RESEARCH ARTICLE

Influence of polyether ether ketone coping crown on the adaptation of implant abutment

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Abstract

Objective: To evaluate the influence of polyether ether ketone coping crown on the adaptation of implant abutment.

Method: The vitro study was conducted at the department of Prosthodontics, Hainan Stomatological Hospital, China, from October 2021 to March 2022, and comprised patients undergoing implant surgery on first molar. Patients were divided into two groups, with group A patients receiving polyether ether ketone coping crowns, and group B receiving zirconia crowns. Replica technique was used to replicate the gap between the crowns and the abutments. The thickness of the silicone film was measured under the stereomicroscope, and the gap between the groups was compared. Data was analysed using SPSS 22.

Results: In group A, mean marginal gap was 82.43±25.00µm, and mean overall gap was 85.45±33.75µm. In group B, the corresponding values were 65.09±11.69µm and 78.04±26.67µm. There was a significant difference in the adaptation between the groups at the marginal and overall measurement points ($p<0.05$).

Conclusion: Marginal and internal adaptations of polyether ether ketone coping crown for abutment could be considered clinically acceptable.

Key Words: Crowns, Dental abutment, Dental implants, Dental marginal adaptation, Polyetheretherketone.

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Introduction

Implant-supported restoration can effectively restore the masticatory function and improve patients' quality of life, and that is why it has been widely used in clinical settings. After surface processing, the physical morphology, chemical composition and biological activity of the implant has changed over the last few years, and osseointegration is greatly improved, therefore, implant has a high-survival rate, and implant-supported restoration has become one of the effective and popular restoration methods for edentulous patients with dentition defect.

At present, there are mainly three kinds of materials for implant-supported restoration: composite resin, metal-porcelain and all-ceramic. Composite resin crown is easy to be worn, aged, discoloured, pigmented and damaged[1]. The opaque property of the metal-porcelain restoration limits its wide acceptance, and metal ions may release, which potentially endanger oral or even overall health. With the development of dental materials and the growing patient demand for high aesthetics, all-ceramic restoration is recognised by many doctors and patients, and is widely used in clinical treatment because of its aesthetic factors. However, fracture of the bridge or chipping of the ceramic have been reported as well[2].

In recent years, polyether ether ketone (PEEK), a semi crystalline organic polymer, has been introduced in dentistry. PEEK is a kind of material with high temperature resistance, chemical stability, low weight, high elastic modulus, excellent biocompatibility and no galvanic effects[3,4]. With its favourable physical, chemical and biological properties, PEEK has been preliminarily used in dental clinics as implant, fixed and removable dental frameworks, temporary abutment, and, in addition to maxillofacial prosthesis, orthodontic bracket, and children's space maintainers[5-7].

There are three approaches to PEEK fabrication: vacuum casting, three-dimensional (3D) printing, computer-assisted design / computer- assisted manufacturing (CAD/CAM)[8], with the CAD/CAM being the most common. Theoretically, the milling accuracy of CAD/CAM is one of the important factors affecting the adaptation of prosthesis.

To the best of our knowledge, literature on PEEK restorations in dentistry comprise a small number of

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clinical case reports, and a few reports on adaptation, especially as implant-supported crown for abutment. Moreover, different effects on adaptation can be attributed to different types of methodologies, milling machines, blocks, testing and restoration ways of a prosthesis[9].

The current study was planned to evaluate the influence of polyether ether ketone coping crown on the adaptation of implant abutment.

Materials and Methods

The vitro study was conducted at the department of Prosthodontics, Hainan Stomatological Hospital, China, from October 2021 to March 2022, and this study was approved by the Ethics Review Committee of Hainan Stomatological Hospital, China. The sample size was calculated on the basis of literature[10-12]. The sample comprised patients undergoing implant surgery on maxillary or mandibular first molars, with normal gap, occlusal space >6.0mm, normal bone morphology and no requirement of bone augmentation surgery. Those with poor oral hygiene, periodontal disease, limited mouth opening and bad compliance were excluded.

Implants (Osstem, Seoul, South Korea) used had a diameter of 5.0mm. CAD/CAM scanbodies of bone horizontal implants were installed to take the impresses, and intraoral scanner (3Shape Trios, Copenhagen, Denmark) was used to collect the working model, the jaw model and the occlusion. Virtual images and information of positions of the scanbodies were obtained.

The virtual scanbodies were selected matching the implants from the database, and the positions were adjusted to achieve the best fit with the solid scanbodies. The selected abutments (Osstem, Seoul, South Korea) had a diameter of 5.0mm, a height of 5.0mm, and a shoulder width of 0.5mm, while the shape of abutments could be properly ground and trimmed in a small range as per the clinical needs.

CAD was used to design the crowns, and the die space between the crown and the abutment was set at 30µm starting 0.5mm above the finish line, and a screw channel was reserved on the crown.

Ten patients with 10 implants were selected, the implant crowns were divided into two groups: A and B, that was, one abutment was used to make two kinds of crowns. With group A patients receiving PEEK (BioPAEK, Changchun, China) coping crowns, and group B receiving full anatomical morphology zirconia crowns (Wieland, Pforzheim, Germany). The inner crowns of group A were polished directly after being milled, and the fabrication was finished, but the crowns of group B needed to be sintered as per the manufacturers' porcelain application instructions procedure.

A low-viscosity yellow silicone (DMG, Hamburg, Germany) was evenly injected into the tissue surface of PEEK coping crown with a machine mixing gun to simulate the cementation process, then seated on the corresponding abutment by using firm finger pressure as this was a common way of seating a crown in normal dental practice. The crown was removed after a total setting time of 4min, and a thin silicone film was adhered to the abutment. This layer of silicone film represented the gap between the crown and the abutment. In order to support this thin film and facilitate cutting and measurement, a high-viscosity blue silicone was mixed and completely covered on its surface and filled into its inner spaces. After the blue silicone was solidified, the two colours of silicone were combined into a block.

The silicon block was sectioned into 4 cross-sections along the mesiodistal and buccolingual directions (Figure 1) by using a blade. The digital image from the margin to the occlusion in each cross-section was captured under ×40 magnification by a stereomicroscope (Carl Zeiss, Jena, Germany). A mesial, distal, buccal and lingual profile for each slice was selected, and the microscope's own software was used to measure different points on each slice, the thickness of the yellow silicone film (Figure 2) at the margin (a), axial wall 1 (b), axial wall 2 (c), axial angle (d), and occlusion (e) to work out the gap value. The replication and measurement procedures of the gap value in group B were the same as those in group A. The grinding of abutment and crown fabrication were completed by a senior technician, and the replication and measurements were completed by the principal researcher.

Data was analysed using SPSS 22. Data was tested for homogeneity of variance and normality. Student's t tests were used to compare the gap values at the same

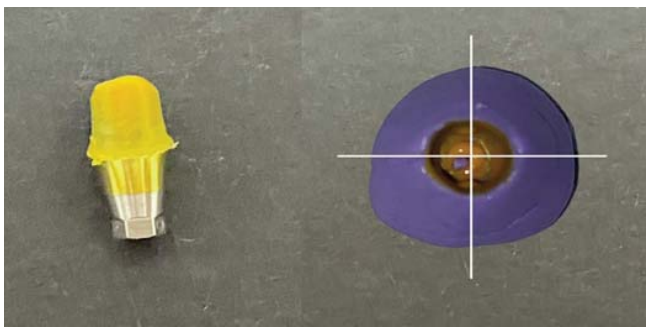

Figure-1: Silicone film and block cutting.

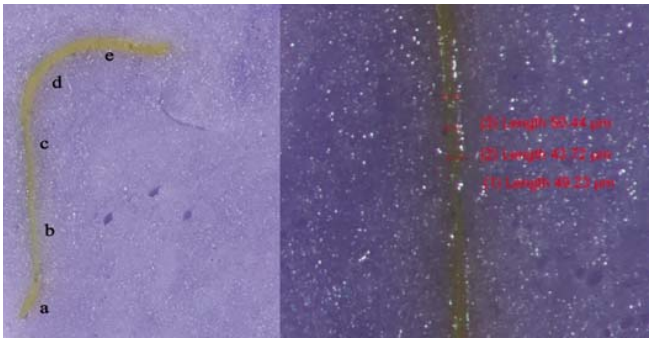

Figure-2: Measurement points and the thickness of the silicone film under the stereomicroscope.

measurement point between the groups. P<0.05 was taken as statistically significant.

Results

In group A, mean marginal gap was 82.43±25.00µm, and mean overall gap was 85.45±33.75µm. In group B, the corresponding values were 65.09±11.69µm and 78.04±26.67µm. There was a significant difference in adaptation between the groups at the marginal and overall measurement points (p<0.05) (Figure 3), with group B showing superior adaptation compared to group A.

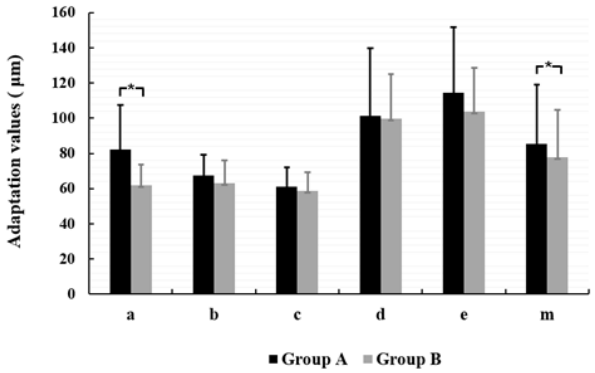

Figure-3: Inter-group comparison of mean adaptation values.

Discussion

The adaptation of a prosthesis includes the interior and the margin[13]. The internal adaptation refers to the vertical distance from the tissue surface at different positions to the abutment preparation inside the prosthesis, such as the axial wall, the axial angle, and the occlusion. The marginal adaptation is the shortest distance from the margin of the prosthesis to the termination line of the abutment preparation edge. The adaptation is considered of pivotal importance for long-term clinical success of a prosthesis[14,15]. For implant crown, the poor internal adaptation has an impact on the transmission and distribution of bite force and the generation of torsion under the functional state, and may lead to loosening of abutment screw, fracture of implant, adverse tissue reaction, and even the loss of bone bonding[16-19]. For marginal misfit, it can influence the onset of periodontal disease, as it is associated with bacteria and plaque retention, affecting the health of the soft and hard tissues, causing complications, such as implant mucositis, gingival recession, and marginal bone absorption[19,20]. Therefore, the best marginal and internal adaptation of implant crown and abutment is the focus of clinicians and technicians, and it is also the basis for the success of implant treatment.

The methods used to evaluate the adaptation of the prosthesis can be divided into qualitative, semi-quantitative and quantitative categories. Qualitative and semi-quantitative methods include clinical exploration, eye direct observation, occlusal paper or indicator examination, and medical magnifier observation, etc. They are mainly used in clinical practice and often used for preliminary judgment before cementation, but the gap value they provide may be less before bonding. Quantitative methods include microscope, replica technique, slice-cutting, and micro-computed tomography Micro-ct technology, etc. According to the intraoral and extraoral differences, such methods can be further divided into direct and indirect. The information provided by quantitative method is relatively true and reliable, and it can primly simulate clinical practice. However, due to the high-level equipment and technology required, this method is mainly used for scientific research only.

The replica technique used in the current study could be quantified concretely, as the internal adaptation of the crown had a 3D shape. The operation of this technique is quite simple, and, as such, the result is considered reliable, and there is no need to destroy the specimen[21-23]. It can be used in single crown, inlay and implant superstructure as well as in bridges.

At present, the number of points needed to be measured in each experimental method is different. Groten et al. proposed that the sampling error of the test results measuring only a few points was large, which might be misleading, and could not better reflect the average gap value of the whole crown. They believed that at least 20-25 points should be measured[24]. In the current study, each silicone block was divided into 4 cross-sections on average along the buccolingual and the mesiodistal direction. A total of 10 points on the marginal and internal gap were selected for measurement on each section, and 200 points in each group, which also met the statistical

comparison requirements.

The American Dental Association (ADA) stipulated that the marginal gap of the crown should float between 25-40μm, but this was difficult to achieve in clinical operation and most researchers[9,25] proposed that the clinically acceptable marginal gap for a good long-term prognosis should be <120μm[26]. However, there was no specific limitation on internal adaptation in literature, with some studies suggesting an acceptable range of 200-300μm based on clinical experience [27]. The marginal and internal average gap of the groups in the current study was <120μm, and both were within the clinically acceptable range (Figure 3).

According to the current findings, the gap of each measurement point of PEEK coping crown was greater than that of zirconia crown, the reason for this could be the fact that the zirconia crown was made according to the sintering procedure after milling, and generally no further adjustment was required for the inner crown. Besides, zirconia had shrinkage properties after sintering. PEEK coping crown did not need to be sintered, but to be polished. Polishing was a loss operation, involving the whole inner crown, so it had a certain impact on the gap value. Furthermore, different milling machines and burs had an impact on the adaptation of the restoration.

The gap values of the margin, axial angle and occlusion in the current study were greater than the axial wall, and the occlusion was the largest. When comparing values and the numerical distribution reported, these were consistent with earlier findings[9,28]. The results might be due to the milling process of fabricating the crown, shape of the milling burs and material properties. In addition, it also showed that the adaptation mainly related to these three points, especially the margin and occlusion points had a great impact on the micro-leakage of the implant crown.

Before the crown was milled, a certain space was often preset in the system, which was very important for the placement and adaptation of the prosthesis. Proper parameter space can obtain better adaptability[29], but if the space is set too large, the thickness of the adhesive increases, affecting the retention of the crown, and producing stress causing crown damage[30]. However, when the space is set too small (<30μm), it is difficult to discharge the adhesive during bonding, and leads to a large floating amount of margin and occlusion surface. Dental CAD/CAM system can generally preset different gap parameter spaces, and it could be seen in the current study that 30μm preset was used (Figure 3), and it did not hinder the placement and retention of the crown, but was conducive to the discharge of adhesive.

The current study analysed the adaptation of a prosthesis as well, but, for a prosthesis, the aspect of strength must also be studied for which further studies are needed.

The limitations of the current studies included its in vitro orientation, use of silicone which was not a clinical adhesive, the sample size which probably needed to be larger, and the fact that clinical long-term restoration effect need more extensive studies.

Conclusion

The marginal and internal adaptation of PEEK coping crown for abutment could be comparable to other materials and techniques.

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Conflict of Interest: None.

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Author's Contributions

XL: Designing and implementation, data analysis, writing.
SL: Proving study site and materials, guidance for revision.
YT and **YZ:** Review data and writing.
YS: Reviewing and final approval.