Evaluation of Discrepancy in Margin Adaptation of Metal Copings Fabricated by Conventional Casting, CAD/CAM And Direct Metal Laser Sintering- A Comparartive In-Vitro Study.

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ABSTRACT

Objectives: To evaluate the marginal fit of metal copings fabricated by casting, to evaluate the marginal fit of metal copings fabricated by CAD/CAM, to evaluate the marginal fit of metal copings fabricated by Direct Metal Laser Sintering and To compare the marginal fit of metal copings fabricated by casting, CAD/CAM and Direct Metal Laser Sintering.

Methodology:A total 30 copings were fabricated on a CAD milled die which was received by scanning a prepared mandibular 1st molar typhodont tooth. Out of the 30 copings ,10 copings were obtained by casting, 10 copings by direct metal laser sintering and 10 copings by CAD/CAM. The 30 copings that were obtained from three different fabrication technique were then evaluated for marginal discrepancy. The copings were not cemented on the master die model to obtain standardization for all copings. The marginal discrepancy were then evaluated and calculated with help of image analyzer attached to the stereomicroscope on four sides that is mesial, distal, buccal and lingual.

Results: The statistical analysis revealed that the maximum discrepancy was seen in Group A which were copings fabricated by casting with mean marginal discrepancy value of 56.875 μm, then followed by CAD/CAM with mean marginal discrepancy value of 31.175 μm and the least marginal discrepancy value were seen in group C which were copings fabricated by Direct Metal Laser Sintering with mean marginal discrepancy value of 24.4 μm. There was not much difference between Group B and Group C which were copings fabricated by CAD/CAM and Direct Metal laser Sintering with the difference being 6.775 μm between the two groups. However in contrast the mean marginal discrepancy value between Group A and group B were statistically significant with mean difference of 25.7 μm and also between group A and group C with mean difference of 32.475 μm.

Conclusion: The mean marginal discrepancy observed in all the three groups were within the clinical accepted range (100-120 μm) but it can be concluded that in order to have optimum results we can opt for Direct Metal Laser Sintering technique or CAD/CAM as a technique for fabrication of metal copings.

Introduction

Long term clinical success of fixed prosthodontic restorations is influenced by many factors and the most important factor being the marginal integrity. The other factors that might affect the fit of a restoration include preparation type and taper, the amount of cement used, the pressure during cementation and the viscosity of the cement. Marginal discrepancies may challenge the survival rate of the restoration by causing dissolution or washout of the cement or luting agent and later sensitivity of the vital prepared tooth leading to failure of prosthesis. (1) .

It is a common accepted dogma that ill-fitting restorations or crowns with imperfect margins either with gap or over/under contoured restorations are potentially harmful for abutment teeth and supporting periodontium as it can provide an area and host bacteria and plaque which can result in secondary caries, gingival irritation or progression of periodontal disease. (2) Microleakage through the dentinal tubules towards the pulp chamber may lead to pulpitis ultimately subjecting the underlying abutment to endodontic treatment. Restoration itself can be affected by poor margin as improper fitting or discrepancies can create stress concentrations which may reduce the strength and long term success of the restoration.(3) A fixed dental prosthesis with good marginal fit will however reduce the risk of any of the above mentioned complications and ultimately would result in a more predictable outcome. The fabrication technique or systems may influence the characteristics of the finished framework such as their surface or marginal and internal fit. Now with the regular studies, development in material science and the efforts to eliminate casting defect factors we have an alternative to the conventional method of producing dental restorations i.e. CAD/CAM and Direct metal laser sintering technologies, which has been developing over the past several years and is now already a part of dental laboratories. Both subtractive and additive production are included among CAD/CAM technologies. The dental prosthesis fabricated by conventional casting technique or lost wax technique depends on the experience and ability of the technician while CAD/CAM system has advantage of having a reduced influence of the dental lab technician. While Laser sintering is a computer controlled, precise additive process that ensures consistent work quality, the CAD/CAM process of producing copings by DMLS technique using automated scanning process and powerful CAD software offers many advantages such as complete control over the framework and coping designing, margin placement, cement space maintenance, coping thickness and pontic designs as well as elimination of casting procedures.

DMLS is an additive manufacturing metal fabrication technology, occasionally referred to as Selective Laser Sintering (SLS) or Selective Laser Melting that generates metal prototypes and tools

directly from computer aided design (CAD) data. The model is scanned and the crown/bridge is designed using CAD design and sent to the central processing unit. The basic principle of the SLS technique is to produce prostheses layer by layer according to their shapes by selectively fusing metal powder through computer-aided laser control. This offers several advantages over the conventional CAD/CAM technique, and it also saves raw materials and requires fewer tools. (9,10)

There is considerable evidence regarding accuracy and efficacy of the conventional technique but literature lacks evidence when it comes to a comparison between the conventional and latest techniques ie., CAD/CAM and Direct metal laser sintering. Therefore the present study was done to compare the marginal discrepancies of copings fabricated by casting, CAD/CAM and Direct metal laser sintering.

Methodology

For the purpose of the study 30 metal copings were fabricated from a CAD milled master die following three different techniques which were conventional casting ie., lost wax technique, CAD/CAM and Direct Metal Laser Sintering. The copings thus obtained were divided into three groups as mentioned below:

Group A- 10 copings fabricated by conventional casting ie.,lost wax technique

Group B- 10 copings fabricated by CAD/CAM

Group C- 10 copings fabricated by Direct metal laser sintering

For fabrication of copings a mandibular typodont set with mandibular 1st molar simulating a preparation of a metal crown with a chamfer finish line was used. After the preparation the typodont in the mandibular 1st molar was scanned in order to generate a virtual model which was used to produce a standardized CAD milled die for future production of the copings to be used in the study.

Figure:10 Buccal view of master die in typodont

Figure:11 Lingual view of master die in typodont

For the purpose of standardization, the copings were designed using the CAD software after scanning the master die using MeditIdentica dental 3D scanner. The design thus obtained was used to mill the wax for the purpose of casting, to mill the cobalt chromium metal and the same specification were used to fabricate the Metal laser sintering copings. 10 copings were obtained using the above mentioned topics which are conventional casting (lost wax technique), CAD/CAM and Direct Metal Laser Sintering.

Figure:13 Cast Metal copings seated on die (Buccal aspect)

Figure:14 Cast Metal copings seated on die (Lingual aspect)

Figure:15 Metal copings fabricated by casting (n=10)

Marginal gap was measured using a stereomicroscope. A point was premarked in the master die with the help of the marker and all copings were evaluated at the predetermined points ie., buccal, lingual, distal, mesial. The copings were not cemented to the master model or die to obtain standardization for all copings and the marginal gap were then calculated with the help of image analyzer attached to the stereomicroscope at the marked points on each four side of the master die.

Results

Each sample was evaluated under stereomicroscope microscope at four points viz. mesial, distal, buccal and lingual. The marginal discrepancy was calculated with the help of image analyzer attached to the stereomicroscope.

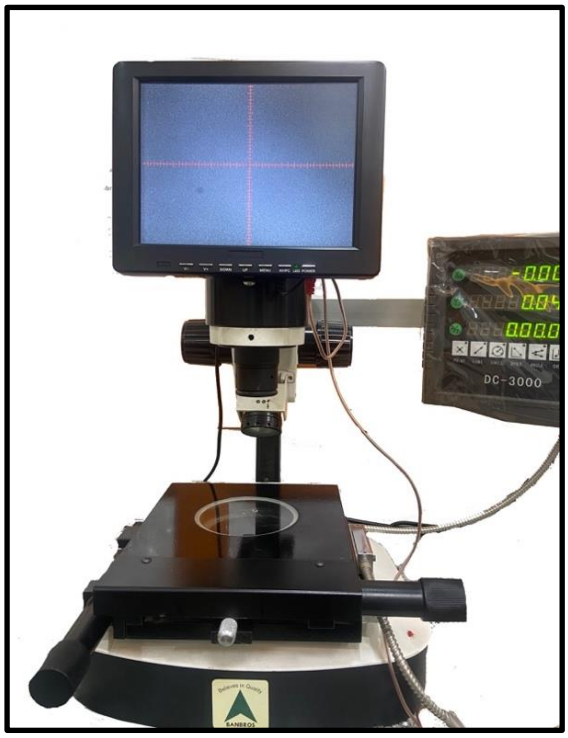

Figure:9 Stereomicroscope attached to image analyzer

The results thus obtained were entered in excel sheet and subjected to statistical analysis. Data analysis was done using STATA version 14 (Statacorp Texas, USA). The marginal discrepancy values observed in each group were recorded as a continuous variable and expressed as mean and standard deviation. Then ANOVA followed by Post hoc test was used as the test of significance for comparing the marginal discrepancy values in each group. A *P*-value <0.005 was considered as statistically significant.

Table 4: Mean marginal Discrepancy Value and Standard Deviation for all three Groups (Group A, B and C)

GROUP	**MEAN**	**SD**
CAST SAMPLES	56.875	4.5449147
CAD/CAM SAMPLES	31.175	4.5537683
DIRECT METAL LASER SINTERING SAMPLES	24.4	2.5391381

(n=30)

Table 4 shows the mean marginal discrepancy values and standard deviation of each group ie., Group A (casting), Group B (CAD/CAM), Group C (Direct Metal Laser Sintering)(n=30).

TABLE 5: One-way ANOVA

SOURCE	**SUM OF SQUARES**	**DEGREE OF FREEDOM**	**F**	***P*-VALUE**
BETWEEN GROUPS	5870.05417	2	184.05	<0.001
WITHIN GROUPS	430.5625	27	15.9467593	

(*P* = <0.001)

Table 5 Depicts the one-way analysis of variance among the three test groups ie., Group A (Casting), Group B (CAD/CAM) and Group C (Direct Metal Laser Sintering) which revealed a statistically significant difference between all three test groups.

TABLE 6: Test of Significance for the Mean Marginal discrepancy observed from all three test Groups (Post hoc test).

GROUP	**MEAN**	**SD**	**MEAN DIFFERENCE**	***P*-VALUE**
CAD/CAM	31.175	4.5537683	25.7	<0.001
Casting	56.875	4.5449147		

GROUP	**MEAN**	**SD**	**MEAN DIFFERENCE**	***P*-VALUE**
Casting	56.875	4.5449147	32.475	<0.001
DMLS	24.4	2.5391381		

GROUP	**MEAN**	**SD**	**MEAN DIFFERENCE**	***P*-VALUE**
DMLS	24.4	2.5391381	6.775	0.002
CAD/CAM	31.175	4.5537683		

Table 6 shows the test of significance between the three test groups which reveals:

Group A with mean marginal discrepancy value of 56.875 μm when compared with Group B of mean marginal discrepancy value 31.175 μm shows a mean difference of 25.7μm.

Group A with mean marginal discrepancy value of 56.875 μm when compared with Group C of mean marginal discrepancy value 24.4 μm shows a mean difference of 32.475 μm.

Group B with mean marginal discrepancy value of 31.175 μm when compared with Group C of mean marginal discrepancy value 24.4 μm shows a mean difference of 6.775 μm.

The statistical analysis above thus reveals that the maximum discrepancy was seen in Group A which were copings fabricated by casting with mean marginal discrepancy value of 56.875 μm, then followed by CAD/CAM with mean marginal discrepancy value of 31.175 μm

and the least marginal discrepancy value were seen in group C which were copings fabricated by Direct Metal Laser Sintering with mean marginal discrepancy value of 24.4 μm. There was not much difference between Group B and Group C which were copings fabricated by CAD/CAM and Direct Metal laser Sintering with the difference being 6.775 μm between the two groups. However in contrast the mean marginal discrepancy value between Group A and group B were statistically significant with mean difference of 25.7 μm and also between group A and group C with mean difference of 32.475 μm.

Discussion

Precisely fitting casting or prosthesis is an important objective while fabricating a prosthesis because the procedure or technique to fabricate an accurate casting is complex and passes through multiple steps which may have the effect on the dimensions and therefore affecting the final fit of the prosthesis.

The marginal fit is one of the important criteria when evaluating the clinical acceptability of the crown/retainer and its accuracy is an important factor in the success and longevity of the restoration. (shillingburg 1987, 20,12, 59') Ideally a crown margins should harmonize with the prepared finish margin of the tooth to achieve absolute marginal integration. But clinically it is not possible as a cement is used to fix the prosthesis (crown/retainer) and the cement particle thickness requires the space. Hence a minimal marginal gap is accepted, a marginal gap of about100-120 μm for good prognosis.

Usually the increase in internal gap will lead to compromised retention of the restoration and the vertical gap between the restoration and tooth preparation margin in the oral environment will quantify the fit of the restoration as this marginal gap if present in excess may become a host for microorganisms and their harmful products causing gingival inflammation, recurrent caries and pulpal lesions leading to failure of prosthesis. (1, 2, 18, 19)

Marginal fit may depend on various factors like geometry of tooth preparation, adaptation of the castings, luting cement used and margin configuration . Choosing the right fabrication method is an important factor that helps to minimize error by reducing or eliminating complex procedures that add to fabrication errors or defects.

Considering the importance of the factor (ie., technique) affecting the marginal fit of a crown/retainer the present research work focused on evaluating and comparing the three techniques of fabricating the metal copings ie., Casting, CAD/CAM and Direct Metal Laser Sintering.

Lost wax technique for casting alloys is a widely used and accepted technique but the method is technique sensitive.(21, 59) Many technical errors such as damage to the margins on die while trimming, excessive thickness of die spacer, inaccurate wax adaptation, incorrect investing and casting failures may occur using this technique. Inherent material related properties of casting also may cause casting inaccuracies such as the pattern material wax/resin shrinkage and stress relaxation properties. Now with the introduction of CAD/CAM systems, wax patterns can be milled more accurately than conventional technique eliminating any chance of incorrect wax adaptation. Another advantage of CAD/CAM and Direct Metal Laser Sintering techniques is

the complete elimination of casting procedure variables where the required crown or prosthesis is fabricated by milling and sintering of the alloys respectively and thus avoiding all technical errors of casting which might be incorporated above.

In the present study in order to standardize the procedure and reduce the number of variables involved in the entire process only one master die was fabricated and all 30 copings were fabricated by scanning the single master die. A mandibular 1st molar typodont tooth was prepared for a metal crown with chamfer finish line. This was scanned in order to generate a virtual model which was used to produce a CAD milled die. This die was taken as standard master die and this master die was then used for fabricating all 30 copings of three different groups where 10 copings were obtained by casting, 10 copings by CAD/CAM and 10 copings by Direct Metal Laser Sintering. The copings were designed using the CAD software after scanning the master die. The design thus obtained was used to mill the wax for the purpose of casting (Group A), to mill the cobalt chromium metal (Group B) and to fabricate the Metal laser sintering copings (Group C). The 30 copings obtained from three different fabrication technique were then evaluated for marginal discrepancy.

There are various method to evaluate the marginal discrepancy like cross sectional method, silicone replica technique, radiography, explorer and visual examination and microscopes.

In the present study visual examination using stereomicroscope attached to image analyzer was chosen as the method of evaluation as it is a non-destructive, non-radioactive method and capable of providing reproducible results anytime with high resolution images.

This study after marginal discrepancy evaluation showed a mean marginal discrepancy value of 56.87 μm for Group A (casting), 31.18μm for Group B (CAD/CAM) and 24.4 μm for Group C (Direct Metal Laser Sintering).

The reason for high marginal discrepancies in Group A (casting) maybe due to wax distortion or shrinkage of wax pattern or in some cases expansion of mold and casting errors and finishing and polishing errors. Copings fabricated using lost wax technique are said to be most likely adjusted since the process of casting creates an oxide layer and there is always risk of casting fins, rough surfaces and gas porosities which affects the final fit of the copings (54) While Group B (CAD/CAM) and Group C (Direct Metal Laser Sintering) showed a lower marginal discrepancy value which could be because CAD/CAM and Direct Metal Laser Sintering techniques use automated scanning procedures and CAD software to fabricate the copings which offers advantages such as control over the framework and coping designing and thus avoiding the manual errors and distortions inherent to casting procedures. Direct Metal Laser Sintering showed the lowest value of marginal discrepancy which could be due to precise and rapid solidification of cobalt chromium powder occurring in small sections which minimizes the chances of shrinkage of the alloyIn Direct Metal Laser Sintering the framework is build in a series of successively thin layers in the range of 0.02-0.06 mm.

Marginal gap according to ADA specifications defined the “clinical

acceptance of bonded prosthesis" as being less than 25 μm. However such gaps are not possible to obtain clinically. Different authors have given different values for clinically accepted range of marginal discrepancy. Mclean and Fraunhofer examined more than 1000 crown over a period of five years and concluded that the marginal opening with 100-120 μm were clinically acceptable while Hung et al suggested a marginal value of 50-75 μm as clinically acceptable.. Christensen concluded that the range of opening for clinically acceptable margins was from 2-119 μm depending on the location of the margin. White SN in his study concluded that marginal fit values of 55 μm or less were acceptable and Dedmon in his study concluded that mean uncemented marginal openings by group of prosthodontists were 106 and 96 μm for vertical and horizontal openings. Ivy S Schwartz in his article on review of methods and techniques to improve the fit of cast restorations concluded that marginal discrepancies ranging from 10 to 160 μm were considered clinically and radiographically acceptable. Aboutara et al also conducted an vivo study and sixty restorations were placed in 39 patients and follow up done after 6 and 12 months for a period of 47 months where they concluded that marginal accuracy ranged from 74 to 99 μm with failure rate of 1.7 % after 47 months. (31, 32,) Thus the clinical acceptance of marginal discrepancy varies with different authors and their studies. The results revealed in this in-vitro study are in agreement with the above mentioned authors and marginal discrepancy values of all 30 copings fabricated by casting technique, CAD/CAM and Direct Metal Laser Sintering are all within the clinically acceptable range (<120μm) with mean marginal discrepancy value of 24.4 μm for Direct Metal Laser Sintering, 31.18 μm for CAD/CAM and 56.88 μm for casting technique. Direct Metal Laser Sintering copings showed the lowest marginal discrepancy value and highest marginal discrepancy value was seen in copings fabricated by casting technique. For CAD/CAM fabricated copings mean marginal discrepancy value did not vary much from mean marginal discrepancy value obtained from Direct Metal Laser Sintering but were statistically significant from the mean marginal discrepancy values obtained from casting technique. The results obtained in this study thus rejects our null hypothesis and accepts the alternate hypothesis.

Conclusion:

Based on the evaluation and data obtained from this study the conclusions could be drawn that the mean marginal discrepancy observed in all the three groups were within the clinical accepted range (100-120 μm) but it can be concluded that in order to have optimum results we can opt for Direct Metal Laser Sintering technique or CAD/CAM as a technique for fabrication of metal copings. However, the evidence generated from randomized controlled trials is expected to generate evidence of high strength.[33]

References

1. Neppelenbroek KH. The clinical challenge of achieving marginal adaptation in direct and indirect restorations. J Appl Oral Sci. 2015;23(5):448-449. doi:10.1590/1678- 77572015ed005

2. Shenoy A, Babannavar R, Shenoy N. Periodontal considerations determining the design and location of margins in restorative dentistry. J Interdiscip Dent. 2012;2(1):3. doi:10.4103/2229-5194.94184
3. Nawafleh NA, Mack F, Evans J, Mackay J, Hatamleh MM. Accuracy and reliability of methods to measure marginal adaptation of crowns and FDPs: A literature review. J Prosthodont. 2013;22(5):419-428. doi:10.1111/jopr.12006
4. Ligthelm, William A. Wiltshire, Maryna R. Ferreira AJ. Allergies to dental materials. Quintessence Publ Co. 1996;27(8):513-520.
5. Wataha JC. Alloys for prosthodontic restorations. J Prosthet Dent. 2002;87(4):351- 363. doi:10.1067/mpr.2002.123817
6. Fusayama T. Factors and technique of precision casting part I. J Prosthet Dent. 1959;9(3):468-485. doi:10.1016/0022-3913(59)90080-0
7. Anand Porwal, Meenakshi Khandelwal, Vikas Punia VS. effect of denture cleanser on color stability, surface roughness and hardness of denture base resins. J Indian Prosthodont Soc. 2017;17(1):61-67. doi:10.1016/0022-3913(59)90081-2
8. Shenoy V, Prabhu Mb. Computer-aided design/computer-aided manufacturing in dentistry – Future is present. J Interdiscip Dent. 2015;5(2):60. doi:10.4103/2229-5194.173229
9. Venkatesh KV, Nandini VV. Direct metal laser sintering: A digitised metal casting technology. J Indian Prosthodont Soc. 2013;13(4):389-392. doi:10.1007/s13191-013- 0256-8
10. Denti L. Evaluation of performance of cast and laser-sintered cr-co alloys for dental applications. Int J ApplEng Res. 2017;12(13):3801-3809.
11. Christensen GJ. MARGINAL FIT OF GOLD INLAY CASTINGS. Int Assoc Dent Res. 1966;16(2):298-305.
12. Sandru Basso Bitencourtisabela A catanoze. effect of acidic beverages on surface roughness and color stability of artificial teeth and acrylic resin. J Adv Prosthodont. 2020;12(2):55-60.
13. Maria Gawriolek MS. How does the color of restorative material change during exposure to dietary liquids due to accquisition of a discolored layer. coatings. 2020;10(sep):866-880. doi:10.1016/0022-3913(90)90260-J
14. Syu JZ, Byrne G, Laub LW, Land MF. Influence of finish-line geometry on the fit of crowns. Int J Prosthodont. 1993;6(1):25-30.
15. Shane N. White Bd. In Vivo Marginal adaptation of cast crowns luted with different cements. J Prosthodont Dent. 1995;(July):25-32.
16. Zheng SX, Li J, Sun QF, et al. In vitro evaluation of the marginal integrity of CAD/CAM interim crowns. J Dent. 2007;35(1):68-73. http://dx.doi.org/10.1016/j.prosdent.2015.04.001%0Ahttp://www.scielo.br/scielo.php?script=sci_arttext&pid=S1678-77572016000300258&lng=en&tlng=en%0Ahttp://dx.doi.org/10.1016/j.jpor.2016.01.003%0Ahttp://dx.doi.org/10.1016/j.jpor.2017.09.002%0Ahttp://dx.doi.
17. Kokubo Y, Ohkubo C, Tsumita M, Miyashita A, Von Steyern PV, Fukushima S. Clinical marginal and internal gaps of ProceraAllCeram

crowns. J Oral Rehabil. 2005;32(7):526-530. doi:10.1111/j.1365-2842.2005.01458.x

18. Ahmad PA and. Effect of Preparation Design on Margin Gap of Metal-ceramic Restorations. Published online 2008:665-668.
19. Tan PL, Gratton DG, Diaz-Arnold AM, Holmes DC. An in vitro comparison of vertical marginal gaps of CAD/CAM titanium and conventional cast restorations. J Prosthodont. 2008;17(5):378-383. doi:10.1111/j.1532-849X.2008.00302.x
20. Quante K, Ludwig K, Kern M. Marginal and internal fit of metal-ceramic crowns fabricated with a new laser melting technology. Dent Mater. 2008;24(10):1311-1315. doi:10.1016/j.dental.2008.02.011
21. Lee KB, Park CW, Kim KH, Kwon TY. Marginal and internal fit of all-ceramic crowns fabricated with two different CAD/CAM systems. Dent Mater J. 2008;27(3):422-426. doi:10.4012/dmj.27.422
22. Rastogi A, Kamble V. Comparative analysis of the clinical techniques used in evaluation of marginal accuracy of cast restoration using stereomicroscopy as gold standard. J Adv Prosthodont. 2011;3(2):69-75. doi:10.4047/jap.2011.3.2.69
23. Tara MA, Kern M. Clinical outcome of metal-ceramic crowns fabricated with laser- sintering technology. J Prosthet Dent. 2012;107(1):62. doi:10.1016/s0022- 3913(12)60021-3
24. Örtorp A, Jönsson D, Mouhsen A, Vult Von Steyern P. The fit of cobalt-chromium three-unit fixed dental prostheses fabricated with four different techniques: A comparative in vitro study. Dent Mater. 2011;27(4):356-363. doi:10.1016/j.dental.2010.11.015
25. Aditya P, Madhav VNV, Bhide S V., Aditya A. Marginal discrepancy as affected by selective placement of die-spacer: An in vitro study. J Indian Prosthodont Soc. 2012;12(3):143-148. doi:10.1007/s13191-012-0119-8
26. Subasi G, Ozturk N, Inan O, Bozogullari N. Evaluation of marginal fit of two allceramic copings with two Finish lines. Eur J Dent. 2012;6(2):163-168. doi:10.1055/s-0039-1698946
27. Vojdani M, Torabi K, Farjood E, Khaledi A. Comparison the Marginal and Internal Fit of Metal Copings Cast from Wax Patterns Fabricated by CAD/CAM and Conventional Wax up Techniques. J Dent (Shiraz, Iran). 2013;14(3):118-129. http://www.ncbi.nlm.nih.gov/pubmed/24724133%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC3927676
28. Bhaskaran E, Azhagarasan NS, Miglani S, Ilango T, Krishna GP, Gajapathi B. Comparative evaluation of marginal and internal gap of Co-Cr copings fabricated from conventional wax pattern, 3D printed resin pattern and DMLS tech: An in vitro study. J Indian Prosthodont Soc. 2013;13(3):189-195. doi:10.1007/s13191-013-0283-5
29. Harish V, Mohamed Ali SA, Jagadesan N, et al. Evaluation of internal and marginal fit of two metal ceramic system – In vitro study. J Clin Diagnostic Res. 2014;8(12):ZC53-ZC56. doi:10.7860/JCDR/2014/10372.5300

30. Svanborg P, Skjerven H, Carlsson P, Eliasson A, Karlsson S, Örtorp A. Marginal and internal fit of cobalt-chromium fixed dental prostheses generated from digital and conventional impressions. Int J Dent. 2014;2014. doi:10.1155/2014/534382
31. Naqvi, A., Gopalakrishnan, D., Bhasin, M.T., Sharma, N., Haider, K., Martande, S. Comparative evaluation of bioactive glass putty and platelet rich fibrin in the treatment of human periodontal intrabony defects: A randomized control trial. J Clin Diagnostic Res. 2017;11(7): ZC09-ZC13.
32. Mahajan, R., Khinda, P., Shewale, A., Ghotra, K., Bhasin, M.T., Bhasin, P. Comparative efficacy of placental membrane and Healiguide™ in treatment of gingival recession using guided tissue regeneration. Journal of Indian Society of Periodontology 2018;22(6): 513- 522.
33. Mittal N, Goyal M, Mittal PK. Understanding and Appraising Systematic Reviews and Meta-Analysis. J Clin Pediatr Dent. 2017;41(5):317-326.