Original Article

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Dentistry Section

Accuracy of Elastomeric Impression Made with Standard and Dual Arch Tray: An In-vitro Study

RUPAL JHANJI[1], SANJEEV MITTAL[2], SANDEEP GARG[3], JEEWAN BACHAN DHINSA[4], DEEPTI GARG[5], GAZAL SONI[6]

ABSTRACT

Introduction: The dual arch impression techniques utilise special stock impression trays of various designs. These trays are made of plastic or metal with fabric or mesh material placed across the occlusal surfaces of the teeth connecting their buccal and lingual flanges. These special trays register the impression of the opposing segments of the dentition. The dual arch impression technique is used in dentistry effectively since many decades but, there is very little evidence published regarding the effect of different tray design on the accuracy of impression.

Aim: To evaluate the accuracy of inter-abutment distance in dies obtained from different dual arch trays and with those obtained from stock metal trays.

Materials and Methods: This in-vitro study was carried out in the Department of Prosthodontics, M.M. College of Dental Sciences and Research, Mullana, Haryana, India between June 2016 to November 2017. A total of 70 elastomeric impressions using heavy and light body addition silicone impression material were made, of the prepared typodont teeth of right mandibular first premolar and first molar for three-unit fixed partial denture. impressions were grouped into four groups, based on the type of tray used i.e. Group A consisted of impressions obtained from plastic dual arch trays (n=20), Group B- plastic reinforced with metal dual arch trays (n=20), Group C- metal dual arch trays (n=20) and Group D-full stock metal trays (n=10). Group A, B and C were further divided into subgroup I (working side poured first) (n=10) and subgroup II (non working side poured first) (n=10) depending upon the sequence of pouring. The measurements were obtained using travelling microscope and statistical analysis was done using one way Analysis of Variance (ANOVA) test which was then followed by a Tukey's Post-Hoc test.

Results: The inter-abutment distance showed a decreased value in all the groups when compared to the master model (p-value >0.05). Percentage decrease in inter-abutment distance was between 0.006-0.48%. The results indicated statistical insignificant difference when full arch metal stock tray impression is compared to all dual arch trays impression. There was insignificant difference between the inter-abutment distance obtained using dual arch trays which were poured with working or non working side first.

Conclusion: The impressions obtained with both dual arch trays and stock tray, produced dies with distortion in a clinically relevant range. Thus, dual arch trays can be recommended for making impressions of short span fixed partial dentures, and can be considered to be an alternative to the conventional method.

Keywords: Die, Impression technique, Inter-abutment distance, Metal stock tray, Plastic tray

INTRODUCTION

The speciality of Prosthodontics has developed from the need to replace the missing dentition and associated structures. The registration of oral structures requires precision in the impression technique, an accurate impression material as well as a rigid impression trays to support the material. A dimensionally accurate recorded impression will account for the precise fit and longevity of the cast restoration [1]. The dual arch impression technique was first reported by Getz in 1951, using the reversible hydrocolloid as an impression material in water cooled impression trays [2]. Later, this technique was used for indirect restorations by Wilson EG and Werrin SR in 1983 [3]. The design of the double arch tray was conceived in 1979 and was registered in 1980 [4]. This procedure is alternatively may be called as closed-mouth impression, double-arch impression, or triple-tray impression [2].

Dual arch technique has several advantages over conventional techniques. It has shown to be more than or as accurate as conventional impressions in producing crowns with superior occlusal accuracy that required minimal adjustments at the time of delivery [5-7]. It simultaneously records the abutment, opposing teeth, adjacent teeth, and the maximum intercuspation position [8,9] at a 60% faster rate utilising 50% less material than a complete arch impression [4], thus, saving both time and money. In patients with hyperactive gag reflex, closed-mouth impressions are 80% more comfortable in comparison with open-mouth impression techniques [10]. It minimises the effects of clinical and technical variables such as flexure of mandible (resulting after elimination of 28% of maximum opening), [11] and iatrogenic errors in articulation [2].

Dual arch impression method is restricted to short span bridges and single unit crowns. The success with such techniques mostly depends upon the ability and diligence of the dentist in selecting an appropriate case with fewer teeth to be restored, a stable occlusion, intact teeth on either side of the abutment, an intact antagonist, canine-protected articulation with no cross arch interferences and an ability to close in maximum intercuspation [7,12]. Several studies evaluated the dimensional accuracy of dual arch technique in various dimensions but were limited to specific trays [13-16]. There is no evidence based data published regarding the comparison of conventional full arch technique and dual arch technique. Therefore, the purpose of the present study was to compare the accuracy of inter-abutment distance of the dies or casts generated from different types of dual arch and full arch trays.

MATERIALS AND METHODS

This in-vitro study was carried out in the Department of Prosthodontics and Crown and Bridge, M.M. College Of Dental Sciences and Research, Mullana, Haryana, India between June 2016 to November 2017. Before the commencement of laboratory study, the study design was approved by the Institutional Ethical Review Committee (Ref. No. MMDC/15/196 (42)).

Study Procedure

The 70 impressions were made using dual mix single step impression technique utilising heavy and light body addition silicone impression material and were grouped under four groups depending upon the type of impression tray used.

Group A: Impressions made with plastic quadrant dual arch trays.

Group B: Impressions made with plastic quadrant dual arch trays reinforced with metal.

Group C: Impressions made with metal quadrant dual arch tray.

Group D: Impressions made using full arch dentulous metal stock trays.

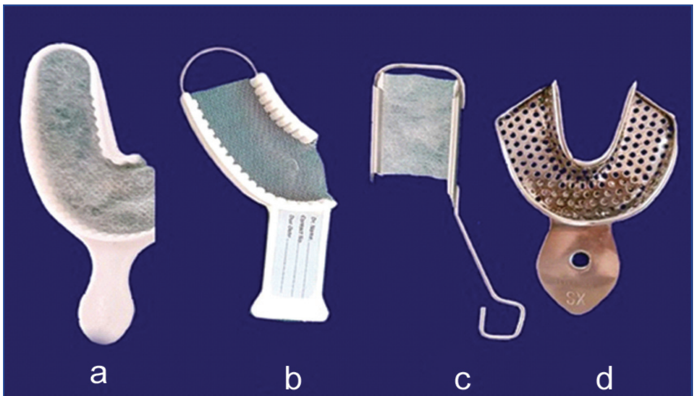
A sample size of 20 each was made for Group (A, B, C) and 10 for Group D yielding a total of 70 impressions. Group D was not further subdivided as impression was made in stock trays and it record only working side. Group A, B, C were further subdivided into subgroup I and subgroup II. In subgroup I, half (10) impressions were poured on the working side first and then the non working side was poured. In subgroup II, non working side was poured first followed by pouring of the working side after an hour. Working side is the surface of dual impression where tooth preparation is done, whereas the opposing occlusal surface of impression is non working side [16]. All the impressions (including group D) were poured in Type IV dental stone [Table/Fig-1].

Group	A	B	C	D
Type of tray used	Plastic dual arch tray	Plastic reinforced with metal dual arch tray	Metal dual arch tray	Full arch dentulous metal stock tray
Subgroup I (working side poured first)	10	10	10	-
Subgroup II (non working side poured first)	10	10	10	-
Total impressions	20	20	20	10

[Table/Fig-1]: Grouping of samples based on the type of impression tray used.

Tray Design

The dual arch trays come with a basic design that has a U-shaped frame with a piece of mesh that divides the tray in a superior-inferior dimension and connects the anterior and posterior sides of the tray. The mesh is fixed in plastic and the plastic is reinforced with metal trays and can be replaced in metal dual arch trays [Table/Fig-2].



[Table/Fig-2]: a) Plastic dual impression tray b) Metal reinforced plastic dual arch tray c) Metal dual arch tray d) Metal stock tray.

Preparation of Master Model

The typodont teeth were embedded in the API model bases of both maxilla and mandible from which the right mandibular second premolar was removed to simulate a three-unit fixed partial denture case. A conservative preparation was done on right mandibular first premolar and right mandibular first molar for a three-unit fixed partial denture. A dimple was prepared on the occlusal surface of both the abutment with a round bur in full length i.e. 1 mm (256; Brasselar, United States of America (USA)) that acted as a reference point for inter- abutment distance. The API models were then mounted on a Hanau wide vue semi-adjustable articulator in maximum intercuspation [Table/Fig-3] [16].

[Table/Fig-3]: Prepared master model, point A and B denotes the prepared dimple on the occlusal surface of both abutments, as a reference point for measurement of inter-abutment distance.

Impression Making Procedures

Impression making for Group A, B and C: Dual arch trays were used to make the impressions with heavy and light body elastomer (Dentsply, Aquasil) using dual mix and single step technique. It was made sure that there is maximum intercuspation and no interference during typodont closure as it may have resulted in distortion of the impression due to flexure of the trays. A double coat of tray adhesive was applied on the inner side walls and also extending it onto the outer walls by 2 mm, followed by drying it for 15 minutes to aid in better mechanical retention for the polyvinyl siloxane material [17].

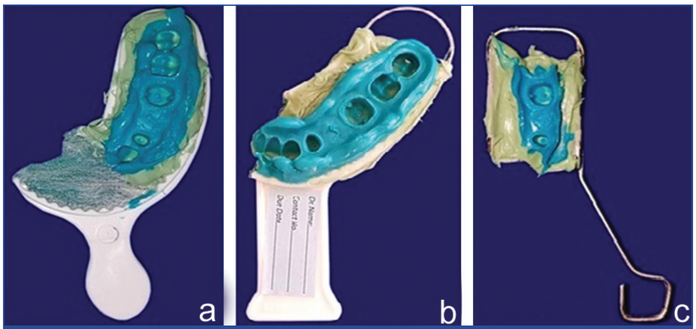
Heavy body was loaded on both sides of the dual arch tray and light body was dispensed onto the prepared teeth using auto mixed dispensing gun. A constant pressure of 1.5 kg was applied for the correct closure of the articulator which was then confirmed upon seeing the guide pin in a closed position [13,18]. The constant reproducible position of the impression trays was ensured by attaching the custom tray positioning jig to an articulator.

All the impressions were allowed to set on the master model for twice the recommended setting time in the mouth. This was in order to compensate for the polymerisation occurring at room temperature (25°C±2°C) rather than mouth temperature (32°C±2°C) in accordance with American Dental Association (ADA) specification no. 19. [19] The impressions were removed after 12 minutes and then rinsed for about 10 seconds under normal tap water and dried [18,20]. Thereafter, all impressions were stored at room temperature (25 °C) for one hour (h) before pouring. [Table/Fig-4] [21,22].

The die was allowed to set and was removed from the impression one hour after pouring. Die models were left at room temperature

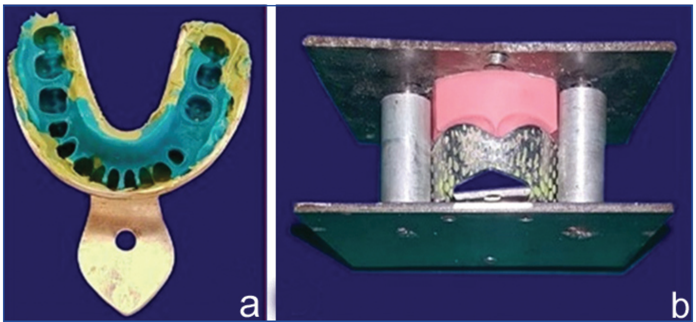
[Table/Fig-4]: Impression making with dual arch tray.

to dry. The procedure used for making impressions in group A, B, C was kept same except that, in group A plastic quadrant dual arch trays, in group B plastic dual arch tray reinforced with metal and in group C metal quadrant dual arch tray was used [Table/Fig-5].



[Table/Fig-5]: Dual arch impressions with heavy body light body.

Impression making for Group D: Full-arch dentulous stock metal tray was used to make impressions using dual mix and single step impression technique as discussed. For standardisation, the prepared master model was attached to an aluminum plate with the help of a screw attached to its base. It had three receiving holes two in the front and one in the back. The full metal stock impression tray was attached to the opposing plate with same dimensions as the first plate but with a difference, that it had three vertical guide pins sliding accurately in the receiving holes when seated on to the first plate while making an impression, thereby, resulting in controlled firm seating of the tray and providing uniform space for the flow of the impression material. A similar mould was used for standardisation in a study conducted by Hoyos A and Soderholm KJ [Table/Fig-6] [23].



[Table/Fig-6]: Impression made in a) Metal stock tray using, b) Custom jig.

Type IV gypsum (Ultrarock) was used in the ratio of 100 g of powder hand mixed for about 10 seconds with 20 mL distilled water followed by 40 seconds of vacuum mix before the samples were poured. Half of the impressions (10) were poured utilising 35 g of stone on the working side first while being vibrated to avoid air entrapment followed by pouring on the non working side after an hour using 35 g stone again [18,20] and vice versa. The poured impressions were retrieved after 24 hours.

Testing of the Samples and Measurement Procedure to Evaluate Linear Dimensional Change

The casts obtained were given a base with dental plaster and labeled according to their respective groups. The measurements were made using a travelling microscope for inter-abutment distance. Measurement were recorded from distal of dimple on the occlusal surface of the right mandibular first premolar abutment to the mesial of dimple on the right mandibular first molar abutment. The values obtained were statistically analysed.

STATISTICAL ANALYSIS

The collected data was subjected to statistical analysed with Statistical Package for Social Sciences (SPSS) software version 16.0. For multiple group comparisons, one way Analysis of Variance (ANOVA) test was used followed by an application of a Tukey's Post-Hoc. The statistical analysis was conducted at the 95% level of confidence and the significance of the linear dimensional changes were analysed at 5%.

RESULTS

All the groups showed a decreased inter-abutment distance (in mm) compared to that of the main master model value (15.536 mm). Group C non working (II) dual arch metal trays (15.5354 mm) produced the most accurate dies, followed by group B non working (II) plastic reinforced dual arch trays ((15.5181 mm), group C working (I) dual arch metal trays (15.5170 mm), group A non working (II) plastic dual arch trays (15.5153 mm), group B working (I) plastic reinforced dual arch trays (15.4857 mm), group A working (I) plastic dual arch trays (15.4798 mm) and then group D, full stock metal trays (15.4624 mm) [Table/Fig-7].

Groups	Mean	Std. Deviation	Std. Error	95% Confidence interval for mean	
				Lower bound	Upper bound
Group A					
Working (I)	15.4798[a]	0.10505	0.03322	15.4047	15.5549
Non working (II)	15.5153[a]	0.60709	0.02121	15.4673	15.5633
Group B					
Working (I)	15.4857[a]	0.05291	0.01673	15.4478	15.5236
Non working (II)	15.5181[a]	0.05913	0.01870	15.4758	15.5604
Group C					
Working (I)	15.5170[a]	0.09504	0.03005	15.4490	15.5850
Non working (II)	15.5354[a]	0.04410	0.01395	15.5038	15.5670
Group D	15.4624[a]	0.13151	0.04159	15.3683	15.5565

[Table/Fig-7]: Descriptive analysis of group A, B, C, and D along with their subgroups (I and II) for inter-abutment distance in mm.
a: denotes; Insignificant difference between similar superscript letters in a column

Percentage decrease in inter-abutment difference in groups A, B and C for working side (I) range between 0.12%-0.37% and for non working side (II) between 0.006%-0.14%. whereas for group D percentage change was 48%. When inter-abutment distance of all the groups was compared with the master model, the difference was statistically insignificant [Table/Fig-8], except for group B (I). Pouring the non working side first of dual arch tray yielded more accurate dies although the difference was statistically insignificant (0.787-0.991).

Master model (mm)	Sequence	Mean±SD (mm)	Mean Diff. (mm)	% Difference	t-value	p-value
15.536	**Group A**					
	Working (I)	15.479±0.100	0.057	0.37%	1.802	0.797
	Non working (II)	15.515±0.064	0.021	0.14%	1.038	0.787
	Group B					
	Working (I)	15.485±0.050	0.051	0.33%	3.225	**0.001**
	Non working (II)	15.518±0.056	0.018	0.12%	1.016	0.756
	Group C					
	Working (I)	15.517±0.090	0.019	0.12%	0.668	0.756
	Non working (II)	15.535±0.042	0.001	0.006%	0.075	0.991
	Group D	15.462±0.125	0.074	0.48%	1.871	0.831

[Table/Fig-8]: Post-hoc Test for comparison (inter-abutment distance) between master model for different groups.
bold p-values are significant

ANOVA for different groups and subgroups for comparison of inter-abutment distance was statistically insignificant (p-value=0.463) [Table/Fig-9]. Multiple group comparisons using Post-Hoc test were made between the group D and groups A, B, C. It was inferred that no statistically significant difference existed [Table/Fig-10]. So, difference between the impression made with full arch metal stock tray (group D) is statistically insignificant when compared with all the dual arch trays (group A, B, C).

Analysis	Sum of squares	Df	Mean square	F	p-value
Between groups	0.041	6	0.007	0.955	0.463
Within groups	0.451	63	0.007		
Total	0.492	69			

[Table/Fig-9]: ANOVA for different groups and subgroups for comparison of inter-abutment distance.

(I)	(J)	Mean difference (I-J)	Std. Error	p-value
A Working (Subgroup I)	Group A (Non working)	-0.03550	0.03784	0.989
	Group B (Working)	-0.00590	0.03784	1.000
	Group B (Non working)	-0.03830	0.03784	0.984
	Group C (Working)	-0.03720	0.03784	0.986
	Group C (Non working)	-0.05560	0.03784	0.901
	Group D	0.01740	0.03784	1.000
A Non working (Subgroup II)	Group B (Working)	0.02960	0.03784	0.996
	Group B (Non working)	-0.00280	0.03784	1.000
	Group C (Working)	-0.00170	0.03784	1.000
	Group C (Non working)	-0.02010	0.03784	1.000
	Group D	0.05290	0.03784	0.921
B Working (Subgroup I)	Group B (Non working)	-0.03240	0.03784	0.993
	Group C (Working)	-0.03130	0.03784	0.994
	Group C (Non working)	-0.04970	0.03784	0.941
	Group D	0.02330	0.03784	0.999
B Non working (Subgroup II)	Group C (Working)	0.00110	0.03784	1.000
	Group C (Non working)	-0.01730	0.03784	1.000
	Group D	0.05570	0.03784	0.901
C Working (Subgroup I)	Group C (Non working)	-0.01840	0.03784	1.000
	Group D	0.05460	0.03784	0.909
C Non working (Subgroup II)	Group D	0.07300	0.03784	0.713

[Table/Fig-10]: Post-Hoc test for multiple group and subgroup comparison (inter-abutment distance).
Non significant -p>0.05, Significant- p<0.05

DISCUSSION

The dual arch impression technique described by Wilson EG and Werrin SR [3] is used popularly because of its simple design, as it makes both the maxillary and mandibular interocclusal records at once and hence, is very time efficient and comfortable to both the patient and practitioner [7,18]. Also, it is a closed-mouth technique that records an impression when teeth are firmly held in maximum intercuspation position eliminating the problems associated with the flexure of mandible [18,24]. It is a challenge to evaluate whether the patient has closed into maximum intercuspation [3]. Another difficulty is the distortion of the impression if the tray extension is short since it will not be able to support the weight of the die stone which will result in inaccurate dies [9].

In the present study, polyvinyl siloxane material (heavy and light body) was used to make impressions with dual mix technique. The similar combination of impression material i.e. heavy and light body addition silicone was also used by Parker MH [5], Cox JR [7], Breeding LC and Dixon DL [14], Ceyhan JA et al., [18] in their studies. Many authors like Wostmann B et al., [15] and Mitchell ST et al., [25] used polyether, while Reddy NR et al., [16] and Bansal S et al., [26] used putty and light body for making impressions with dual arch trays.

The measurements were made using travelling microscope with 0.01 mm resolution. Breeding LC and Dixon DL [14] and Reddy NR et al., [16] used travelling microscope for measuring the dimension of their samples. In agreement with the present study Reddy JM et al., [11], Bansal S et al., [26] and Kulkarni PR et al., [27] also showed decreased inter-abutment distance. This decrease in distance might have been a result of the polymerisation shrinkage of the polyvinyl siloxane impression material mostly occurring towards the centre. The application of tray adhesive is usually more towards the walls and not interproximally which results in stretching of the material (like a rubber band) in a bucco-lingual dimension that will eventually result in decreased mesio-distal dimension and hence, a decreased inter-abutment distance.

The pouring of the non working side first resulted in dies with an increased dimension and values more close to the master model. So, pouring the non working side first resulted in more precise dies than pouring the working side first. However, the difference observed was statistically insignificant, the reason lays in the compensation of the polymerisation shrinkage by the weight of the die stone that result in a little deflection of the impression material at the unsupported terminal end of the tray. These results were similar to the studies conducted by Reddy JM et al., [11], Kulkarni et al., [27] and Cayouette MJ et al., [28].

No significant difference was found when inter-abutment distance of all groups were compared to the value obtained from the master model. The dimensional change percentage when non working side was poured first lie between 0.006%-0.14% whereas for the impressions that were poured on the working side first showed a change between 0.12%-0.48%. According to the reports by International Dental Standards, the maximum linear dimensional change is seen to be 1.5% and the expected contraction value is considered to be in between 0.05 and 0.15% [29].

The comparison between different dual arch trays showed that the metal dual arch trays produced dies with dimensions closer to that of the master model value (15.536 mm). These results were in agreement with the studies conducted by Reddy JM et al., [11], Ceyhan JA et al., [18], Bansal S et al., [26] and Davis RD and Schwartz RS [30] which stated that metal dual arch trays can be used for making accurate dies for inter-tooth distances and are preferred over plastic dual arch trays. However, no statistical significant difference was observed.

The stock full metal trays produced the least accurate dies when compared to that of the other three groups, which was in agreement with the results of a study conducted by Reddy JM et al., [11]. This may be due to the polymerisation shrinkage affecting both the horizontal and vertical component that indicates a lateral shift subjectively, whereas, it is not the case in a three dimensional dual arch impression. Also, the amount of material used in a stock tray is more as compared to a dual arch tray. According to Parker MH [5] an error in a full arch impression cast produces six times larger standard deviation when compared to a cast obtained with dual arch impression trays.

The results of the present study also contradicts the conclusion that flexibility of a tray plays a major role in obtaining an accurate dual arch impression as stated in the studies conducted by Cox JR [7] and Kaplowitz GJ [8]. However, it is in favor of the results compiled by Wasell RW and Ibbetson RJ [31] who inferred that flexure of a tray during impression making is not the sole reason leading to the distortion of the dies.

The results of the present study showed that dual arch trays perform better than full metal stock trays, even though there was statistically insignificance difference (p-values=0.713-1.00). The change in dimensions are not only because of the tray deformation or impression material/technique but is also attributed to the linear expansion of stone. The reported expansion in stone is 0.08% to 0.1% which brings in a positive effect by compensating the shrinkage of the impression material. However, the difference in the magnitude is clinically insignificant and can be compensated by coating the surfaces that are narrower with a die spacer (single coat) of varying thickness between 8-40 μm [11] in order to mask the undersized dimensions especially in the mesio-distal direction, where two coats can be applied for better fit and results of the fabricated prosthesis.

Limitation(s)

In the present study, the change in dimension was evaluated in a mesio-distal direction only. Hence, the change in bucco-lingual and inciso- cervical dimensions should also be considered for analysing the accuracy of impression trays. While testing on the travelling microscope, it was difficult to accurately locate the measurement points on the casts which might have resulted in a measurement error even if the points are well-defined. The influence of saliva and the bite pressure exerted on the dual arch trays are assessed better in an in-vivo set up.

CONCLUSION(S)

There was insignificant decrease in inter-abutment distance in cast obtained from all impression trays when compared to the master model. Any side of dual arch tray i.e. working or non working side can be poured first as difference was non significant. When inter-abutment distance obtained in full arch metal stock tray is compared with that of all dual arch tray impression, results was statistically insignificant (p>0.05). The dies obtained from all the impression trays were within the clinical standard to make clinically successful prosthesis. The flexibility of the dual arch tray has no major role in the distortion of the impression. So, the plastic or metal dual arch trays can be considered as an alternative to metal full arch stock trays for making impressions of short span Fixed Partial Dentures (FPDs).

To widen the vistas of using dual arch trays, further studies should be conducted about the changes in bucco-lingual, inciso-cervical and cross-arch dimension utilising different types of impression materials, impression techniques, so as to further analyse the perspective of using dual arch trays.

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PARTICULARS OF CONTRIBUTORS:
1. Consultant, Department of Prosthodontics Including Crown and Bridge, Maharishi Markendeshwar College of Dental Sciences and Research, Mullana, Haryana, India.
2. Professor, Department of Prosthodontics Including Crown and Bridge, Maharishi Markendeshwar College of Dental Sciences and Research, Mullana, Haryana, India.
3. Professor and Head, Department of Prosthodontics Including Crown and Bridge, Maharishi Markendeshwar College of Dental Sciences and Research, Mullana, Haryana, India.
4. Senior Lecturer, Department of Prosthodontics Including Crown and Bridge, Maharishi Markendeshwar College of Dental Sciences and Research, Mullana, Haryana, India.
5. Senior Lecturer, Department of Prosthodontics Including Crown and Bridge, Maharishi Markendeshwar College of Dental Sciences and Research, Mullana, Haryana, India.
6. Senior Lecturer, Department of Prosthodontics including crown and Bridge, Maharishi Markendeshwar College of Dental Sciences and Research, Mullana, Haryana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Sanjeev Mittal,
Professor, Department of Prosthodontics Including Crown and Bridge, Maharishi Markendeshwar College of Dental Sciences and Research, Mullana, Haryana, India.
E-mail: ambaladental@yahoo.com

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