - Descriptive statistics of Occlusal force distribution in % of both types of crowns at different time intervals on right side

Parameter	N	Mean	Std. Deviation
Pre treatment	15	44.62	9.53
Post cementation of conventional crown	15	57.98	12.31
Post cementation of DMLS crown	15	54.84	5.06
Post cementation of both crowns before correction	15	46.26	17.47
Post cementation of both crowns after correction	15	50.70	1.10

Interpretation – In our study, Descriptive statistics of Occlusal force distribution in % of both types of crowns at different time intervals on right side was performed. The mean occlusal force distribution was 44.62 % (9.53) at pre-treatment and was increased at post cementation for conventional crown (fabricated by lost wax technique) and DMLS crown; 57.98 % (12.31) and 54.84 % (5.06) respectively. The occlusal force distribution at Post cementation of both crowns before correction was 46.26% (17.47) and Post cementation of both crowns after correction was 50.70% (1.10). This shows that the occlusal force distribution increased after cementation in both the crowns with a higher mean value for conventional crown as compared to DMLS crown (closer to 50%); whereas after correction for both the crown the occlusal force distribution increased as that of before correction.

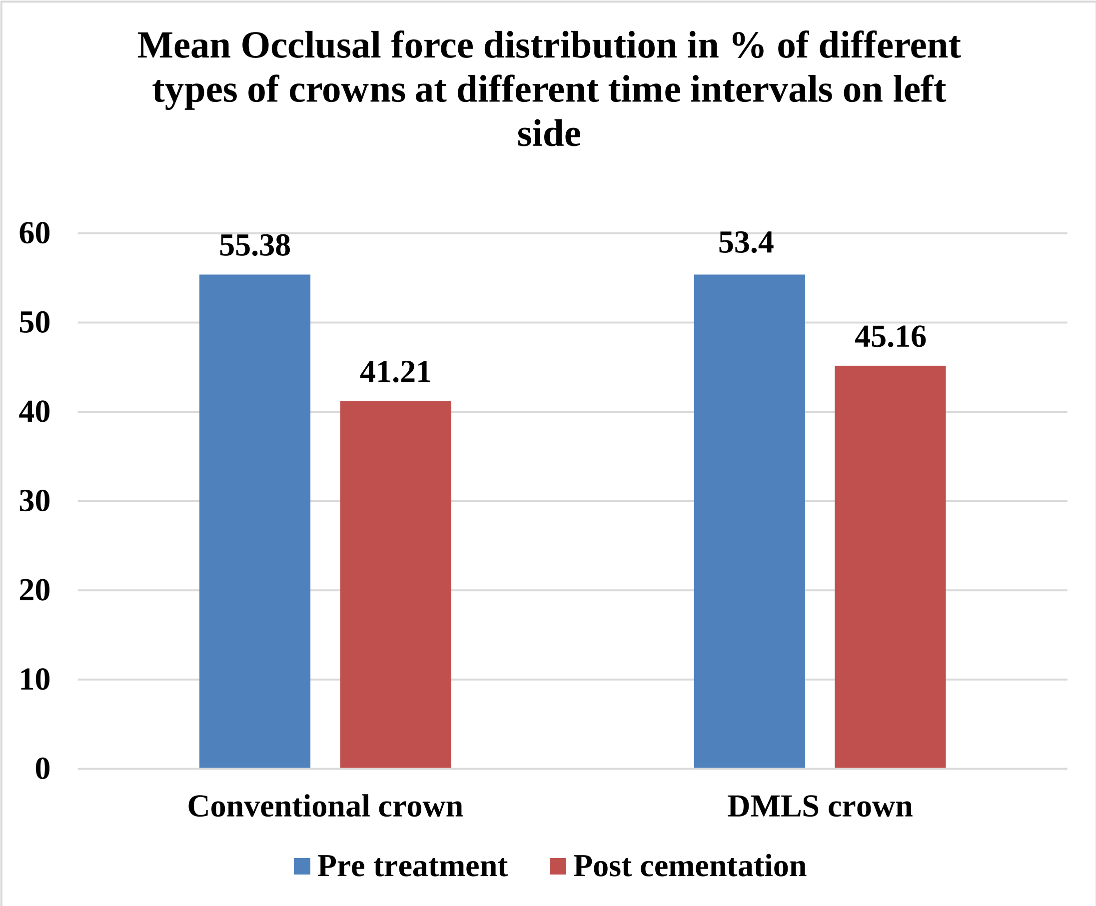


Graph no. 1: Mean Occlusal force distribution in percentage of different types of crowns at different time intervals on right side states that DMLS crown shows better uniform distribution on right side than the conventional crown as the deviation from ideal value of fifty percent is lesser in DMLS group.

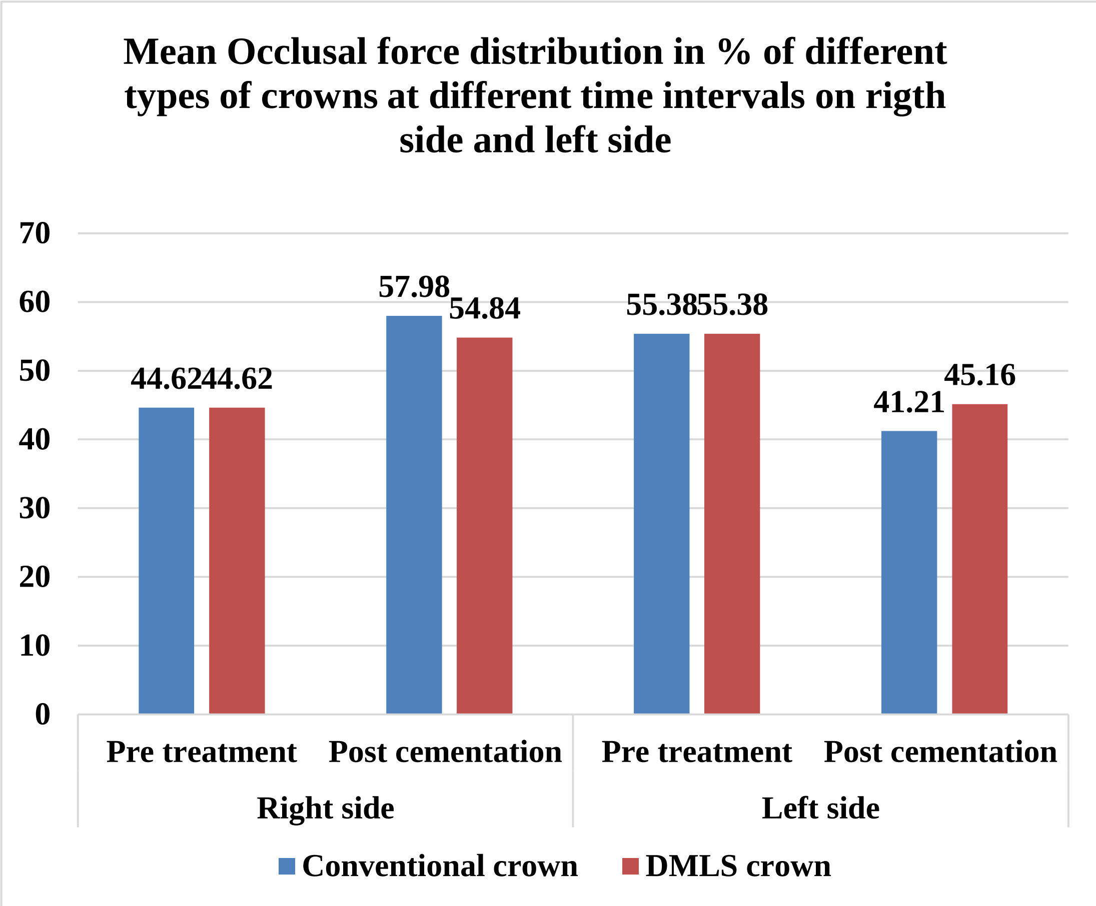
Table no. 4 - Descriptive statistics of Occlusal force distribution in % of both types of crowns at different time intervals on left side

Parameter	N	Mean	Std. Deviation
Pre treatment	15	55.38	9.53
Post cementation of conventional crown	15	41.21	4.98
Post cementation of DMLS crown	15	45.16	5.06
Post cementation of both crowns before correction	15	53.80	17.38
Post cementation of both crowns after correction	15	49.29	1.10

Interpretation – In our study, Descriptive statistics of Occlusal force distribution in % of both types of crowns at different time intervals on left side was performed. The mean occlusal force distribution was 55.38 % (9.53) at pre-treatment and was decreased at post cementation for Conventional crown (fabrication by lost wax technique) and DMLS crown; 41.21 % (4.98) and 45.16 % (5.06) respectively. The occlusal force distribution at Post cementation of both crowns before correction was 53.80% (17.38) and Post cementation of both crowns after correction was 49.29% (1.10). This shows that the occlusal force distribution decreased after cementation in both the crowns with a higher mean value for DMLS crown (closer to 50%) as compared to conventional crown; whereas after correction for both the crown the occlusal force distribution decreased as that of before correction.



Graph no. 2: Mean Occlusal force distribution in percentage of different types of crowns at different time intervals on left side states that DMLS crown shows better uniform distribution on left side than the conventional crown as the deviation from ideal value of fifty percent is lesser in DMLS group.



Graph no. 3 Interpretation: When the values of conventional and DMLS crowns are compared on right and left side it was observed that there is higher deviation from ideal value of fifty in conventional crown i.e. 57.98% and 41.21% on right and left sides respectively. Whereas the values of DMLS crown are closer to the value of fifty i.e. 54.84% and 45.16% on right and left sides respectively. This depicts that higher premature contacts are observed on conventional crowns as compared to DMLS crowns.

Table no. 5 – Pre and post comparison of Occlusal force distribution in % of both types of crowns at different time intervals on right side

Pre and post comparison	Mean difference	t-value	df	p-value
Pretreatment vs Post cementation of conventional crown	-13.3601	-.954	14	.356
Pretreatment vs Post cementation of DMLS crown	-10.22000	-4.334	14	.001*
Pretreatment vs Post cementation of both crowns before correction	-1.64000	-.354	14	.729
Pretreatment vs Post cementation of both crowns after correction	-6.08667	-2.473	14	.027*

*p value <0.05 denotes statistically significant, <0.001 implies high significance, and <0.001 suggests high significance.

Interpretation – In the present research, Pre and post assessment of Occlusal force distribution in percentage of each type of crowns at different intervals of time on right side was done using paired T-test. Pretreatment and post-cementation of the DMLS crown and pretreatment and post-cementation of both crowns after corrections were shown to vary statistically significantly ('p' value <0.05).

Table no. 6 –Comparison of Occlusal force distribution in % of before and after correction of both the crowns on right side

Comparison of Before and after correction	Mean difference	t-value	df	p-value
Post cementation of both crowns before correction vs Post cementation of both crowns after correction	-4.44667	-.956	14	.355

*p value <0.05 denotes statistically significant, <0.001 implies high significance, and <0.001 suggests high significance.

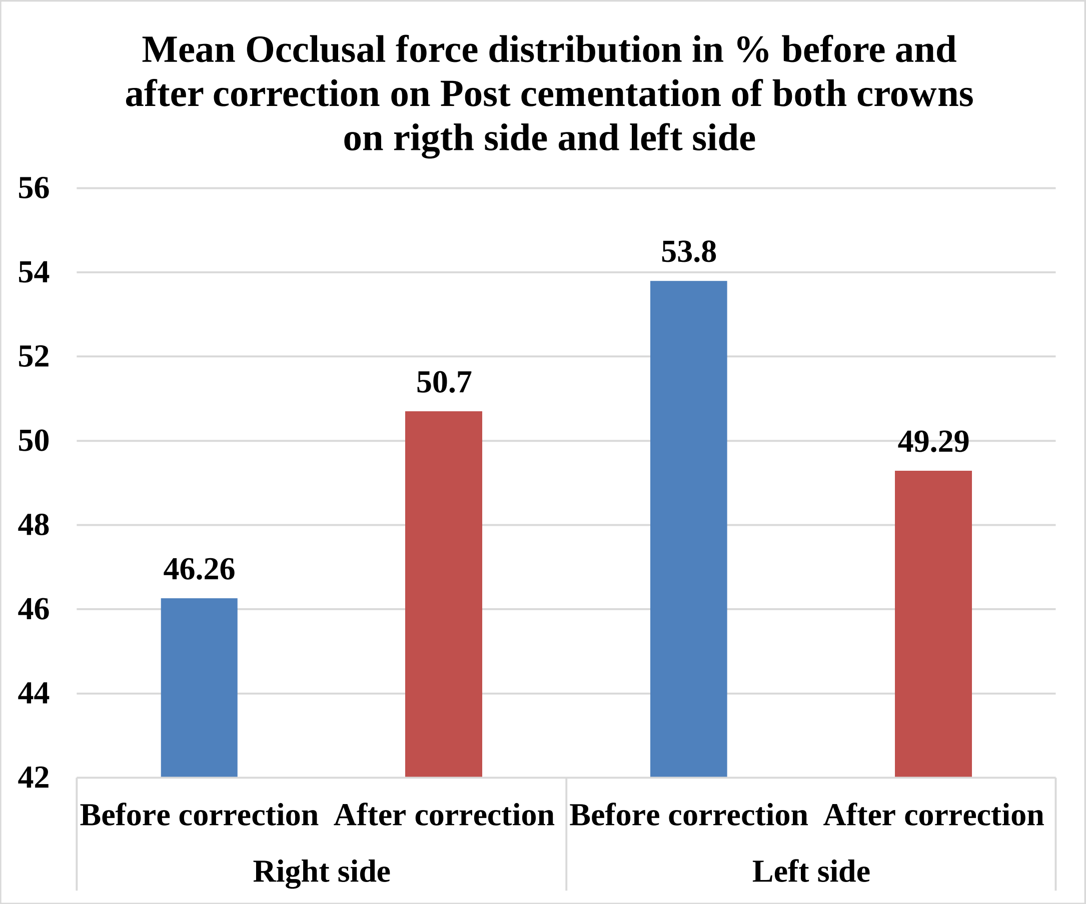
Interpretation – The paired t-test was used in our study to compare the occlusal force distribution in percentage of the right-side crowns before and after correction. Post-cementation of the two crowns before and after rectification on the right side did not differ statistically significantly ('p' value >0.05), according to this comparison.

Table no. 7 – Pre and post comparison of Occlusal force distribution in % of both types of crowns at different time intervals on left side

Pre and post comparison	Mean difference	t-value	df	p -value
Pretreatment vs Post cementation of conventional crown	14.1701	.954	14	.356
Pretreatment vs Post cementation of DMLS crown	10.22000	4.334	14	.001*
Pretreatment vs Post cementation of both crowns before correction	1.57333	.340	14	.739
Pretreatment vs Post cementation of both crowns after correction	6.08667	2.473	14	.027*

*p value <0.05 denotes statistically significant, <0.001 implies high significance, and <0.001 suggests high significance.

Interpretation: In our study, Comparison of Occlusal force distribution in % for Pre and post cementation between Conventional crown and DMLS crown on right side and on left side after correction was performed using independent samples t-test. This comparison showed statistically significant differences (‘p’ value >0.05) for Occlusal force distribution in % for Post cementation between Conventional crown and DMLS crown on right side and on left side after correction**.**



Graph no. 4: interpretations: After correction of premature contacts, the values of occlusal forces became average on both right and left sides. On right side the value improved from 46.26% to 50.7% and on left side from 53.8% to 49.29%.

Table no. 8 –Comparison of Occlusal force distribution in % of before and after correction of both the crowns on left side

Comparison of Before and after correction	Mean difference	t-value	df	p -value
Post cementation of both crowns before correction and Post cementation of both crowns after correction	4.51333	.976	14	.346

*p value <0.05 denotes statistically significant, <0.001 implies high significance, and <0.001 suggests high significance.

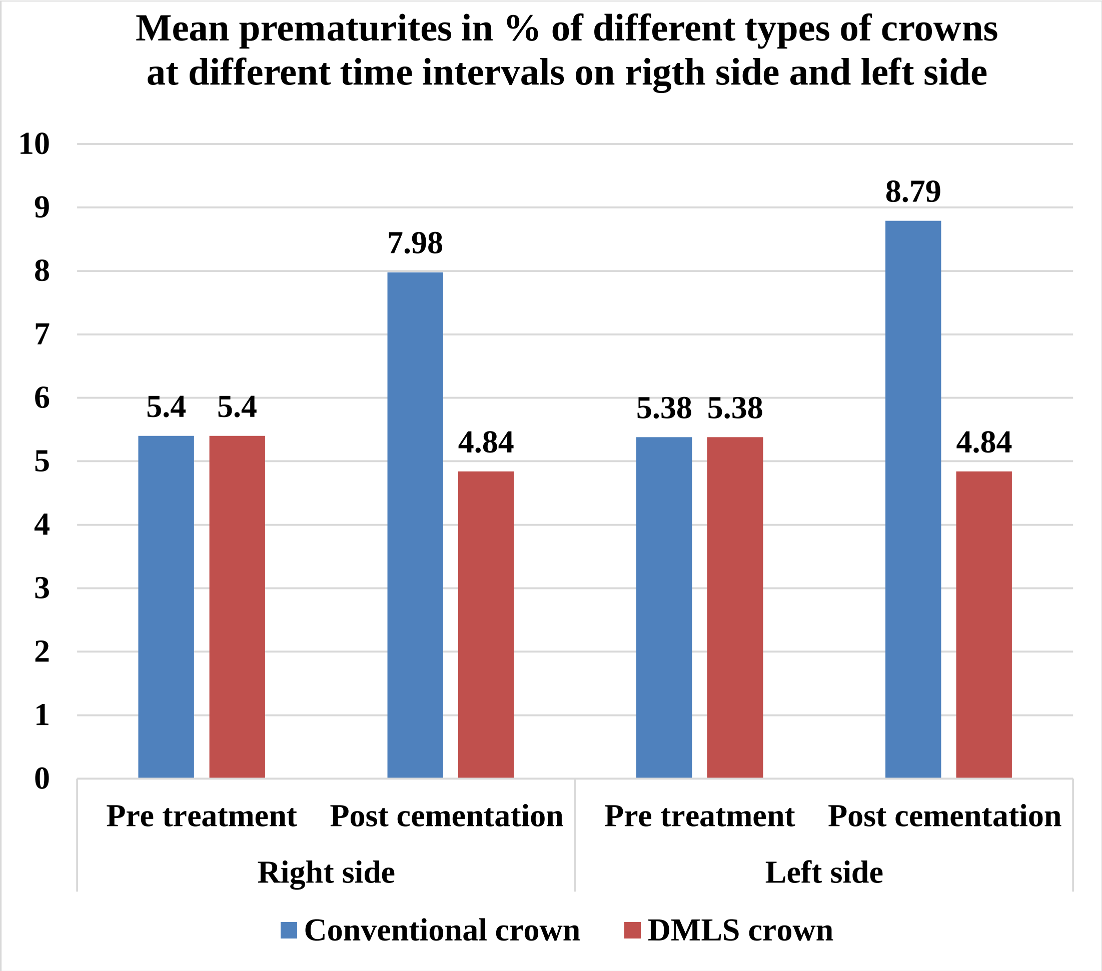
Interpretation: In our study, Comparison of Occlusal force distribution in % for Post cementation between Conventional crown and DMLS crown on right side and on left side after correction was performed using independent samples t-test. This comparison did not show statistically significant differences (‘p’ value >0.05) for Occlusal force distribution in % for Post cementation between Conventional crown and DMLS crown on right side and on left side before correction.

Table no. 9–Comparison of Occlusal force distribution in % for Post cementation between Conventional crown and DMLS crown on right side and on left side

Post cementation: Conventional crown vs DMLS crown	Mean difference	t-value	df	P-value
Right side	3.1431	.192	28	.528
Left side	-3.951	-.216	28	.718

*p value <0.05 denotes statistically significant, <0.001 implies high significance, and <0.001 suggests high significance.

Interpretation –In our study, Comparison of Occlusal force distribution in % for Post cementation between Conventional crown and DMLS crown on right side and on left side was performed using independent samples T-test. This comparison did not show statistically significant differences (‘p’ value >0.05) for Occlusal force distribution in % for Post cementation between Conventional crown and DMLS crown on right side and on left side



Graph no. 5: interpretations: Premature contacts were identified after cementation of conventional crowns i.e. 7.98% and 8.79% on right and left sides respectively. Whereas, the values of DMLS crown were lower on right and left side i.e. 4.84% and 5.38% respectively

Table no. 10–Comparison of Occlusal force distribution in % between right and left side of different types of crowns at different time intervals

Right side vs left side comparison	Mean Difference	t-value	df	p-value
Pre treatment	-10.76000	-3.089	28	.004*
Post cementation of conventional crown	-16.77	.472	28	.771
Post cementation of DMLS crown	-9.68	6.131	28	.000*
Post cementation of both crowns before correction	-7.54667	-1.186	28	.246
Post cementation of both crowns after correction	1.41333	3.516	28	.002*

*p value <0.05 denotes statistically significant, <0.001 implies high significance, and <0.001 suggests high significance.

Interpretation – The independent samples t-test was used in our study to compare the occlusal force distribution in percentage between the right and left sides of both types of crowns at various time intervals. The force distribution during the post-cementation of the DMLS crown and the post-cementation of the two crowns after correcting between the right and left sides differed statistically significantly ('p' value <0.05) in this comparison.

DISCUSSION

Occlusion plays a crucial role in the stomatognathic structure because it directly affects tooth health and speech, swallowing, and chewing. It is crucial for successful mastication because a proper occlusion effectively distributes chewing forces, by minimising tooth wear and promotes optimal food digestion.[6,7]

The general well-being of the stomatognathic system depends on maintaining a balanced occlusion; any deviation should be diagnosed and treated with orthodontic, prosthodontic, or reconstructive treatments to avoid long-term complications.[10] Malocclusion can result in habits such as a condition resembling bruxism, pulverizing, clenching, as well as tongue thrusting, that can harm teeth and strain facial muscles.[11]

The shape, strength, and functionality of damaged or weak teeth can be restored using dental crowns, which are tooth-shaped coverings. They are significant because they include: crowns that prevent additional harm by reinforcing teeth that have been damaged by decomposition, fractures, or extensive fillings.[18] Crowns, which are made of ceramic, porcelain, metal, or zirconia, can last for ten to fifteen years or longer with proper care.[19,20] They also help distribute bite forces evenly, avoiding excessive wear on other teeth. They restore adequate chewing and biting effectiveness, thereby ensuring that the tooth functions normally, and also provide strength to the teeth that have had root canal therapy.[25,26]

The Sorensen and Martinoff retrospective study examined endodontic treated teeth over a period of one to twenty-five years. It was concluded that coronal coverage considerably increased the clinical efficacy of maxillary and mandibular posterior teeth, but it had no discernible effect on the success of front teeth. In order to avoid fractures under occlusal stresses, this promotes crown placement on posterior teeth.[68]

In accordance with Stavropoulou and Koidis' systematic review, which analysed ten studies, dental crowns provide acceptable long-range survival for RCT teeth, whereas direct restorations only prove satisfactory in the short term. The combined longevity probabilities for crowned RCT teeth were 99% at twelve months and 95% at five years, respectively.[69] In a similar manner, the patients selected for this study received dental crowns on molars that had undergone root canal therapy.

In the present study, metal crowns were chosen as the prosthesis as they are the considered as the gold standard material of choice when it comes to rehabilitating posterior teeth owing to their innate properties of strength, prolonged durability and cost effectiveness. Both the crowns were fabricated by two different techniques i.e. by conventional lost wax technique and DMLS technique in order to compare whether digitally fabricated crowns provide better occlusion than the conventionally fabricated metal crowns or vice versa.

The marginal precision for metal copings made by ringless casting, electronic milling, lost wax method, and DMLS was compared by Walia TS et al. Through an analysis of the minor differences between cobalt-chromium copings made with DMLS and other fabrication techniques, the study illustrates the accuracy of copings made with DMLS. The holes discovered in significantly less than the previously documented tolerable marginal gap widths of 150–125 μm were the results of that experiment for laser-sintered restorations. Internal spaces were clinically acceptable, as were mean marginal differences.[70]

This justification led to the inclusion of DMLS crowns in this study along with traditional metal crowns made using the lost wax process.

Adapting DMLS metal ceramic crown prostheses to the first molar after endodontic treatment produced both aesthetically acceptable and clinically satisfying outcomes, according to an experiment conducted by Arpit Sikri.[71] This claim is further supported by the post-treatment examinations, which show minimal patient pain, adverse clinical test responses, and no discrepancy with the restoration margins or surrounding gingival tissues.[72]

Since all the clinical findings of both conventional metal crowns and DMLS crowns are clinically acceptable and biocompatible, therefore these crowns were selected for comparison for determining occlusal force distribution.

Along with mechanical properties and material integrity, harmony with the surrounding biologic structures is equally significant after rehabilitating a tooth with prosthesis. Therefore, a prosthesis which gives a uniform distribution of occlusal forces on all teeth is considered as a biologically and clinically acceptable and comfortable to patient.[68]

Amirah F Aldowish in his study has concluded that, both molars have maximum biting force values of 390–800 N, the bicuspid region is about 288 N, the canine area is 208 N, and the incisor region is 155 N.[71] Occlusal trauma may arise from an uneven force distribution caused by a single tooth coming into early contact during mandibular excursions.[73]

T-Scan III's application was evaluated by examining occlusal alterations in molar fixed restorations by Zhang et al. The T-Scan III equipment was used in that study to evaluate the distribution of occlusal force prior to and subsequent to molar restorations.[75] In order to ensure uniform force distribution after restoration, the study found that T-Scan offers reliable and objective data that can successfully guide therapeutic occlusion modifications.

Therefore, according to the current study, a more harmonising prosthesis was the crown that, as shown by T-scan, uniformly distributed occlusal pressures on both halves of the mouth. T-scan was used to determine the percentage of occlusal force distribution on either sides of the oral cavity since it is the only method that can offer quantitative data, whereas articulating sheets can only provide qualitative data.

The percentage variation of occlusal force on the right and left sides after adjustment for conventional and DMLS crowns was compared before and after cementation using the independent samples t-test. The investigation showed statistically significant variations ('p' value >0.05) among the conventional and DMLS restorations on both sides in the percentage variation in occlusal pressure for post-cementation after correction.

In an experiment done by Hei Chan when occlusal force distribution over longitudinal variation preceding and following fixed replacement for molar complete crowns using T-SCAN III was studied. There was no discernible change in the percentage of occlusal pressure prior and after the rehabilitated tooth position was restored ($10.15 \pm 2.33\%$ and $9.08 \pm 2.08\%$, respectively) ($P > 0.05$).[66]

Likewise, in this investigation, there was no discernible change in the percentage of occlusal pressure on the left side (average disparity of 1.57333, $p>0.05$) or right side (mean disparity of 1.64000, p value>0.05) before to and following the corrected tooth position. The mean differences in the occlusal force distribution percentage between the right and left sides of various crown types before treatment, after the DMLS crown was cemented, and after rectification were -10.76000 ($p<0.05$), -9.68 ($p<0.050$), and -9.68 ($p<0.05$), respectively.

This demonstrates that the occlusal pressure distribution reduced in both crowns following cementation, with the DMLS crown having a greater average value (nearer 50%) than the conventional metal crown. However, following removal of premature contacts, the occlusal pressure distribution lowered in both crowns when compared to pressure distribution before correction.

According to the current study, Aishwarya N. carried out a study in which she used T-scan to assess the occlusal force dispersion following cementation of metallic crowns in children. It was determined that the proportion of biting force on the crowned teeth (SSC placement) at various time intervals did not significantly change. All groups had premature contacts; however, the crowned tooth showed a significant decrease from baseline to the a one-month monitoring ($p = 0.03$). Additionally, there was no statistical difference between the genders, however there was a statistically significant rise in biting force in those older than 7 years ($p = 0.006$).[76]

In the present study, more premature contacts were identified on conventional crowns than on the DMLS crowns indicating that DMLS crowns are more precise in fabrication and providing accurate bite as compared to conventional crown.

Results of the present research depicts the occlusal force dispersion in percentage of various crown types at various time intervals on the right side. For both the conventional crown and the DMLS crown, the average occlusal force dispersion was 44.62 percent (9.53) at prior to treatment and rose to 57.98 percent (12.31) and 54.84 percent (5.06) at post-cementation. Prior to correction, the occlusal force dispersion at post-cementation for both crowns was 46.26% (17.47), and following correction, it was 50.70%.

This indicates that the occlusal pressure dispersion rose in both crowns following cementation, with the mean value for the conventional crown being greater than that of the DMLS crown (nearer 50%); nevertheless, following correction, the occlusal force redistribution increased in both crowns as it had before correction.

The study investigated the occlusal force distribution when bilateral endo-treated molars were cemented with conventionally fabricated metal crowns and DMLS metal crowns with the aid of T-SCAN. The analysis is done based on percentage of occlusal force re-distribution on each tooth after temporary cementation of both crowns was done individually and when both crowns were permanently cemented.

Within the limitation, the finding of the study state that although both conventional and DMLS metal crowns are clinically acceptable, DMLS crowns prove to be superior in uniformly re-distributing the occlusal forces amongst all teeth as compared to conventionally fabricated metal crowns by lost wax technique.

According to the clinical findings and the results drawn from the present study, it has been observed that crowns fabricated by DMLS technique showed better re-distribution of occlusal forces on all teeth uniformly as compared to crowns fabricated by conventional lost wax technique.

SCOPE OF THE STUDY

- The present study evaluated the uniformity of occlusal force distribution when bilateral endo-treated molars were rehabilitated with metal crowns fabricated by lost wax technique and DMLS technique.
- Other factors like compressive, shear strength and internal marginal fit can be determined in future studies.
- Incorporating articulating papers to find association between qualitative and quantitative evaluation can be undertaken in in-vivo studies.
- Similar to this study, bilateral metal multiple-unit bridges can be assessed with the aid of T-SCAN.
- Crowns fabricated by other materials like zirconia, porcelain fused to metal, etc. can also be evaluated with the help of T-SCAN.
- In accordance with this study, occlusal force distribution achieved by bilateral placements of dental implants can be evaluated with T-SCAN.

LIMITATIONS OF THE STUDY

1. In the present study, only 15 patients were considered for assessment. A greater sample size could have been considered for better evaluation.
2. Only single crowns on molars were included in this study. For better comparison between the two types of technique fabrication, more teeth could have been included.
3. Only one parameter of occlusal force distribution was studied. Other factors like marginal fit, compressive and shear strength were not considered for comparison in split mouth study.
4. Follow- up records for were not undertaken for evaluation of redistribution of occlusal forces after cementation of both crowns bilaterally.

CLINICAL IMPLICATIONS

In the present study, the results have showed that DMLS metal crowns depict better uniform distribution of occlusal forces when the patient was asked to bite in maximum intercuspation position as compared to the metal crown fabricated by conventional lost wax technique.

As metal crowns are considered as gold standard for rehabilitation of endo-treated molars, with digitalization of dentistry, metal crowns fabricated digitally have shown great acceptable clinical findings.

The occlusal force distribution by both the crowns have given values which are clinically acceptable. However, when compared, the crowns fabricated by DMLS technique have proven to be better and have undergone minimal corrections after cementation.

Since DMLS metal crowns have shown great occlusal force re -distribution, the stomatognathic system which incorporates of periodontal ligament, alveolar bone, masticatory muscles and temporomandibular joint all can be in the most harmonious functionality.

Therefore, DMLS crowns are equally significant in rehabilitating endo-treated molars to provide near-about equal distribution of occlusal forces during maximum intercuspation.

CONCLUSION

The following results were reached within the constraints of this split-mouth in vivo investigation.

When it comes to the rehabilitation of endodontically treated molar teeth, DMLS metal crowns have shown to be a superior option than metal crowns fabricated by traditional lost wax approach.

When DMLS metal crowns were cemented, the percentage of force distribution during occlusal pressure showed almost similar on both left and right sides of oral cavity i.e. values were closest to 50% on both sides of the jaw depicting that DMLS crowns are accurately precise to maintain the function and harmony in the stomatognathic system and are highly biologically acceptable. With the use of T-SCAN, quantification of occlusal forces aids in evaluating the percentage of occlusal stresses on every tooth as well as depicts the total force being loaded on left and right sides of the jaw dynamically with the precision till 0.001 second. Therefore, digital method of metal crown fabrication is not just clinically acceptable but has also proved to redistribute masticatory stresses uniformly to maintain the entire stomatognathic system in harmony.

SUMMARY

The following observations were reached within the constraints of this split-mouth in vivo investigation.

When it comes to the rehabilitation of endodontically treated molar teeth, DMLS metal crowns have been demonstrated to be a superior option than metal crowns made using the traditional lost wax approach.

The amount of force dispersion during occlusal force applied to the left and right sides of the oral cavity was nearly identical when DMLS metal crowns were cemented. Proving that DMLS crowns are highly biologically acceptable and precisely maintain the function and harmony of the stomatognathic system.

Occlusal force quantification using T-SCAN helps determine the proportion of occlusal loads on each tooth and shows the total force dynamically loaded on each of the two sides of the jaw with utmost accuracy. In order to preserve the harmony of the entire stomatognathic system, the computerised approach of metal crown fabrication has been shown to evenly distribute masticatory forces uniformly in addition to being clinically acceptable.

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ANNEXURES

ANNEXURE I- ETHICAL CLEARANCE CERTIFICATE

Research and Ethics Committee
KLE VK INSTITUTE OF DENTAL SCIENCES
A Constituent Unit of KLE Academy of Higher Education & Research
Accredited 'A' Grade by NAAC Placed in Category 'A' by MHRD (GoI)
Nehru Nagar, Belagavi - 590 010, Karnataka State
☎: 0831-2470362
FAX: 0831-2470640
Web: http://www.kledental-bgm.edu.in
E-mail:principal@kledental-bgm.edu.in

Sl. No. : 1643

CERTIFICATE

This is to Certify that the synopsis titled Assessment of Occlusal force distribution using T-scan Pre-operative and post-cementation of full metal crowns fabricated by conventional and direct metal laser sintered (DMLS) Technique - A split mouth randomized clinical study *Submitted by Dr.* REG. NO- IM0222003 *P. G. Student / Staff, Guided by* *from Department of* Prosthodontics and Crown and Bridge *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date :

Member Secretary
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

MEMBER SECRETARY
Research & Ethical Committee
KLEVK Institute of Dental Sciences
BELAGAVI.

Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

Chairman
Research and Ethical Committee
KLE VK Institute of Dental Sciences
Belgaum

ANNEXURE II-CONSENT FORM

IN ENGLISH

DEPARTMENT OF PROSTHODONTICS AND CROWN & BRIDGE.

KLE V.K INSTITUTE OF DENTAL SCIENCES, BELAGAVI.

"ASSESSMENT OF OCCLUSAL FORCE DISTRIBUTION USING T-SCAN PRE-OPERATIVE AND POST-CEMENTATION OF FULL METAL CROWNS FABRICATED BY CONVENTIONAL AND DIRECT METAL LASER SINTERED (DMLS) TECHNIQUE – A SPLIT-MOUTH RANDOMIZED CLINICAL STUDY"

I, ________________________, aged _______ have been informed about my involvement in the study.

I agree to give my personal details like name, age, sex, address, previous dental history and the required details for the study to the best of my knowledge.

I will cooperate with the dentist for my intra oral and /or extra oral examination.

I have been informed about the crowns/caps fabricated by two techniques being given to me.

I will follow the instruction given by the doctor during the study

I permit the operator to utilize the information given by me and results obtained from this study for presentation and publication.

I will not claim any returns for my cooperation in the study, even if it is being sponsored by an agency. I am participating with my own will and wish.

In my full consciousness and presence of mind, after understanding all the procedure in my vernacular language, I am willing and give my consent to participate in this study.

Patient's name:

Patient's signature:

Address:

Dentist's Name:

Dentist's signature

ಒಪ್ಪಿಗೆ ಪತ್ರ

ಸಾಂಪ್ರದಾಯಿಕ ಮತ್ತು ನೇರ ಲೋಹದ ಲೇಸರ್ ಸಿಂಟರ್ಡ್ (DMLS) ತಂತ್ರದಿಂದ ತಯಾರಿಸಿದ ಪೂರ್ಣ ಲೋಹದ ವೆನಿರ್ ಕಿರೀಟದ T-ಸ್ಕ್ಯಾನ್ ಪೂರ್ವ ಮತ್ತು ಶಸ್ತ್ರಚಿಕಿತ್ಸೆಯ ನಂತರದ ಸಿಮೆಂಟೇಶನ್ ಅನ್ನು ಬಳಸಿಕೊಂಡು ಆಕ್ಲೂಸಲ್ ಬಲ ವಿತರಣೆಯನ್ನು ನಿರ್ಣಯಿಸುವುದು - ಒಂದು ಸ್ಪ್ಲಿಟ್-ಮೌತ್ ಯಾದೃಚ್ಛಿಕ ವೈದ್ಯಕೀಯ ಅಧ್ಯಯನ

ನಾನು, ______________________________ ವಯಸ್ಸಿನ ______________ ಅಧ್ಯಯನದಲ್ಲಿ ನನ್ನ ಪಾಲ್ಗೊಳ್ಳುವಿಕೆಯ ಬಗ್ಗೆ ತಿಳಿಸಲಾಗಿದೆ.

ನನ್ನ ವೈಯಕ್ತಿಕ ವಿವರಗಳಾದ ಹೆಸರು, ವಯಸ್ಸು, ಲಿಂಗ, ವಿಳಾಸ, ಹಿಂದಿನ ಹಲ್ಲಿನ ಇತಿಹಾಸ ಮತ್ತು ಅಧ್ಯಯನಕ್ಕೆ ಅಗತ್ಯವಾದ ವಿವರಗಳನ್ನು ನನ್ನ ಜ್ಞಾನದ ಅತ್ಯುತ್ತಮವಾಗಿ ನೀಡಲು ನಾನು ಒಪ್ಪುತ್ತೇನೆ.

ನನ್ನ ಇಂಟ್ರಾ ಮೌಖಿಕ ಮತ್ತು / ಅಥವಾ ಹೆಚ್ಚುವರಿ ಮೌಖಿಕ ಪರೀಕ್ಷೆಗೆ ನಾನು ದಂತವೈದ್ಯರೊಂದಿಗೆ ಸಹಕರಿಸುತ್ತೇನೆ.

ಅಧ್ಯಯನದ ಸಮಯದಲ್ಲಿ ವೈದ್ಯರು ನೀಡಿದ ಸೂಚನೆಯನ್ನು ನಾನು ಅನುಸರಿಸುತ್ತೇನೆ

ನಾನು ನೀಡಿದ ಮಾಹಿತಿ ಮತ್ತು ಈ ಅಧ್ಯಯನದಿಂದ ಪಡೆದ ಫಲಿತಾಂಶಗಳನ್ನು ಪ್ರಸ್ತುತಿ ಮತ್ತು ಪ್ರಕಟಣೆಗಾಗಿ ಬಳಸಿಕೊಳ್ಳಲು ಆಪರೇಟರ್‌ಗೆ ನಾನು ಅನುಮತಿ ನೀಡುತ್ತೇನೆ.

ಎರಡು ರೀತಿಯ ಪುನಃಸ್ಥಾಪನೆಗಳ ಬಗ್ಗೆ ನನಗೆ ತಿಳಿಸಲಾಗಿದೆ

ಏಜೆನ್ಸಿಯಿಂದ ಪ್ರಾಯೋಜಿಸಲ್ಪಟ್ಟಿದ್ದರೂ ಸಹ, ಅಧ್ಯಯನದಲ್ಲಿ ನನ್ನ ಸಹಕಾರಕ್ಕಾಗಿ ನಾನು ಯಾವುದೇ ಆದಾಯವನ್ನು ಪಡೆಯುವುದಿಲ್ಲ. ನಾನು ನನ್ನ ಸ್ವಂತ ಇಚ್ will ಾಶಕ್ತಿ ಮತ್ತು ಆಶಯದೊಂದಿಗೆ ಭಾಗವಹಿಸುತ್ತಿದ್ದೇನೆ.

ನನ್ನ ಪೂರ್ಣ ಪ್ರಜ್ಞೆ ಮತ್ತು ಮನಸ್ಸಿನ ಉಪಸ್ಥಿತಿಯಲ್ಲಿ, ನನ್ನ ಸ್ಥಳೀಯ ಭಾಷೆಯಲ್ಲಿನ ಎಲ್ಲಾ ಕಾರ್ಯವಿಧಾನಗಳನ್ನು ಅರ್ಥಮಾಡಿಕೊಂಡ ನಂತರ, ನಾನು ಸಿದ್ಧನಾಗಿದ್ದೇನೆ ಮತ್ತು ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ನನ್ನ ಒಪ್ಪಿಗೆಯನ್ನು ನೀಡುತ್ತೇನೆ.

ರೋಗಿಯ ಹೆಸರು:

ರೋಗಿಯ ಸಹಿ:

ವಿಳಾಸ:

ದಂತವೈದ್ಯರ ಹೆಸರು:

ದಂತವೈದ್ಯರ ಸಹಿ:

संमती पत्र

पारंपारकि आणि DMLS तंत्राने बनवलेल्या संपूर्ण मेटल क्राउनचे टी-स्कॅन प्री-ऑपरेटव्हि आणि पोस्ट-समिंटेशन वापरून ऑक्लुसल फोर्स वतिरणाचे मूल्यांकन करणे - एक स्प्लटि-माउथ यादृच्छकि क्लनिकिल अभ्यास"

दंतवैद्यांनी माझ्या भाषेत मला कार्यप्रक्रयिास्पष्ट करून मला सांगतिलेली आहे. ह्याचे नकिाल भवष्यिात प्रकाशति होऊ शकता तह्याचे मला ज्ञान आहे.

1. मी माझ्या वैयक्तकि तपशीलांसह नाव ______________, वय,________ लगिं ______, पत्ता आणि अभ्यासण्यासाठी लागणारे तपशील माझ्या चांगल्या ज्ञानास देण्यासाठी सहमत आहे .

2.मी दंतवैद्याला माझ्याकडून दलिेल्या माहतिीचा वापर करण्यास परवानगी देतो आणि ह्या अभ्यासातून प्राप्त झालेल्या परणिामांचे प्रस्तुतीआणि प्रकाशन हेतूसाठी वापर करण्याची परवानगी देतो.

3. मला दलिेल्या दोन तंत्रांद्वारे तयार केलेल्या क्राउनबद्दल मला माहतिी देण्यात आली आहे.

4. मी ह्या अभ्यासात माझ्या सहकार्यासाठी कोणत्या ही परताव्याचा दावा करणार नाही जरी तो कोणत्या ही संस्थेद्वारा प्रायोजति असेल. मी स्वतःच्या इच्छे सहसह भागी होतआहे.

5. मी दंतवैद्यांनी दलिेल्या नरि्देशांचे पालन करनि.

माझ्या प्रादेशकि भाषेतील सर्व प्रक्रयिा समझून घेतल्या नंतर माझ्या पूर्ण चेतनेने आणि मनाच्या उपस्थतिी मध्ये, मी ह्या अभ्यासात सहभागी होण्यासाठी माझी सहमती आणि संमती देत आहे.

तारीख: स्थान:

संमतीदाराची स्वाक्षरी

साक्षीदाराची स्वाक्षरी

ANNEXURE III – MASTER CHARTS FOR OCCLUSAL FORCE DISTRIBUTION ON RIGHT SIDE

Sl No	(Occlusal force distribution on right side of mouth in %) patient. Name	Pre-treatment (occlusal force distribution in %)	Post cementation of conventional crown (occlusal force distribution in %)	Post cementation of DMLS crown (occlusal force distribution in %)	Post cementation of both crowns before correction (occlusal force distribution in %)	Post cementation of both crowns after correction (occlusal force distribution in %)
1	Ms. Bhagyashree Kittur	52.8	14.7	56.6	20.3	51.5
2	Mrs. Chaitra Pujari	40.9	26.6	60.9	35.9	52.3
3	Ms. Pooja Bhide	48.7	43.1	51.8	69.9	48.7
4	Mr. Prakash Patil	23.5	71.5	51.2	50.3	50.3
5	Ms. Preeti Upadye	52.4	98	59	29	52.4
6	Mrs. Reshma Kalkundrikar	55.7	41.7	52.3	50.9	50.9
7	Mr. Sanjiv Patil	34.9	96.9	59.3	19.3	51.6
8	Mr. Shantanu Doddamani	57.6	73.5	60.8	48.3	49.7
9	Mrs. Shashikala Varpe	53.4	93.2	50.6	78.2	51.4
10	Mrs. Madhu Shintri	52.3	65.5	63.9	69.5	50.3
11	Ms. Shweta Pujeri	36.4	37.4	47.9	54.6	49.7
12	Mrs. Sudha Dandagi	41	40.1	51.3	43.7	49.2
13	Ms. Susmita Koladur	40.2	19.8	56.8	35.5	50.7
14	Ms. Vidya Kajagar	40.2	34.7	48.1	51.6	51.6
15	Ms. Ankita Patil	39.3	21.3	52.1	36.9	50.3

ANNEXURE IV – MASTER CHARTS FOR OCCLUSAL FORCE DISTRIBUTION ON LEFT SIDE

Sl No	(Occlusal force distribution on left side of mouth in %) Patient Name	Pre treatment (occlusal force distribution in %)	Post cementation of conventional crown (occlusal force distribution in %)	Post cementation of DMLS crown (occlusal force distribution in %)	Post cementation of both crowns before correction (occlusal force distribution in %)	Post cementation of both crowns after correction (occlusal force distribution in %)
1	Ms. Bhagyashree Kittur	47.2	85.3	43.4	79.7	48.5
2	Mrs. Chaitra Pujari	59.1	73.4	39.1	64.1	47.7
3	Ms. Pooja Bhide	51.3	56.9	48.2	30.1	51.3
4	Mr. Prakash Patil	76.5	28.5	48.8	49.7	49.7
5	Mrs. Preeti Upadye	47.6	2	41	71	47.6
6	Mrs. Reshma Kalkundrikar	44.3	58.3	47.7	49.1	49.1
7	Mr. Sanjiv Patil	65.1	3.1	40.7	80.7	48.4
8	Mr. Shantanu Doddamani	42.4	26.5	39.2	51.7	50.3
9	Mrs. Shashikala Varpe	46.6	6.8	49.4	21.8	48.6
10	Mrs. Madhu Shintri	47.7	34.5	36.1	31.5	49.7
11	Ms. Shweta Pujeri	63.6	62.6	52.1	45.4	50.3
12	Mrs. Sudha Dandagi	59	59.9	48.7	56.3	50.8
13	Ms. Susmita Koladur	59.8	80.2	43.2	64.5	49.3
14	Ms. Vidya Kajagar	59.8	65.3	51.9	48.4	48.4
15	Ms. Ankita Patil	60.7	78.7	47.9	63.1	49.7

ANNEXURE V – CTRI REGISTRATION

CTRI No	**CTRI/2024/12/078282** [Registered on: 18/12/2024] **Trial Registered Prospectively**	
Acknowledgement Number	REF/2024/12/095629	
Last Modified On:	10/12/2024	
Post Graduate Thesis	Yes	
Type of Trial	Interventional	
Type of Study	Dentistry	
Study Design	Randomized, Parallel Group, Active Controlled Trial	
Public Title of Study Clarification(s) with Reply Modification(s)	Comparing occlusion when two types of metal crowns are fabricated and cemented on molars	
Scientific Title of Study	Assessment of occlusal force distribution using T-SCAN pre-operative and post-cementation of full metal crowns fabricated by conventional and direct metal laser sintered (DMLS) technique -A split-mouth randomized clinical study	
Trial Acronym	NIL	
Secondary IDs if Any	**Secondary ID**	**Identifier**
	NIL	NIL
Details of Principal Investigator or overall Trial Coordinator (multi-center study) Clarification(s) with Reply Modification(s)	**Name**	[redacted]
	Designation	PG student
	Affliation	KLE VK Institute of dental sciences
	Address	Department number 3, Prosthodontics and crown and bridge, Ground floor, KAHERS KLE Vishwanath Katti Institute of Dental Sciences, JNMC campus, Nehru nagar, Belagavi 590010, Karnataka, India Nehru Nagar Belgaum KARNATAKA 590010 India
	Phone	[redacted]
	Fax	
	Email	[redacted]
Details Contact Person Scientific Query Clarification(s) with Reply Modification(s)	**Name**	[redacted]
	Designation	Reader
	Affliation	KLE VK Institute of dental sciences
	Address	Department number 3, Prosthodontics and crown and bridge, Ground floor, KAHERS KLE Vishwanath Katti Institute of Dental Sciences, JNMC campus, Nehru nagar, Belagavi 590010, Karnataka, India Nehru Nagar KARNATAKA 590010 India
	Phone	9986497005
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	Email	[redacted]
Details Contact Person Public Query Clarification(s) with Reply Modification(s)	**Name**	[redacted]
	Designation	PG student
	Affliation	KLE VK Institute of dental sciences
	Address	Department number 3, Prosthodontics and crown and bridge, Ground floor, KAHERS KLE Vishwanath Katti Institute of Dental Sciences, JNMC campus, Nehru nagar, Belagavi 590010, Karnataka, India Nehru Nagar KARNATAKA 590010 India
	Phone	[redacted]
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	Email	[redacted]
Source of Monetary or Material Support	Department of Prosthodontics and crown and bridge, KAHERs KLE Vishwanath Katti Institute of Dental Sciences, JNMC campus, Nehru nagar, Belagavi-590010, Karnataka, India	
Primary Sponsor	**Name**	[redacted]
	Address	Department of Prosthodontics and crown and bridge, KAHERs KLE Vishwanath Katti Institute of Dental Sciences, JNMC campus, Nehru Nagar, Belagavi-590010, Karnataka, India
	Type of Sponsor	Other [(Self funded)]

Details of Secondary Sponsor

Name	Address
NIL	NIL

Countries of Recruitment

India

Sites of Study
Clarification(s) with Reply
Modification(s)

No of Sites = 1			
Name of Principal Investigator	Name of Site	Site Address	Phone/Fax/Email
	KAHERs KLE VK Institute of dental sciences	Department number 3, Ground floor, Prosthodontics and crown and bridge, KLE VK Institute of dental sciences, JNMC campus, Nehru nagar Belgaum KARNATAKA	

Details of Ethics Committee
Clarification(s) with Reply
Modification(s)

No of Ethics Committees= 1						
Name of Committee	Ethics Committee registered with DHR /CDSCO or not	Ethics Committee Registration No.	Approval Status	Date of Approval	Approval Document	Is IEC?
Institutional Research and Ethics Committee KLE KVIDS	Yes	EC/NEW.INST/2021/2435	Approved	16/11/2023	Approval File	No

Regulatory Clearance Status from DCGI

Status	Date	Aproval Document
Not Applicable	No Date Specified	No File Uploaded

Health Condition / Problems Studied
Clarification(s) with Reply
Modification(s)

Health Type	Condition
Patients	(1) ICD-10 Condition: K040||Pulpitis,

Intervention / Comparator Agent
Clarification(s) with Reply
Modification(s)

Type	Name	Details
Comparator Agent	Conventional metal crowns	Molar crowns fabricated by conventional lost salt technique for 3 months
Intervention	DMLS metal crowns	Molar metal crowns fabricated by Direct Metal Laser Sintered technique for 3 months

Inclusion Criteria

Age From	18.00 Year(s)
Age To	54.00 Year(s)
Gender	Both
Details	1) Patients who have undergone endodontic treatment in posterior teeth bilaterally, followed by post-obturation restoration in occlusion. 2) Teeth with one- or two-walled defects 3) Opposing teeth should have sound tooth structure without any restorations

Exclusion Criteria

Details	1) Patients are not willing to participate in the study. 2) Patients treated with post and core. 3) Teeth having more than 2 walled defects 4) Patients having para-functional habits like bruxism and TMDs 5) Patients having missing teeth adjacent and opposite to endodontically treated teeth. 6) Patients having periapical pathologies after RCT. 7) Patients having periodontally compromised teeth

Method of Generating Random Sequence	Coin toss, Lottery, toss of dice, shuffling cards etc
Method of Concealment	An Open list of random numbers
Blinding/Masking	Participant and Outcome Assessor Blinded

Primary Outcome

Outcome	TimePoints
1) To evaluate the occlusal force distribution by using T-scan pre-operative and post-cementation of full metal crowns fabricated by conventional technique. 2) To assess the occlusal force distribution by using T-scan pre-operative and post-cementation of crowns fabricated by DMLS technique. 3) To evaluate and compare the occlusal force distribution by using T-scan pre-operative and post-cementation of crowns fabricated by conventional and DMLS techniques.	Baseline

Secondary Outcome

Outcome	TimePoints
1) Patient comfort	Baseline

Target Sample Size

Total Sample Size="15"
Sample Size from India="15"
Final Enrollment numbers achieved (Total)= "Applicable only for Completed/Terminated trials"
Final Enrollment numbers achieved (India)="Applicable only for Completed/Terminated trials"

Phase of Trial: Phase 2

Date of First Enrollment (India) Clarification(s) with Reply Modification(s)	11/01/2025
Date of Study Completion (India)	Applicable only for Completed/Terminated trials
Date of First Enrollment (Global)	If country of recruitment is only India, global date would be not applicable.
Date of Study Completion (Global)	Applicable only for Completed/Terminated trials
Estimated Duration of Trial	**Years**="0" **Months**="6" **Days**="0"
Recruitment Status of Trial (Global)	If country of recruitment is only India, global status would be not applicable.
Recruitment Status of Trial (India)	Not Yet Recruiting
Publication Details	N/A
Individual Participant Data (IPD) Sharing Statement	**Will individual participant data (IPD) be shared publicly (including data dictionaries)?** **Response** - NO
Result Disclosure	**Do you wish to upload results?** **Response** - Summary results have not yet been disclosed
Brief Summary	In patients who have undergone prosthetic rehabilitation with crowns and bridges, the distribution of occlusal forces may not be the same as before. Bite force evaluation helps to understand the mechanics of mastication, muscle activity during mastication, and the influence of physiological factors during the masticatory performance. These forces need to be evaluated and eliminated to achieve harmonious occlusal force distribution to protect the stomatognathic system. The prostheses fabricated by using conventional (lost wax technique) or DMLS technique are clinically acceptable. Comparative studies on the accuracy and precision of DMLS and conventionally fabricated crowns have been done. The studies have shown that a range of 0.4mmâ€"2.8mm occlusal discrepancy is seen and is variable when posterior dental crowns are fabricated by conventional method or by DMLS method. The T-SCAN system records an accurate way of determining and evaluating the time sequence and force magnitude of occlusal contacts by converting qualitative data into quantitative parameters and displaying them digitally. Using this system, multiple corrections of occlusal discrepancies can be performed for every segment of the dentition. Comparative studies have been done to evaluate occlusal discrepancy by conventional methods, but the literature on T scans is sparse. Hence, the present study is undertaken to assess the occlusal force distribution by using T-scan pre-operative and post-cementation of metal crowns fabricated by conventional and DMLS techniquesâ€"a split-mouth randomized clinical study.