Comparative Analysis of Marginal Adaptation and Internal Fit of Zirconia Implant Suprastructures Fabricated Using Different Scanning Strategies

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Abstract: ***This study aims to compare the marginal adaptation and internal fit accuracy of zirconia implant suprastructures fabricated using two different scanning methodologies. Specimens were designed using dental CAD software, and the marginal discrepancies and internal fits were evaluated using microsections and a stereoscopic microscope. Results indicated that both study groups exhibited larger internal gaps in the marginal and axial regions compared to the specified cement space. However, the mean values in the scan body group were significantly lower than those in the scanned abutment group. The differences observed between the two groups can be attributed to the varying optical properties and geometries of the objects during scanning.***

Keywords: CAD/CAM, scan body, marginal adaptation, scanning strategies

1. Introduction

With the advent of CAD/CAM technologies (computer aided design/computer aided manufacturing), digitization has entered many different fields of dental medicine. These innovations enable more precise and efficient design and manufacturing of dental prosthetics, while simultaneously reducing the time and effort required for their fabrication, as well as the risk of human errors (1, 2, 3). The technology is based on three main stages: first - scanning the prosthetic field to create a virtual model, second - designing using CAD software and third - manufacturing in the CAM unit (4). Implant - prosthetic treatment using digital technologies has also made significant progress in recent years, replacing traditional analog methods. This approach offers higher precision and efficiency in the planning and implant procedures, leading to better results for patients (5, 6). Accurate information transfer to the dental laboratory is crucial for the fabrication of high - quality prosthetic constructions. Even small defects in impressions can affect the accuracy of the fit of implant suprastructures (7, 8). This can lead to biomechanical problems (9, 10). Scanning can be performed directly with an intraoral scanner in the oral cavity or indirectly with an extraoral scanner, usually on a model (11, 12, 13). Different strategies are used to transfer the position of the implant. One of the most common methods is the use of scanning components called scan bodies (14).

To be considered successful, implant - supported restorations, regardless of the materials and manufacturing technologies, must meet the following criteria: aesthetics, strength, good marginal adaptation and passive fit (15, 16).

2. Materials and Methods

A study model of the lower jaw (FrasacoTM) was used, scanned with a laboratory scanner 3ShapeTM, D850 and converted in a digital format (. STL file). A 3D model (master model) with a defect in the area of teeth 35 - 37 and a gingival mask was created. The design was developed using specialized 3D design non - medical software Tinkercad. A defect was specified in the area of teeth 35, 36 and 37, where implant analogs replacing teeth 35 and 37 can be placed. The STL file was exported to software PreForm (Formlabs) and the model was printed using the selective laser polymerization method with a Form 2 (FormlabsTM) printer from resin. The implant analogs and abutments Neodent (Titanium base, Ti, 4, 5x6x1, 5) were placed in the edentulous area. Two scanning strategies with an intraoral scanner Meddit i600 were used to create a testing suprastructures: scanning the scan bodies (GM scan body, Neodent) and scanning of the abutments. After scanning the model, a virtual design of the specimen was created using specialized software 3Shape Dental System®.

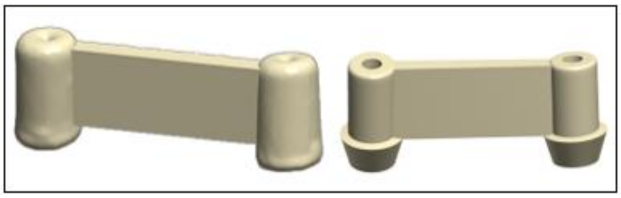

Figure 1. Designed of a virtual model of the suprastructers in software 3Shape Dental System® after a) scanning of the abutments and b) scanning the scan bodies.

Standart 3Shape settings were used „0, 020mm" cement gap, "0, 080 mm" extra cement gap ", "1mm" distance to margin line. The. stl file was exported to a milling machine (CORiTEC® 150i, Imes Icore) and they were milled by zirconium dioxide. A total 20 CAD/CAM zirconia suprastructures in two groups were bonded onto the abutments of the model with modified glass ionomer cement (GC Fuji Plus) and the screw access hole was sealed with polytetrafluoroethylene tape. After 24 hours they were separated and embedded in acrylic resin blocks. Each specimen was cut with a diamond disk and water cooling in the precision cutting machine IsoMet 1000 (Buehler Ltd.,

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Lake Bluff, IL, USA). The cross section was examined at x50 magnification with a stereoscopic microscope Leica M80 (Leica Microsystems GmbH, Wetzlar, Germany) with microscope's camera Leica IC90E and photo software Leica Application Suite V4.13.0, Leica Microsystems GmbH, Wetzlar, Germany). By evaluating the thickness of the luting space at 3 point for each side: external and internal - towards the connecting beam, marginal discrepancy and internal gaps were measured.

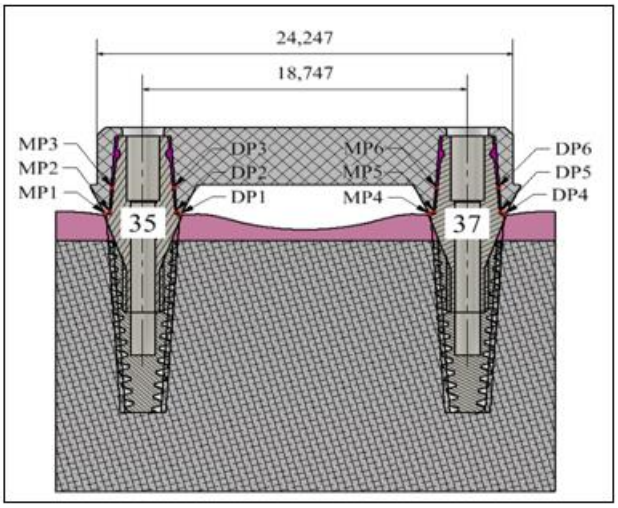

Figure 2: Schematic representation of the measured points.

3. Results

In both study groups, the zirconia suprastructures had larger internal gaps in the marginal and axial regions compared to the specified cement space.

The values obtained for the distal wall of 35 and the medial wall of 37, i. e on the side of the connecting beam in the group of scanned abutments are lower than the corresponding "external points" towards the adjacent teeth bordering the defect.

Table 1: Marginal discrepancy (mµ) after cementation of zirconia suprastructures presenting different luting spaces (mean ±standard deviation) for ZrO2 suprastructures and scanned abutment.

	35		37
MP1	51, 816±2, 396	MP4	48, 215±3, 454
DP1	48, 624±2, 374	DP4	52, 955±3, 876
p - value	p<0, 05	-	p<0, 05

Table 2: Internal fit (mµ) after cementation of zirconia suprastructures presenting different luting spaces (mean ±standard deviation) for ZrO2 suprastructures and scanned abutment

	35		37
MP2	123, 94±4, 674	MP5	117, 269±3, 45
DP2	116, 241±4, 183	DP5	125, 269±4, 126
MP3	137, 923±5, 619	MP6	130, 027±4, 06
DP3	128, 97±5, 107	DP6	140, 12±3, 719
p - value	p<0, 05	-	p<0, 05

The mean values for these points in the group using the scan body are significantly lower than those measured in the group of scanned abutments. Furthermore, such differences are not observed between the medial and distal walls.

Table 3: Marginal discrepancy (mµ) after cementation of zirconia suprastructures presenting different luting spaces (mean ±standard deviation) for ZrO2 suprastructures and scan body.

	35		37
MP1	32.209 ± 2.740	MP4	30.703 ± 1.811
DP1	30.584 ± 1.563	DP4	32.181 ± 1.897
p - value	p>0, 05	-	p>0, 05

Table 4: Internal fit (mµ) after cementation of zirconia suprastructures presenting different luting spaces (mean ±standard deviation) for ZrO2 suprastructures and scan body

	35		37
MP2	96.898 ± 2.405	MP5	94.610 ± 2.310
DP2	95.625 ± 2.243	DP5	96.549 ± 2.639
MP3	113.472±3.912	MP6	112.505±3.139
DP3	113.178±4.059	DP6	114.675±4.072
p - value	p>0, 05	-	p>0, 05

4. Discussion

In the present study, we used the method with microsections and stereomicroscope measurements, as the aim is to observe the actual thickness of the layer after definitive fixation. This will provide information regarding the marginal adaptation and internal fit. These parameters are crucial for the success of implant prosthetic treatment with fixed prosthetic restorations. The stages of laboratory process are essential for the final marginal adaptation and internal fit of the restorations. The design steps for the suprastructures, as well as the manufacturing process itself, both play crucial roles in achieving these outcomes. The type of material used, the milling process with different diameters of milling burs, as well as the firing and sintering cycles, can lead to shrinkage and affect marginal adaptation. The methodology of scanning and transferring the implant position to the CAD software is especially significant.

The use of scan bodies in practice reduces the risk of optical distortions that can occur when scanning objects with metal surfaces, such as the abutments in this study. They are compatible with CAD/CAM systems and their components are standardized, ensuring compatibility with digital models, repeatability during scanning and reducing the risk of deviations and inaccuracies.

The surface of the abutments can create reflections, which can disrupt the distribution of light used by the scanner and reduce scan accuracy. When scanning, especially in the distal area, light access can sometimes be difficult, which is more often observed on the side of the teeth bordering the defect, due to the "bridging" effect provided by the intraoral scanners.

5. Conclusion

The study demonstrates that zirconia suprastructures fabricated using scan bodies have a better marginal adaptation and internal fit compared to those fabricated by scanning abutments. This difference is likely due to the varying optical properties and geometries of the scanned objects. These findings underscore the importance of selecting appropriate scanning methodologies for optimal prosthetic outcomes.

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