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ORIGINAL ARTICLE

A Comparative Evaluation of the Effect of Double Casting Technique Using Functionally Generated Path and Conventional Single Casting with Respect to Functional Articulation, Patient Satisfaction and Chair Side Time, in Single Unit Molar Teeth: An In Vivo Study

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Abstract A stable centric occlusal position that shows no evidence of occlusal disease should not be altered. Confirmative restorative dentistry deals with making restorations that are in harmony with existing jaw relations. Conventional techniques for construction have been unsuccessful in producing a prosthesis that can be inserted without minor intraoral occlusal adjustment. This study was conducted to evaluate the benefits of the double casting technique with FGP over the conventional casting technique. Ten patients with root canal treated maxillary molar were selected for the fabrication of metal crown. Two techniques, one involving the conventional fabrication and other using functionally generated path with double casting were used to fabricate the prosthesis. A comparison based on various parameters which was done between the two techniques. The change in the height of castings for the double casting group was less compared to the conventional group and was highly statistically significant ($P < 0.001$). The time taken for occlusal correction was significantly lower in double casting group than the conventional group ($P < 0.001$). The patient satisfaction (before occlusal correction) indicated better satisfaction for double casting group compared to conventional ($P < 0.01$). The functionally generated path with double casting technique resulted in castings which had better dimensional accuracy, less occlusal correction and better patient satisfaction compared to the conventional castings.

Keywords Functionally generated path · Double casting · Conventional casting

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Introduction

A stable centric occlusal position that shows no evidence of occlusal disease should not be altered. Confirmative restorative dentistry deals with making restorations that are in harmony with existing jaw relations [1].

The centric and eccentric occlusal relations between maxilla and mandible need to be reproduced in the edifice of a precise fixed prosthesis, to be in harmony with the stomatognathic system and to ensure the quality of rehabilitation [2]. An understanding of mandibular movements and use of fully adjustable articulator, simulating these movements are required, in order to accomplish the harmony. Intricacies in the use of fully adjustable articulator make it not readily feasible for routine clinical practice.

A way back in 1930's another substitute method to reproduce a precise occlusion was developed, m functionally named as generated path technique (FGP) [2]. The functionally generated path (FGP) is a simple notion for recording and using a precise pattern for occlusal and border movements [3].

The inventive technique was described by Meyer, for obtaining the "functional occlusal path" for complete dentures [4] and fixed partial dentures [5] fabricated by a direct or indirect technique. Meyer said that "no adjustment of the occlusion in the mouth should be necessary if the technique is correctly carried out [6]."

Many authors have refined FGP methods. Later this technique was adapted for use in complete occlusal rehabilitation by Mann and Pankey [7, 8]. FGP Technique had been used for complete dentures, removable partial denture and also fixed partial denture successfully. Recently use of FGP has been done in the fabrication of implant retained fixed partial dentures [9].

The technique so called FGP, can also be used either during the actual fabrication of the restorations or as a three dimensional checkbite technique to correct the completed restorations [10].

For overcoming some of the disadvantages of the conventional casting as well as the conventional functionally generated path technique, has some of the disadvantages, and to overcome, a double casting with FGP technique has been suggested. Double casting technique does not only provide a stable base for recording the occlusal paths, it also results in less dimensional inaccuracy in the casting [2].

An extrapolation of the published literature showed only one in vitro study showing the comparative evaluation between double casting technique and conventional casting technique for fixed prosthesis [2]. Further the study has not been conducted in vivo, hence, it was felt necessary to conduct an in vivo study between the double casting technique and conventional casting technique.

The null Hypothesis assumed were:

1. There is no significant difference in the height of casting obtained by conventional or double casting group.
2. There is no significant difference in time taken for occlusal correction by conventional or double casting group.
3. There is no significant difference in patient satisfaction for the crown obtained by the conventional and double casting.

Materials and Methods

Patients reported to the O.P.D of the Department of Prosthodontics, Crown and Bridge, K. M. Shah Dental College and Hospital, Piparia, Vadodara, were taken for the study. Ten patients were included in the study.

Study Design

Ethical approval to conduct the study was obtained from Institutional Ethics Committee, Sumandeep Vidyapeeth. Patients, who required Single unit Molar crowns, were selected for the study after they satisfied inclusive or exclusive criteria. Information about the study was provided to them through patient information sheet in the language they understood (English or Gujarati). An informed consent was then signed by the patient after whom the patient was included in the study.

In each patient two methods of generating the occlusal morphology and two methods of castings were employed. Grouping was done based on the technique used for generating occlusal anatomy and casting.

Group A: Conventional wax pattern fabrication and conventional casting technique,

Group B: Occlusal wax pattern fabricated by functionally generated occlusal morphology technique and a double casting technique.

Method Employed

In the initial appointment, a preliminary impression was made using irreversible hydrocolloid impression material (Imprint, DPI) and diagnostic casts were mounted on a semiadjustable articulator (Hanau-Wide Vue, Water Pik) using a face-bow transfer. Protrusive records were made using polyether bite registration paste (Jet Bite, COLTENE, WHALEDENT). The patient was trained to close in maximum intercuspation (MIP) and perform various other eccentric movements. [right lateral (RL) left lateral (LL) and protrusive (P)].

The tooth preparation for the restored teeth was done following the principles of tooth preparation given by Schillingburg et al. [11]. Gingival displacement was done using retraction cord (Sure Endo, Knitted, KOREA) and tetrahydrozoline HCl astringent (Visine) (Fig. 1). A Polyvinyl siloxane impression (Exaflex, GC,) was made using the putty reline technique. Temporization was made using Bisacryl Composite (Cool Temp, COLTENE, WHALEDENT) using Indirect Direct Technique and cemented using Temporary Cement (Temposil, COLTENE, WHALEDENT).

Preparation of Wax Pattern

Impression was poured using a Diestone (Elite Rock). The master die preparation was accomplished in the

Fig. 1 Tooth preparation with gingival retraction

Fig. 2 Preparation of conventional wax pattern

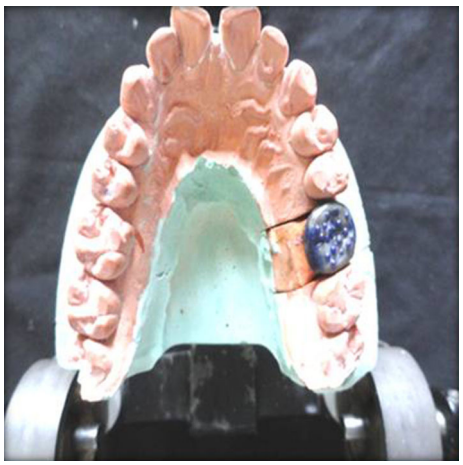

Fig. 3 Preparation of wax coping with retentive beads

conventional manner as suggested by Schillingburg et al. [11]. A metal ball bearing having a horizontal notch was luted to the die below the ditch with cyanoacrylate this then acted as a standard reference point for the future measurements. Die spacer (Duralon, Gold) was applied on the prepared tooth for creating space for luting cement. The die hardener (Coat All) was applied all over the prepared tooth and the adjacent area so that the die is not scraped while preparing wax pattern. At this stage two wax patterns were made.

Group A: Wax pattern was fabricated using inlay wax (Type II) (Delta Wax) in the conventional manner, with normal occlusal anatomy (Fig. 2). Before the wax pattern in Group A has been given for casting, the height of the wax pattern from a standard reference point on the die to the highest point on the occlusal surface of the molar [2] was measured using a Profile projector (BanBris, JT Series, 300 mm) (A1).

For Group B: Wax pattern was made with 1 mm occlusal clearance and retentive beads were placed (in wax) for aiding in the retention of the pattern resin during functional generation of the occlusal morphology [2] (Fig. 3). Both the wax patterns (Group A and B) were invested and cast using base metal alloy. After the castings were obtained, they were sandblasted and checked for accuracy of fit on the models and in the mouth. Any adjustments needed to ensure the fit was done. Fit of the crown was verified using the magnifying lens on the die.

Generation of FGP

In Group B, before generating the occlusal morphology it was ensured that the casting had adequate occlusal clearance and proper fit on to the prepared teeth. The occlusal morphology was generated using the Pattern Resin (GC,

Fig. 4 Functionally generated path with pattern resin metal coping with retentive beads

JAPAN) following the technique described by Dawson [10].

Pattern resin was mixed according to manufacturer's instructions and applied on the occlusal surface of the metal coping with retentive beads. The patient was instructed to close in maximum intercuspation position and then perform right lateral, left lateral and protrusive movements in succession ending in maximum intercuspation position. The excess pattern resin was trimmed off using an acrylic trimmer. The occlusal surface was examined for any exposure of the metal (Fig. 4). If present, the metal in the area was trimmed, pattern resin was added again in that area and movements were performed once again.

Once the occlusal morphology was perfected, the MIP contacts were marked using 50 μ blue articulating papers (Arti Fol, JAPAN). Zinc oxide powder (NeelKanth,

Fig. 5 Profile projector measuring crown height from midpoint of ball bearing to tip of the cusp

JODHPUR) was sprinkled and brushed onto the occlusal surface to form a thin uniform coat. Patients were instructed to perform the eccentric movements. All eccentric contacts were visible, with the wiping away of the zinc oxide powder. Care was taken not to grind the MIP contacts registered in blue. The wiped out areas were trimmed using an acrylic trimmer to eliminate all eccentric interferences and FGP patterns were completed [10].

After the elimination of all eccentric interferences the height of the casting along with the generated pattern was measured. The same standard point as used for the conventional wax pattern was used and readings were noted using the Profile projector (B1), where ball bearing was attached as standard point, and the distance was measured from the midpoint of the ball to the tip of the cusp (Fig. 5).

The pattern along with the base casting was invested and double casted. The sprue for both the conventional and double casting patterns were attached with care not to hinder with the points used for measurements. The casting procedure was accomplished in the conventional manner as suggested by Schillingburg et al. [11]. The castings obtained in both the groups were checked in the cast and measured for height using the standard reference points and the profile projector (A2 and B2). All the measurements were done before any occlusal corrections were made. The castings were tried individually and checked for accurate fit with an explorer tip on the prepared tooth in the patients.

A double blind protocol was adopted in this study. Both the patient and the operator who adjusted the crowns were blinded with regards to the technique used to adjust the crowns. The patient was asked for subjective symptoms by placing one casting at a time (before occlusal correction) to know which one feels more comfortable. The subjective findings were noted based on a Likert's 3 point scale:

0 No interference
1 Moderate interference
2 High interference

Once all the corrections were done for both the crowns, they were verified in the centric and in the eccentric i.e. right lateral, left lateral and protrusive. The clinical time taken for the entire occlusal correction from the beginning of the adjustment to the point when the intercuspation was achieved was noted for both the groups. The Single Unit Crown which was best comfortable and yielded the best articulation was cemented using glass ionomer cement (GC, Gold label). Data with respect to pattern height and casting height, time for adjustment, and subjective findings were subjected to statistical analysis.

Results

It was observed that the mean difference in the conventional group was 0.238 mm with a standard deviation of 0.021 mm. The difference was found to be much less in the double casting group with a value of 0.098 mm with a standard deviation of 0.014 mm (Table 1).

Statistical analysis of the intragroup ($P < 0.001$) and intergroup ($P < 0.001$) comparison resulted in a highly statistically significant difference in both conventional as well as double casting groups (Table 1).

Table 1 Summary statistics of change in height of castings (Mann–whitney test and paired *t* test)

Groups	Before	After	Difference	Significance	
	Al	A2	A2−A1	T	*P*
Conventional	11.603 ± 0.32	11.841 ± 0.33	0.238 ± 0.021	5.02	$P < 0.001$ HS
	Bl	B2	B2−B1		
Double casting	11.82 ± 0.36	11.918 ± 0.35	0.098 ± 0.014	3.66	$P < 0.001$ HS
Conventional V double casting			$P < 0.001$ HS		

The intergroup comparison of crowns (between conventional and double casting) was highly statistically significant, indicating a less change in the double casting group compared to the conventional ($P < 0.001$) (Table 1).

The clinical time taken for the occlusal correction with median was found to be 12.5 min for the conventional group whereas for the double casting group it was only 8.5 min. The mean differences for the conventional group was found to be 12.8 ± 2.74 and for double casting group it was found to be 7.8 ± 2.86 (Table 2). The Mann–Whitney test revealed a highly statistically significant difference between both the groups ($P < 0.001$) indicating significantly less time for correction needed in double casting (Table 2).

The patient's satisfaction (subjective data) data which was recorded using a three point scale (based on Likert scale) before occlusal correction of castings were tabulated for the conventional and double casting groups (Table 3). There was a highly significant difference between the scores before occlusal correction in both the groups ($P < 0.001$) (Table 3). The intergroup comparison also revealed statistically significant difference ($P < 0.01$) indicating more patient satisfaction for the double casting group (Table 3).

Discussion

In the natural articulation the mandibular teeth move over the maxillary teeth in a harmonious manner. The cusps move in the fossae and grooves between the opposing cusps, avoiding any interference during various mandibular movements. The FGP technique helps to overcome several obstacles in fabricating prosthesis in harmony without disturbing the stomatognathic system.

Table 2 Statistics of time taken for occlusal correction (Mann–whitney test)

Groups	Time (min)			*P* value
	Range	Mean + SD	Median	
Conventional	9–17	12.8 + 2.74	12.5	$P < 0.001$ HS
Double casting	2–11	7.8 + 2.86	8.5	

The functionally generated path technique utilizes a different approach to achieve occlusal harmony between the restoration and the other teeth in the mouth. It has been expressed as "three dimensional static expression of dynamic tooth movement" [12]. This technique uses a tracing made in the mouth to capture the pathways travelled by the opposing cusps in mandibular function, rather than employing an articulator to simulate the movements of the mandible. In this situation, the articulator is reduced to the role of a simple hinge [11]. The procedure can produce accuracy with fairly simple instrumentation, and it can be used in combination with almost any laboratory method for waxing posterior restorations. Whenever properly used, functionally generated path procedures are unsurpassed in accuracy and they require no compromise with the finishing of occlusal contours.

The conventional method for fabrication of fixed restorations has been popular since decades. Many inherent errors may occur at every step of fabrication in the conventional technique [2] like, from diagnostic impressions, using semi adjustable articulator, wax patterns and casting.

Rajgopal et al. [13] showed in their study that pattern resin undergo a significantly less dimensional change than the inlay waxes on prolonged storage when compared inlay casting wax.

In the present study, increase in height of the castings may be due to the investment expansion which was more compared as to the casting shrinkage. The intergroup comparison (between conventional and double casting) showed that though there was an increase in the height of castings for both the groups, the increase was relatively less for the double casting group when compared to the conventional group ($P < 0.001$), and the results were in agreement as shown by Minagi et al. [2]. Prashanti et al. [14] also showed in their case report that three unit fixed partial dentures showed that only minimal clinical adjustments of the bridge were required for the double casting technique when compared with conventional castings. The intergroup comparison of the crowns indicated a less increase for double casting group with a highly statistically significant difference ($P < 0.001$). So the first null hypothesis that there is no significant difference in the height of castings between conventional and double casting group gets rejected.

Table 3 Summary statistics of patients satisfaction (Chi square test and Mann–whitney)

Groups	Before scores			Significance	
	0	1	2	X2	*P*
Conventional	Nil	4 (40 %)	6 (60 %)	10.00	$P < 0.001$ HS
Double casting	3 (30 %)	7 (70 %)	0	10.80	$P < 0.001$ HS
Conventional V double casting	$P < 0.01$, s				

For the double casting group the decrease in the eccentric contacts was genuinely due to removal of eccentric interferences in the pattern resin, directly in the patients mouth. Hence it was observed that very minimal, and in some cases no eccentric interferences were present on the castings proper.

Carr and Brantley [15] showed in their study that there was a good union between the 2 castings since the same type of metal was used. Also, for the double casting method, the first casting serves as a rigid base to allow pattern resin to work on it. It also reduced the volume of the second casting and hence limited any unwanted effects such as distortion. The second casting completely encased in the first and filled any micro-defects that might occur in the first casting. It is logical to expect that there may not be adequate union between the two metals. However, naked eye observation of the casting in this study did not show such malunion/discrepancy of flow. In the present study the results obtained for the time taken for occlusal correction clearly indicate that the conventional castings had a considerable discrepancy and needed more time for correction, whereas for the double casting group, the morphology being more nearer to normal contacts during articulation, with the discrepancy in the casting being minimal, the time taken for correction was also drastically reduced. This has a definite role to play in the patient satisfaction. Henceforth, here the second null hypothesis also gets rejected as there is highly statistically significant difference for time taken for occlusal correction between conventional group and double casting group.

The patient satisfaction data which was assigned the scores 0, 1, 2 (no interference, moderate interference and high interference respectively) indicated that before occlusal correction, 30 % of the patients had a score 0 in the double casting group and none had the score 0 in the conventional group.

The rest 70 % cases of double casting group exhibited moderate interferences with a score 1. 40 % of the cases in the conventional group exhibited a score of 1. Majority of the cases (60 %) in the conventional group had high interference with a score 2.

These results indicate that, as the occlusal morphology for the double casting group was generated in the patients mouth and all eccentric contacts were checked and eliminated directly in the patients mouth, the chances for interferences were less. The moderate interferences, which were found in the 70 % of the cases, might be due to the casting discrepancy, which resulted in an increase in the height of the castings. For the conventional group, the occlusal morphology developed in the articulator cannot be as precise as the occlusion developed in the patient's mouth directly. It was also observed that the casting discrepancy was more for the conventional group. These reasons might have accounted for more interference in the conventional group leading to less patient satisfaction. Thus, third null hypothesis as stated there is no significant difference for patient satisfaction for conventional and double casting group gets rejected.

If this technique is carefully done, minimal occlusal adjustments are required during the clinical try-in stage, which is the major drawback of the conventional technique.

Conclusion

Within the limitations of the study, it shows that 1. The overall height of castings increased for the conventional and double casting groups when compared to the pre-existing height (patterns). The change in height of castings was less for the double casting group when compared to the conventional group. 2. The clinical time taken for occlusal correction was significantly less for the double casting group when compared to the conventional group. 3. The patient satisfaction data revealed better satisfaction for the double casting group compared to the conventional group.

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