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RESEARCH ARTICLE

EVALUATING THE MARGINAL DISCREPANCY AND SURFACE ROUGHNESS OF CAD - CAM MILLED VS 3D PRINTED PROVISIONAL CROWNS - AN INVITRO STUDY

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Abstract

Aims &Objectives: To evaluate Marginal discrepancy and Surface roughness of CAD-CAM Milled and 3D Printed provisional crowns after subjecting them to thermocycling.

Materials and Methods: A stainless-steel metal die with ANSI/ADA specifications had been fabricated for the study. It was scanned with an intraoral scanner and the data was sent to VHF S5M CAD CAM milling and R3Pro printing machine. A total of 10 samples Milled Group A(n=10) and 10 Printed Group B(n=10) provisional crowns were fabricated from PMMA material using the scanned data. The temperatures for thermocycling are 37ºC and 60ºC. Each group is subdivided into two subgroups(n=5) based on thermocycling temperatures. The timeduration selected for Thermocycling was 7,14 and21 days. Marginal discrepancy was measured by using Stereomicroscope and Surface roughness was measured with Profilometer.

Results: Marginal discrepancy values were greater in CAD CAM milled crowns(141.47 µm) than in Printed crowns(109.87 µm) at 60ºC after a time-period of 21days.Surface roughness values were higher in Milled crowns(3.915µm) than in CAD CAM Printed crowns(3.817µm) at 60ºC for a given time duration of 21days. One-way ANOVA statistical analysis was done. The mean marginal gap of CAD CAM Milled crowns was statistically significant than Printed crowns($p>0.05$).

Conclusion: Printed provisional restorationshad better Marginal accuracythan CAD CAM Milled provisional crowns. Surface roughness was higher in CAD CAM Milled crowns than in Printed provisional restorations.

Introduction:

Computer-aided design/Computer-aided manufacturing (CAD/CAM) techniques tofabricate dental prosthesis[1] is the new trend in dentistry. This digital technology reduces material and lab expenses by reducing manufacturing time and thereby increases productivity[2]. The CAD/CAM unit utilizes digital technology to mill crowns, removable partial dentures, surgical guides, maxillofacial prosthesis[3], study models, and complete dentures[4].

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Provisional crowns protect abutment teeth and pulpal tissues after preparation[5]. They should have sufficient strength, good marginal accuracy, less irritation to pulpal tissues, low exothermic heat and should be easy to fabricate or repair[6]. The clinical goal of an interim restoration is to have a minimal marginal gap, protect the tooth, prevent caries and maintain gingival health[7].

CAD/CAM provisional restorations are fabricated from polymerized blocks, avoiding exothermic temperature and polymerization shrinkage to a larger extent[8] when compared to conventional techniques. Many clinical studies support the fact that provisional CAD/CAM prosthesis[9,10] can be used for longer time period than Conventional crowns.Auto-polymerized polymethyl methacrylate (PMMA) used to fabricate Interim fixed dental prosthesis absorbs more water which leads to mechanical failure[11]. CAD-CAM technology application in dentistryfor the fabrication of IFDPs has its own advantages[12,13]. Fabrication of prosthesis using CAD/CAM technology includes the subtractive(Milling) or additive(3D Printing) methods[14,15].

Additive 3D-printing technology helps in fabricating IFDPs at less cost[16] with minimal material and less fabrication time[17]. It also provides adequate marginal and internal fit [18]of the restorations. 3D-printing technologies available are Stereolithography (SLA) and Digital light projection (DLP). SLA was preferred over DLP in this study because of its high accuracy in producing details and smooth surfaces of restorations[19]. There are very few studies on the impact of thermomechanical aging on milled and 3D-printed IFDPs [20]. Hence, the current study aims to assess the Marginal discrepancy and Surface roughness of CAD/CAM milled and 3D-printed crowns before and after thermocycling. The null hypothesis is that no difference would be found in the Marginal accuracy and Surface roughness of provisional restorations fabricated.

Materials and Methodology:

A Stainless- Steel Die of ANSI/ADA specifications (8.015 mm in height, 6.330- mm diameter and 8.450 mm base, shoulder margin-1.5 mm, taper-5° with anti-rotational bevel was fabricated (Fig no. I). Impression of Stainless-Steel die is made with addition silicone impression material and is poured with Die stone (type IV dental stone). The die was digitally scanned with an intra-oral scanner (TRIOS 4)and software was used to design the die (Fig no. II). After receiving the scanned data VHF S5M CAD CAM milling machine is used to mill the crowns from pre polymerized Polymethyl Methacrylate (PMMA) resin block. Similarly8K Dental 3D R3 Pro printing machine receives the scanned data and prints the crowns from PMMA fluid resin.

A total of 10 Milled crowns Group A (n=10) and 10 Printed crowns Group B (n=10) were fabricated(Fig no. III). Each group was further divided into two subgroups based on the temperatures included in thermocycling at 37^0C(n=5) and 60^0C(n=5). The crowns were stored in water for (7days,14days and 21days at 37°C) followed by 600 thermal cycles (5°C/55°C) and 100,000 mechanical cycles (at 50N). Values were recorded after each thermocycling period of 7days,14days and 21days. Marginal gap of each crown placed on die was measuredby Stereomicroscope using a 3D superimposition technique (Fig no. IV). Surface roughness (Ra) was determined using a Profilometer at 0.5 mm/ second cross-head speed (Fig no. V).

Results:

One-way ANOVA statistical analysis gave the mean values.

Marginal discrepancy

The mean value for the marginal discrepancy were 111.1 µm, 120.32µm, 130.63µm at 37^0C (n=5) and at 60^0C (n=5) the values were 124.8µm, 133.37µm, 141.47µm for Milled crowns for a period of 7, 14, 21 days respectively (Graph no. I). The mean values for Printed crowns at 37^0C (n=5) are 80.96µm, 86.32µm, 91.39µm, and values at 60^0C (n=5) are 89.32µm, 95.81µm, 109.87µm for a period of 7,14, and 21 days, respectively (Graph no. II). The marginal discrepancy, when comparedto the milled crown subjected to 60 degrees for 21 days, shows a higher value, and the most negligible value is the printed crown when subjected to 37 degrees for seven days(Table no. I).

Surface Roughness

The mean value for the surface roughness(Ra) of Milled crowns were 2.305Ra, 2.319Ra, 2.419Ra at 37^0C (n=5), and at 60^0C (n=5), the values were 3.504Ra, 3.614Ra, 3.915 Ra for a period of 7, 14, 21 days respectively (Graph no.III). The mean values obtained for Printed crowns are 2.468Ra, 2.617Ra, 2.636Ra at 37^0C (n=5) and 3.629Ra,3.725Ra, 3.817Ra at 60^0C (n=5) at 7, 14, and 21 days, respectively (Graph no. IV). The surface roughness of Milled crowns when comparedto the Printed crown subjected to 60^{0}C for 21 days, shows a higher value, and the most negligible value is the milled crown when subjected to 37^{0}C for seven days(Table no. II).

Discussion:

Dentists adapted well to CAD/CAM technology as it provides highly accurate provisional restorations which can be milled from PMMA, Polyether-ether ketone (PEEK), and acetateblanks[21]. The restorations fabricated by this technique often have higher strength and precise margins than the conventional fabricated restorations[22].3D Printing or Additive manufacturing technique produces 3D restorations by laying down successive layers of material. Printing consumes less material when compared to the milling technique. Also, this technology can create more complex structures than the milling technique[1,23,24].

The temperatures included in this study are 37 ^{0} C and 60 ^{0} C.Temperature of 37 ^{0} C is selected as it is the normal temperature of oral cavity and 60 ^{0} C was included in the study as the maximum temperature withstood in oral cavity according to numerous studies was around 70 ^{0} C.Youngson et al[25] recorded values at several sites in the dental arch and achieved maximum values of 68 ^{0} C and minimum values of 15.4 ^{0} C. Barclay[26] stated that maximum and minimum mouth temperatures recorded when hot fluids taken was around 70 ^{0} C and consumption of iced drinks lowered the temperature to around 0 ^{0} C.

The use of CAD-CAM and 3D printing machines to fabricate temporary restorations have only fewstudies to assess the marginal fit of restorations fabricated[27] and hence in this study marginal accuracy is included. Surface roughness is included in the study as smooth surfaces of restorations promote hygiene in the oral cavity.In the present study the mean value of Marginal discrepancyis greater in CAD CAM Milled crowns than in Printed crowns. This can be attributed to the fact that printed materials are fabricated by a layering technique and develop a significant bond between the layers. This layer-by-layer adaptation leads to better fit & precision in printed crowns[27]. Also, 3D-printed materials show increased mechanical properties[28]. According to the values obtained from this study Surface roughness appears to be high in CAD CAM Milled crowns when compared to Printed crowns fabricated from PMMA fluid resin. Milling is a subtractive technique done with burs of different sizes and ranges, and fine grooves can be found on the surface of Milled PMMA block. Due to the milling and polishing process, additional surface defects could increase the surface roughness[11,29].

Lee et al. [18] conducted a study evaluating the internal fit of interim crown and concluded that the 3D printing method was more outstanding than the CAD/CAM milling method.Mahasa et al.[28] fabricated provisional restorationsusingConventional, CAD/CAM Milling, and 3D Printingmethods and concluded that the marginal fit of restorations fabricated by all three methods was within the acceptable range.Nada Aldahian[29]in their study concluded that the highest surface roughness was observed in the conventional technique, followed by CAD-CAM and 3D printing techniques before and after cyclic loading. 3D-printed provisional restorations showed improved fit, adaptation, and wear resisting properties compared to other groups.

Simge Tasin et al.[30] concluded that 3D-printed restorations had less surface roughness values when compared to conventional and CAD/CAM PMMA resins. They stated that due to the milling and polishing process, additional surface defects could increase surface roughness.Saurabh Jain et al.[31]in theiranalysis concluded that compared to Conventional and CAD/CAM Milled provisional restorative materials, 3D Printed crowns have better mechanical properties but inferior physical properties.Kelvin Khng et al.[32] conducted a study evaluating the marginal integrity of CAD/CAM interim crowns and concluded that a significant marginal gap was observed in the provisional crowns fabricated by CAD/CAM compared to PMMA crowns.

Conclusion:

1. The 3DPrinted provisional restorations displayed better marginal accuracy when compared to CAD-CAM Milled crowns.

2. The 3D Printed provisional restorationsexhibited lowSurface roughness values when compared to Milled crowns.

Fig No. I: Stainless-steel metal die (ANSI/ADA specifications).

Fig No. II: Scanning of dieand Crown placed on digitally fabricated die.

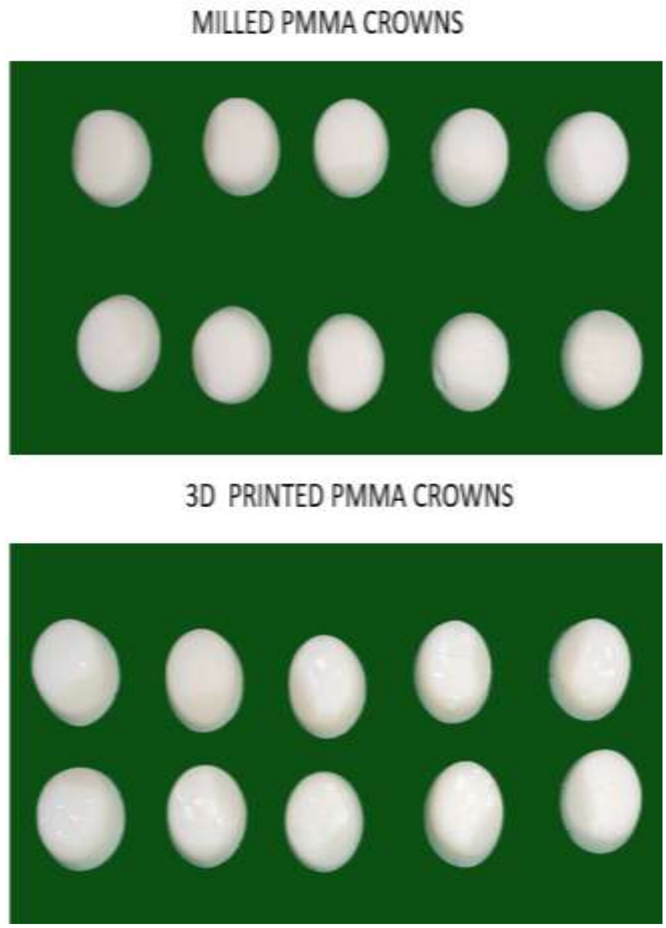


Fig No. III: Milled and 3D printed PMMA crowns.

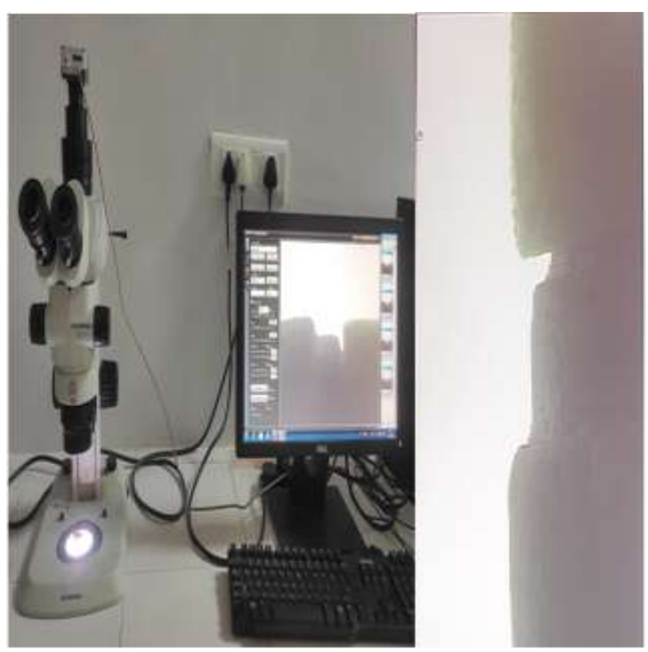


Fig No. IV: Marginal discrepancy measured using Stereomicroscope.

Fig No. V: Surface Roughness measured using Profilometer.

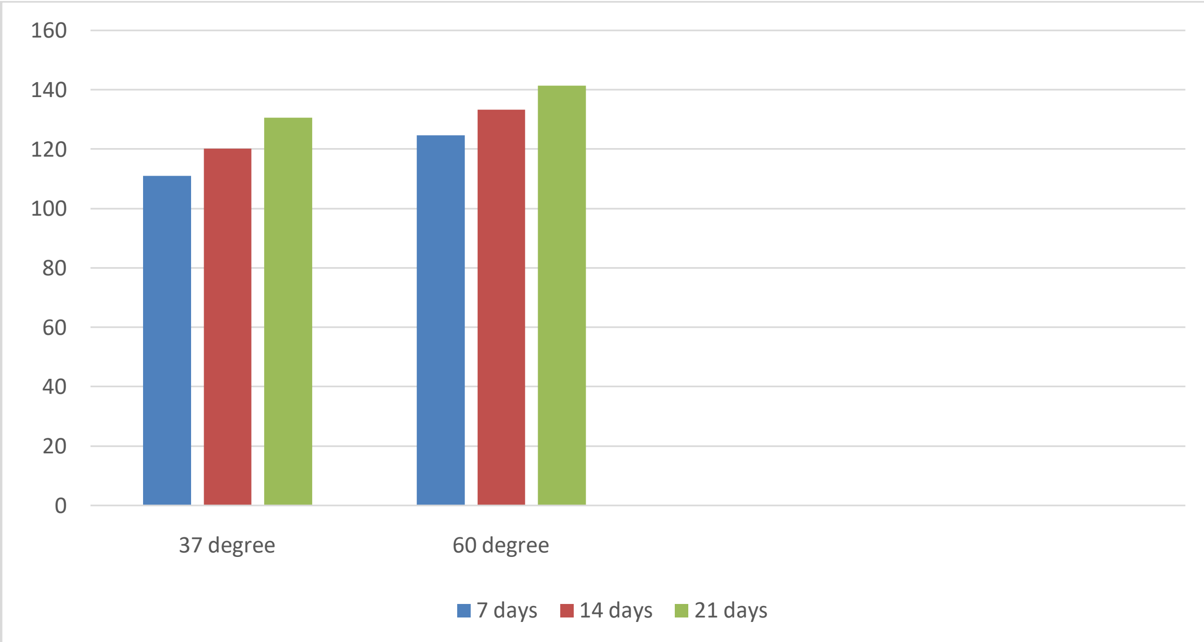
Table no. I: Mean values for Marginal discrepancy.

	Temperature	**7 days**	**14 days**	**21 days**
Milled crowns	37^0C	111.1µm	120.32 µm	130.63 µm
Milled crowns	60^0C	124.8 µm	133.37 µm	141.47 µm
Printed crowns	37^0C	80.96 µm	86.32 µm	91.39 µm
Printed crowns	60^0C	89.32 µm	95.81 µm	109.87 µm

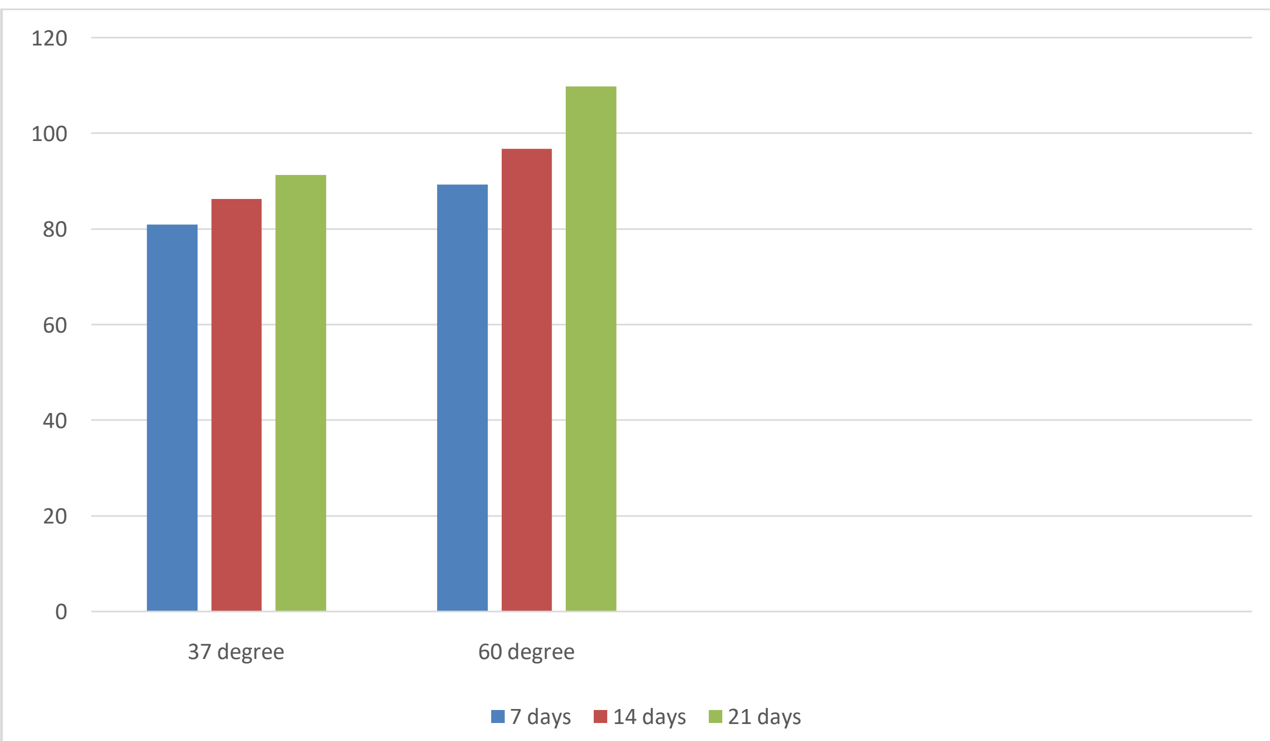
Table no. II: Mean values for Surface Roughness.

	Temperature	**7 days**	**14 days**	**21 days**
Milled crowns	37^0C	2.305Ra	2.319 Ra	2.419 Ra
Milled crowns	60^0C	3.504 Ra	3.614 Ra	3.915 Ra
Printed crowns	37^0C	2.468 Ra	2.617 Ra	2.636 Ra
Printed crowns	60^0C	3.629 Ra	3.725 Ra	3.817 Ra

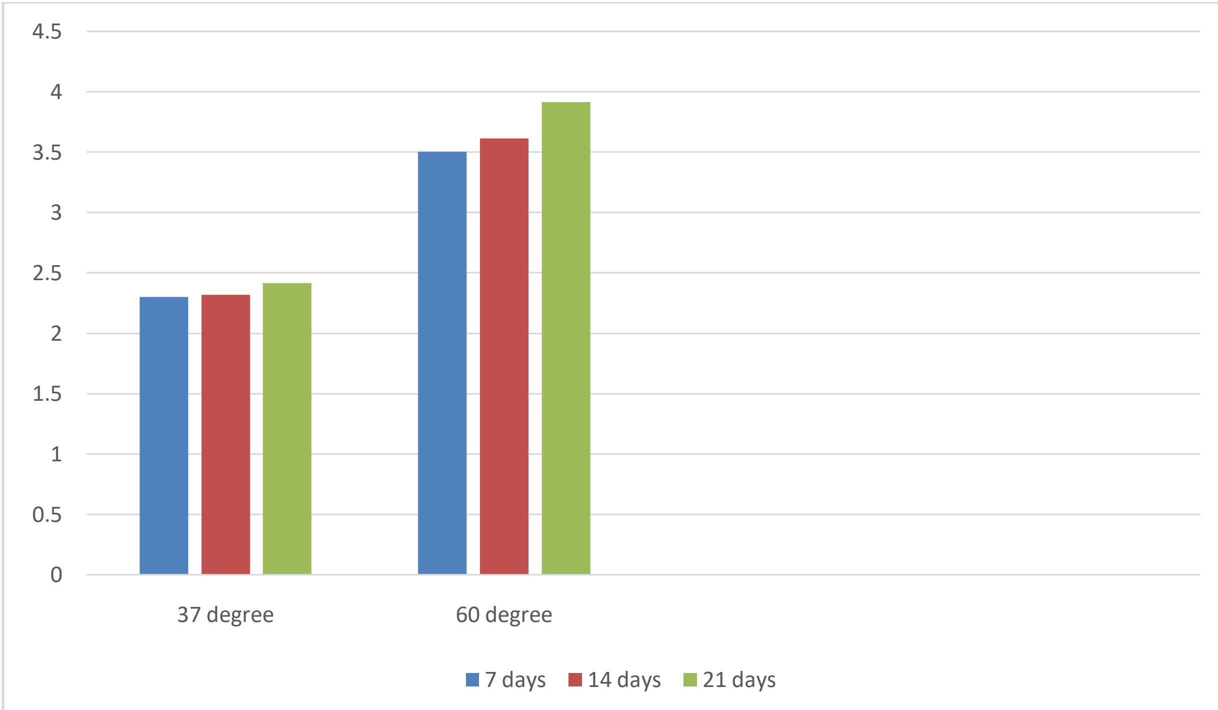
Graph no. I: Marginal discrepancy of Milled crowns



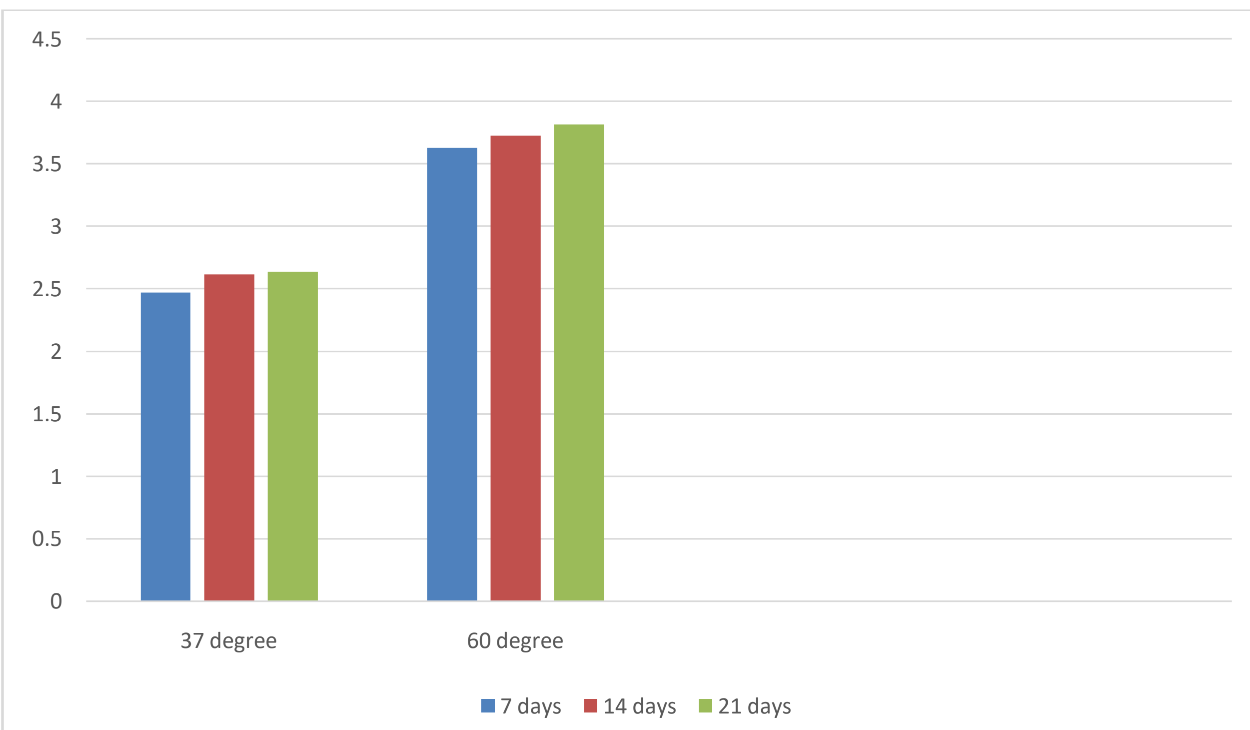
Graph no. II: Marginal discrepancy of Printed crowns



Graph no. III: Surface Roughness of Milled crowns



Graph no. IV: Surface Roughness of Printed crowns



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