Original Research

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An evaluation of the compressive strength of zirconia crowns fabricated with various tooth preparation finish lines using a CAD/CAM system

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Abstract

INTRODUCTION. In clinical dentistry, fixed prosthetic restorations, especially those composed completely of zirconia – are frequently utilized to restore natural teeth. The design of the tooth preparation, particularly the finish line type, and the restoration's resistance to occlusal forces during mastication are critical factors in its effectiveness.

AIM. This in vitro study aimed to assess the impact of two gingival finishing lines (45° chamfer and 90° shoulder) on the compressive strength resistance of complete contour zirconia CAD/CAM all-ceramic crowns.

MATERIALS AND METHODS. All sixteen lower primary molars were prepped to receive full contour CAD/CAM ceramic crowns utilizing a sophisticated paralleling equipment. Based on the kind of finishing line that was planned, the teeth were split into two groups. group A prepared with 90° shoulder finish line and group B prepared with 45° chamfer finish line. Materials are tested for compressive strength using a universal testing machine.

RESULTS. The data analysis manifested that, shoulder and chamfer margins of zirconia crowns showed that the mean compressive strength resistance of chamfer margin is 5287.50N and the shoulder margin is 3200.00N. The statistically significant difference between the groups and compressive strength of chamfer margin was more than shoulder margin.

CONCLUSIONS. The study's findings suggested a connection between the finishing line's design and the entire CAD/CAM zirconia crowns' compressive strength.

Keywords: finishing line, compressive strength, CAD/CAM system, zirconia full contour, shoulder finishing line, chamfer finishing line

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Оценка прочности на сжатие циркониевых коронок, изготовленных с различными вариантами финишной линии препарирования зуба с использованием системы CAD/CAM

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Резюме

ВВЕДЕНИЕ. В клинической стоматологии фиксированные ортопедические реставрации, особенно полностью циркониевые конструкции, широко применяются для восстановления естественных зубов. Существенное значение для их клинической эффективности имеют особенности препарирования зуба, в частности тип финишной линии, а также способность реставрации противостоять окклюзионным нагрузкам, возникающим в процессе жевания.

ЦЕЛЬ. Оценить влияние двух вариантов десневой финишной линии (шамфер 45° и плечевой уступ 90°) на прочность на сжатие полноанатомических циркониевых коронок, изготовленных методом CAD/CAM.

МАТЕРИАЛЫ И МЕТОДЫ. В исследование было включено 16 нижних моляров, которые были препарированы под полноанатомические керамические коронки, изготовленные методом CAD/CAM.

Препарирование выполнялось с использованием параллелометрического устройства для обеспечения стандартизации. В зависимости от типа сформированной финишной линии зубы были разделены на две группы: группа А – препарирование с плечевой финишной линией 90°; группа В – препарирование с финишной линией типа шамфер 45°. Испытание образцов на прочность на сжатие проводили с использованием универсальной испытательной машины.
РЕЗУЛЬТАТЫ. Анализ полученных данных показал, что циркониевые коронки с финишной линией типа шамфер и плечевой уступ демонстрируют различную устойчивость к сжимающим нагрузкам. Среднее значение прочности на сжатие для коронок с шамферной финишной линией составило 5287,50 Н, тогда как для коронок с плечевой финишной линией – 3200,00 Н. Между группами выявлены статистически значимые различия; прочность на сжатие коронок с шамферной финишной линией была выше по сравнению с коронками с плечевой финишной линией.
ВЫВОДЫ. Полученные результаты свидетельствуют о наличии связи между типом финишной линии препарирования и прочностью на сжатие полноанатомических циркониевых коронок, изготовленных с использованием CAD/CAM-технологии.

Ключевые слова: финишная линия, прочность на сжатие, CAD/CAM-система, полноанатомическая циркониевая коронка, плечевой уступ, шамфер

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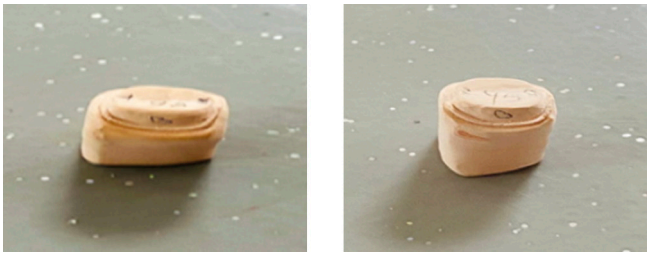
INTRODUCTION

All-ceramic systems can be used in place of metal ceramic systems as cosmetic restorative materials for crowns and fixed partial dentures (FPDs). Since1965, numerous full ceramic systems have been developed and enhanced to satisfy the needs of patients and dentists with high aesthetic qualities and to resemble natural teeth [1]. Zirconia is one of the ceramics that has been utilized a lot lately, usually taking the place of other ceramics [2]. When at room temperature Pure zirconia is monoclinic structure, and changed to tetragonal structure upon sintering at high temperature. During cooling It transited from tetragonal to monoclinic phase. In this way, the volume will expand, resulting in severe compression pressure that make the material brittle [3]. Dental prostheses are currently made using CAD-CAM (computer-aided design and computer-aided manufacture) methods, which offer good outcomes and simplicity of use [4]. CAD/CAM technology has driven the development of diverse ceramic materials for monolithic dental restorations, and producing presintered blocks that minimize milling errors and defects enables these restorations to achieve both high strength and excellent aesthetics. [5]. Both the all-ceramic materials and their processing techniques, such as CAD/CAM technology, have improved with the introduction of stronger materials [6]. Ceramic materials are highly sensitive to tensile stresses, and their fracture resistance is significantly influenced by surface flaws and internal voids [7]. All ceramic restorations' susceptibility to fracture is determined by the material's fracture resistance, finish line design and appropriate thickness of the material. In addition to the colour difference between the natural tooth and the ceramic restoration, one of the most frequent issues is the potential for all ceramic restorations to fracture in reaction to occlusal and lateral force [8]. For all-ceramic crowns, the types of finish lines and ceramic production techniques have been studied [1]. The purpose of this study was to analyze the effect of two gingival finishing lines (90° shoulder finish line and 45° chamfer finish line) on the compressive Strength of full anatomic zirconia crowns.

MATERIALS AND METHODS

Tooth preparation

In the dental model (Nissin Dental Products), the lower six molar tooth was prepared as follow, 1.5 mm oclussal reduction, 1 mm axial reduction with different finishing line.To replicate the shape of the perfect prepared plastic tooth to accept all ceramic crowns. A full arch mandibular impression tray was used to make impression of the prepared tooth model using light bodied consistency (DENTSPLY). Two cast with a different finishing line namely a 90° shoulder and 45° chamfer were prepared as shown in Fig. 1. Section the preparation lower six as a die by saw to get master die.



A **B**

Fig. 1. Master die with a different finishing line: *A* – 90° shoulder and *B* – 45° chamfer

Рис. 1. Мастер-штамп с различной финишной линией: *A* – с плечом 90° и *B* – фаской 45°

A B

Fig. 2. Samples with 45° shoulder finish line (*A*) and 90° chamfer finishing line (*B*)

Рис. 2. Образцы с линией чистовой обработки плеча под углом 45° (*A*) и фаски под углом 90° (*B*)

Sample grouping

Sixteen samples were fabricated by CAD/CAM machine. Depending on their finishing line samples were split randomly for two groups, each group contains 8 samples. Specimens with 45° shoulder finish line and 90° chamfer finishing line, as shown in Fig. 2.

Tooth scanning

Three-dimension dental light scanner scanned prepared tooth. The digital model of the die was transmitted to the computer added machine software to begin the die's, milling process after a three-dimensional picture was captured that clearly showed the plastic die's finishing line and all of its surfaces. Dental stone type IV was used to make the metal die's base.

Following the completion of the scanning procedure, the final three-dimensional (3D) virtual model was displayed on the computer screen. The margin line, crown border, and undercut were then identified, and the final design of the samples was built [9].

Milling process

The type, size of block and positioning of virtual crown after determination, (Aconia Block) all the information were sent to the milling machine to start milling process. The grinded zirconia samples were sintered in rise temperature furnace depending on the recommendations that provided by manufacturers. The heat was elevated for 1450 °C in two hour then kept at final heat (1450 °C to two hour) samples were quietly cooled to under than 100 °C to one hour [10].

Compressive strength test

Compressive strength refers to a materials or structure's capacity to withstand loads that act to decrease its dimensions. It can be quantitatively evaluated by recording the applied load and the resulting deformation using a suitable testing apparatus and analysing the resulting force-deformation curve [11]. Samples were examined using universal testing machine (UTM) to test compressive strength of zirconia crown [12].

Statistical analysis

SPSS Statistics was used for the statistical analysis. For compressive strength, descriptive statistics such as means and standard deviations were computed. To assess the differences between each group, a post hoc multiple comparison test (Student Newman Keuls) was used.

RESULTS

Table 1 show the compressive strength of zirconia crown with chamfer finish line, the highest compressive strength was 6000 N while the minimum was 5000 N, the mean of this group was 5287.50 N.

Table 2 show the compressive strength of zirconia crown with shoulder finish line, the highest compressive strength was 3500 N while the minimum was 2900 N, the mean of this group was 3200.00 N.

Table 3 shows the standard error (S.E), mean and standard deviation (S.D) for all Samples.

Table 1. Descriptive result of compressive strength of chamfer finish line

Таблица 1. Результаты определения прочности на сжатие по линии среза

Total samples	Maximum	Minimum	Mean
8	6000	5000	5287.50

Table 2. Descriptive result of compressive strength of shoulder finish line

Таблица 2. Описательный результат испытания на прочность при сжатии на линии финиша

Total samples	Maximum	Minimum	Mean
8	3500	2900	3200.00

Table 3. Descriptive and compare of compressive strength between chamfer and shoulder finish line

Таблица 3. Описание и сравнение прочности на сжатие при наличии фаски и буртика

Total Samples	Mean	S. E	S. D	Minimum	Maximum	T-test	*p*-value
Chamfer finish line (8N)	5287.50	114.076	322.656	5000	6000	15.554	0.001
Shoulder finish line (8N)	3200.00	70.711	200.000	2900	3500		

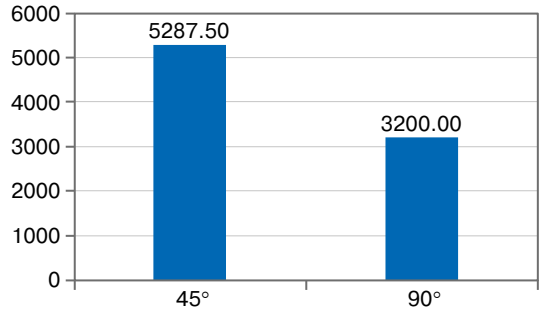


Fig. 3. The mean of statistics for all samples 45° and 90°

Рис. 3. Среднее значение статистических показателей образцов для углов 45° и 90°

DISCUSSION

In restorative dental practice, Fixed prosthetic restorations, particularly full-contour zirconia crowns, are frequently used [13]. The cervical margin design is One of the most crucial factors to consider as it can impact the marginal fit of the crown leading to recurrent caries and periodontal complications [14]. The ability of the restoration to withstand occlusal pressures during mastication and the design of tooth preparation, especially the finish line layout, are crucial components of its clinical efficacy [15]. Factors such as a rough, irregular, or stepped finish line, as well as a non-anatomical occlusal surface, may contribute to an increased marginal gap and therefore must be carefully considered during tooth preparation for CAD/CAM crowns [16]. Monolithic zirconia's resistance to fracture is improved by narrowing the finish line [17]. Regarding the material utilized, Zirconia is a typical material used in crown restorations because of its exceptional mechanical, cosmetic, and biological qualities [18]. This in-vitro study was to evaluate the effect of two gingival finishing lines (90° shoulder and 45° chamfer) on the compressive strength resistance of full contour zirconia CAD/CAM all-ceramic crowns. A statistically significant difference between the groups was found in this investigation using the student's t-test. Compressive strength of chamfer finish line was more than shoulder finish line. The mean compressive strength resistance of chamfer margin is 5287.50 N and the shoulder margin is 3200.00 N because Chamfer margin has a curve and round internal angle which leads to more marginal fitness and spread load better and we don't have such a condition in a 90° shoulder margin [19].

This study is agreement with the study of Jalalian et al. [7] noticed that chamfer margin was further resistant than shoulder in zirconia and Inceram crown copings. In comparison to a 90° shoulder, they ascribed this discrepancy to the rounded internal angle, improved force distribution, and chamfer margin marginal fit. Conversely, Di Iorio et al. [2] reported that the fracture resistance of Procera all-ceramic crowns fabricated with a shoulder finish-line design is greater than that of crowns prepared with a chamfer finish-line configuration.

CONCLUSION

The following results were reached within the constraints of our study:

1. The compressive strength of all-ceramic crowns is significantly influenced by the finish line design.

2. A 45° chamfer finish line significantly increases the compressive strength of monolithic zirconia crowns.

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AUTHOR'S CONTRIBUTION

All the authors made equal contributions to the publication preparation in terms of the idea and design of the article; data collection; critical revision of the article in terms of significant intellectual content and final approval of the version of the article for publication.

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