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Comparison between Marginal Gap of Stone and Metal Dies in a CAD/CAM System

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Abstract

Objective: The purpose of this study was to evaluate and contrast the zirconia crown's marginal gap on stone and metal dies in a CAD/CAM system. Materials and Methods: After preparing a melamine tooth (lower six molar) with 1.5mm occlusal reduction, 1 mm axial reduction and deep shoulder finishing line to construct metal and stone die .It was scanned with a 3D laser scanner by CAD/CAM system. Melamine tooth was milled and replicated into chrome –cobalt die and stone die. Twenty samples as a total, 10 for metal die and 10 for stone die were prepared. On the master die, marginal gaps were measured at four specific locations on each surface (mesial, buccal, distal, and lingual). Using a microscope digital camera (Dino Lite) at a magnification of 110X, the direct view technique was employed, and the measurements of the marginal gap were recorded using the image J software. Results: In the metal group the highest marginal gap was recorded while the lowest marginal gap was recorded with the stone group. Conclusion: The metal group recorded a statistically significant higher marginal gap than the marginal gap that was recorded in the stone group. Stone die was more accurate when 3D scanner is used.

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Introduction

A master cast and die must be precisely created in order to fabricate a dental prosthesis that fits properly. The working cast and die must accurately replicate the patient's teeth to ensure a precise and successful final restoration [1]. For CAD/CAM restorations to be successful, precise 3D images of teeth and surrounding tissues must be acquired either directly through intraoral scanning or indirectly through extra oral scanning of physical replicas of the tooth arch and surrounding tissues, such as models or castings [2]. In dental practice, die materials are frequently used to create hard dies for inlays, onlays, crowns, and bridges. High strength, excellent abrasion resistance, the capacity to replicate the imprint's details, high dimensional stability, and outstanding colour contrast with impression and pattern materials are all characteristics of the perfect die material [3]. In many biomedical applications, advanced ceramic materials like zirconia offer a lot of potential to replace conventional materials because of an intrinsic transformation toughening mechanism that gives it exceptional strength and better fracture resistance. Furthermore, zirconia bioceramic exhibits low radioactivity, improved biocompatibility, and intriguing optical characteristics [4]. In dentistry, computer-aided design (CAD) and computer-aided manufacturing (CAM) have grown in popularity. Some issues were addressed by the development of CAD/CAM technology. Creating posterior restorations with adequate strength was one of the difficulties. Making restorations look natural was the second issue [5].

Materials and Methods

A lower sixth molar tooth was created as follows in the dental model (Nissin Dental Products Kyoto, Japan).1 mm axial reduction,1.5 mm at the centre of occlusal reduction with a deep shoulder finishing line tooth preparation to obtain stone die After that we make index to obtain 10 samples of die stone [6], as shown in Figure 1.

Metal dies have been employed in numerous CAD/CAM research due of their resistance to wear throughout fabrication processes to replicate the shape of the optimum prepared tooth [7]. The digital die model was downloaded into the CAM application in order to start the metal die milling operation. The milling unit was then loaded with a 14 mm diameter cobalt chromium disc. Two fresh carbide burs with a diameter of 2 mm and 1 mm were used to grind the metal die. According to the manufacturer's instructions, the burs were automatically adjusted from a 2 mm bur for cutting the metal die's contour to a 1 mm bur for fine details [8].

The stone die is placed inside the shining 3D dental scanner unit and fixed on scan stage without sprayed the die by dental scan spray. The stone die was scanned converted into the digital stereo-lithography (STL) file and send to block sectioning machine (BSM) for fabrication the same designing for all crowns.

To lessen light reflection during the scanning procedure, two coatings of dental scan spray were applied to the metal die. The distance between the metal die and the nozzle of scan spray bottle was (7 cm) according to the manufacturer's instructions. The metal die is placed inside the shining 3D dental scanner [9].

Zircon block CAD was used as material for constriction. Exocad software was used to design the crowns, and the identical design is programmed . Data were sent to the block sectioning machine, 5-axis milling device, dry grinding (imes-icore). The milling procedure was finished after (11 minutes) for each crown, the block was removed from the milling machine and the crowns were separated from the block with a fissure bur with straight hand piece [10].

Following the construction of the crowns, Using a stereomicroscope, four indentations were selected to measure the marginal gaps along vertical planes on the buccal, lingual, mesial and distal sides of the metal and stone die at the midway.

To determine the marginal gap of the crown, the vertical marginal gap between the die's and the crown's margins was measured perpendicular to the die axis. Each surface had four different locations measured (two on the right and left sides of the depression. The first point was at the indentation's edge, and the second point was one millimetre away from the first [11].

A digital microscope (Dino-Lite, Taiwan) at magnification of 110X was used to analyze each sample that was locked in the locking device.

The vertical distance between the prepared cavosurface angle of the die parallel to the core withdrawal path on each die at the midpoint of the buccal, mesial, lingual, and distal surfaces was measured in order to determine the marginal discrepancy.

By taking a digital picture of a millimetre ruler at a distance of (1 mm) at the same magnification (110X), opening it in the (image j) program, choosing an order analysis, and then setting the scale, the digital reading was captured in pixels and converted to micrometres [1]. At 110X magnification, the digital microscope's calibration was set at 0.001mm (1µm). Additionally, the sample was placed on the stage of the microscope, "which was adjusted until the image of the marginal area was displayed clearly on the computer monitor." after which a digital picture of the gaps was taken. The vertical marginal gap between the crown and master die was measured after the image was processed using the application Image J. By drawing a line between the crown margin line and the die's finishing line. The value of a pixel mark could be ascertained by the program. All digital measurements were recorded [12].

Results

The averages and standard deviations of the marginal gaps of the crown groups on the metal die by measurement sites and margin configuration, expressed in micrometres are displayed in Table 1. Table 2 displays, in micrometres, the averages and standard deviations of the marginal gaps of the crown groups on the stone die by measurement sites and margin configuration.

Table 3 shows the higher marginal gap was for metal group while the lower marginal gap was for the stone group. There were statistical differences for all surfaces of crown was significant in comparative between marginal gap of them.

Discussion

This study compared and assessed the marginal gaps of single zirconia crowns made with stone and metal dies. The results showed that there were substantial differences between the two groups ($p < 0.05$).

Currently, interest in CAD/CAM systems in dentistry is rising due to their potential to reduce costs associated with traditional methods of making dental restorations, which need significant manpower and labour-intensive laboratory processes [13].

In order to overcome the differences that are appear in naturalistic teeth and to gain the preparation more standardized, (Nissin Dental Products) used from the working dies of all the samples were fabricated [14].

This study focused on the marginal accuracy of zirconia coping produced on stone die and metal die in CAD/CAM system. Dental scanner accuracy was dependent on two distinct factors: The resolution of the receptor sensor (camera or receptor matrix) is the first parameter of the optical scanning apparatus, and the accuracy of the second parameter is gathered information (dental scanner should obtain sufficient points cloud from the surface of an object with a specific degree of precision and density, which indicate that the points cloud should be adequately dispersed throughout the surface [15].

Since many dental labs still utilize standard Type IV stones, they were examined in this study instead of special scanning stones [16].

Many techniques are employed to assess the marginal gap of CAD/CAM dental restorations, including, laser videography ,impression replication technology, direct viewing ,cross section view, profilometry, three-dimensional (3-D) superimposition analysis and x-ray micro- tomography [17].

The direct viewing method using a digital microscope and image analysis measurement (image J) was chosen for the current study because it is a non-destructive, quick, easy, and simple method that lowers the possibility of errors that could accumulate from multiple processes and affect the accuracy of results [18].

According to the marginal gap for each group measurement , stone dies generally provide a better marginal fit for CAD/CAM crowns compared to metal cobalt-chromium dies, largely because stone more closely replicates the dimensional behavior of natural tooth preparations, reducing distortion during scanning and milling. Metal dies, while durable, often introduce discrepancies due to differences in reflectivity and thermal expansion [19].

Conclusion

Within the limitations of this study, the results clearly demonstrate that the type of die material has a significant effect on the marginal accuracy of the fabricated crowns. The crowns constructed on the metal die consistently exhibited higher marginal gap values across all measured surfaces (mesial, distal, lingual, and buccal) compared to those fabricated on the stone die.

Therefore, it can be concluded that crowns fabricated using stone dies provide superior marginal fit compared to those fabricated using metal dies. This suggests that stone dies may be more favourable in clinical and laboratory procedures where optimal marginal accuracy is critical for the longevity and success of dental restorations.

Conflict of Interest

The authors certify that they have no financial or other conflicts of interest.

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Table 1. Descriptive of group (metal die).

Surfaces	N	Minimum	Maximum	Mean	Std. Error	Std. Deviation
Mesial	10	51.19	78.65	62.6664	2.79137	8.82708
Distal	10	52.72	72.23	60.2646	2.40800	7.61477
Lingual	10	51.35	76.52	62.0650	2.92401	9.24654
Buccal	10	51.41	72.57	62.0246	2.37058	7.49642

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Table 2. Descriptive of group (stone die).

Surfaces	N	Minimum	Maximum	Mean	Std. Error	Std. Deviation
mesial	10	12.37	24.58	18.0660	1.45482	4.60054
distal	10	12.52	23.56	17.2730	1.29813	4.10505
lingual	10	12.13	24.51	18.1494	1.75243	5.54167
buccal	10	14.33	23.33	19.2757	1.05296	3.32976

Table 3. T-test comparative between marginal gap of metal and stone dies.

Surfaces	Die	T-test	P-value
Mesial	Metal die	4.307	0.049
	Stone die		
Distal	Metal die	6.711	0.018
	Stone die		
Lingual	Metal die	4.337	0.048
	Stone die		
Buccal	Metal die	3.758	0.049
	Stone die		