

# Resistance of full veneer metal crowns with different forms of axial grooves

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**Abstract.** Dental crowns or bridges can occasionally come loose or separate from the tooth during chewing, particularly when they are situated on small, short, and conical teeth. The main cause of this separation is a lack of retention and resistance to the tooth. There are several methods available to increase the retention and resistance of the crown during both inlay and onlay preparation, including parallelism, groove preparation, crown build-up, and surface roughness. The aim of this study was to determine the differences in resistance of full veneer metal crowns with various forms of groove preparation. The study involved the compressive strength testing of a total of 24 specimens, namely six specimens without groove preparation, six specimens with box-shaped grooves, six specimens with V-shaped grooves, and six specimens with half round grooves. The mean values of the metal crowns that separated from the teeth during testing were  $27.97 \pm 1.08$  kgF for the crowns with box-shaped grooves,  $6.15 \pm 0.22$  kgF for those with V-shaped grooves,  $1.77 \pm 0.12$  kgF for those with half round grooves, and  $0.95 \pm 0.13$  kgF for those without grooves. This study found that the resistance is best in crowns with box-shaped grooves, followed by those with V-shaped grooves, half round grooves, and those without groove. When clinicians are working on short and conical molar teeth, it is therefore recommended that box-shaped grooves are used to increase the resistance of the crown.

## 1. Introduction

The loosening of dental crowns or bridges during chewing is a known problem. The main cause of this loosening is a lack of resistance and the retention factor of the abutment teeth, although other causes include the size of the abutment teeth, the conical form of the abutment teeth, and a lack of abutment teeth due to caries. The failure of laboratory or cementation procedures may also cause the loosening of crowns [1,2]. Retention and resistance issues represent the main factors behind the success of fixed denture treatments. The level of retention is influenced by the utilized preparation process, and it serves to prevent the removal of the restoration due to vertical force. Further, resistance is again influenced by the preparation process, although it serves to protect the restoration from horizontal force. The convergence angle of the preparation also affects the resistance [1-5].

The requisite retention and resistance factors are a cervico-occlusal crown height of 3–5 mm and a total occlusal convergence of 6 degrees. Moreover, the surface area of the preparation is affected by the teeth diameters. It has previously been assumed that a box-shaped form of groove preparation achieves the best resistance due to it having a larger surface area than the V-shaped form or half round form of groove preparation. However, the requisite retention and resistance factors are not always



available. Thus, there exist various methods to increase both the resistance and retention of the crown preparation and alignment, namely groove, cement, build-up, and roughness methods [1,6-10].

Prior studies have investigated the best means by which to obtain greater resistance, although they have principally focused on the most appropriate positioning of the grooves. The grooves used in the crown preparation can be located at the mesial or distal surfaces, but not at the buccal or lingual surfaces. Different forms of axial groove are available, including box-shaped grooves, V-shaped grooves, and half round grooves, although half round grooves are most frequently used [1,2]. In this study, different grooves will be investigated so that it is possible to determine which grooves best increase the resistance factor of conical and short molar teeth.

## 2. Materials and Methods

The specimens used in this study were full veneer metal crowns, which were constructed in stainless steel on molar teeth models. The specimens had a cervico-occlusal height of 3 mm and a convergence angle of 20 degrees. A total of 24 specimens were used in this study, namely six specimens with box-shaped grooves, six specimens with V-shaped grooves, six specimens with half round grooves, and six specimens without grooves.

Four master models were constructed in stainless steel with the requisite convergence angle of 20 degrees and the requisite cervico-occlusal height of 3 mm. One master model was constructed without grooves, while the remaining three master models had either box-shaped, V-shaped, or half round grooves. The grooves were positioned in the middle of the mesio-distal and buccal-palatal surfaces. A stabilizing block was made from iron. It comprised three parts fused into one so that a specimen with a 45-degree slope was achieved.

The specimens used in this study were 24 full veneer metal crowns made from a CoCr alloy. They had a cervico-occlusal height of 5 mm. A disto-palatal groove was made by positioning the blade for the specimen analysis. Each crown was in turn paired with the appropriate master model and then located on the stabilizing block. The blade of the universal testing machine was located on the occlusal groove, and the press was started at 0 kgF and 5 mm/mnt of speed. A univariate analysis was performed to determine the frequency distribution of the variables, as well as to identify the mean, standard deviation, and maximum-minimum range. Further, a bivariate non-parametric analysis was performed using the Kruskal-Wallis test, which was used as a post hoc test to determine which group exhibited a difference.

## 3. Results and Discussion

### 3.1 Results

A total of 24 specimens were used in this study. The specimens were divided into four groups so that there were six specimens in each of the no grooves, box-shaped grooves, V-shaped grooves, and half round grooves groups (Table 1). A compression test was performed using a universal testing machine with a maximum force of 50 kgF and a maximum speed of 5 mm/mnt. The results of this study were then processed using SPSS. V20.

**Table 1.** Removal force required for dental crowns with box-shaped, V-shaped, and half round grooves, as well as with no grooves

Specimen	Mean (kgF)	SD	Minimum	Maximum
No grooves	0.95	0.13	0.90	1.22
Box-shaped	27.97	1.08	27.15	30.10
V-shaped	6.15	0.22	5.95	6.50
Half round	1.77	0.12	1.57	1.90

The mean force needed to remove the dental crowns with box-shaped grooves was  $27.97 \pm 1.08$  kgF, followed by  $6.15 \pm 0.22$  kgF for the crowns with V-shaped grooves,  $1.77 \pm 0.22$  kgF for the

crowns with half round grooves, and  $0.95 \pm 0.13$  kgF for the crowns with no grooves. It was determined that the data distribution was not normal ( $p > 0.05$ ). Next, a non-parametric analysis was performed using the Kruskal-Wallis test. This analysis was conducted in order to compare the different resistances of the specimen groups, which were found to be non-normal, with more than two groups being unpaired.

**Table 2.** Resistance of each specimen group

	Mean	p-value
No grooves	3.50	.000
Box-shaped	21.50	
V-shaped	15.50	
Half round	9.50	

**Table 3.** Difference in resistance in each group

Group	Mean	p-value
No grooves – box-shaped	3.50 – 9.50	0.003
No grooves – V-shaped	3.50 – 9.50	0.003
No grooves – half round	3.50 – 9.50	0.003
Box-shaped – V-shaped	9.50 – 3.50	0.004
Box-shaped – half round	9.50 – 3.50	0.004
V-shaped – half round	9.50 – 3.50	0.004

The non-parametric independent-samples Kruskal-Wallis test yielded a result of  $p = 0.000$  (Table 2). Hence, there were differences between the groups. A post hoc test was then performed to determine which groups had differences. Based on the findings depicted in Table 3, it can be assumed that the lack of groove preparation and the different groove preparations can all affect the resistance of the crown, while there were differences found between the groups ( $p < 0.05$ ).

### 3.2 Discussion

In this study, a compression test was performed using a universal testing machine in order to determine how much force was required to remove metal crowns made of CoCr alloy with either box-shaped, V-shaped, or half round grooves, as well as crowns with no grooves. The compression test involved the use of a stabilizing block made of iron, which was designed so that the specimen was positioned at a 45-degree angle. This position was intended to mimic the lateral force applied to the crown during chewing. CoCr was chosen as the material for crafting the specimens because it has long been used for making dental crowns. During the investing and casting procedures, materials might expand. If the utilized material exhibited a high level of thermal expansion, then the result would not be accurate because there would be a significant amount of distortion. Hence, it is necessary that the materials used for making crowns exhibit only a low level of thermal expansion [11]. The CoCr alloy is commonly used for making crowns because it is characterized by good clinical performance, a high elasticity modulus, and adequate strength for metal-ceramic restoration [12,13].

In this study, each specimen from every group was first tested using a self-retention test. The test was performed by positioning the crown on a master model and then reversing it. If the crown separated from the tooth, the specimen did not exhibit the requisite level of retention and so was not used in the study. Previous study stated that the use of grooves can serve to increase the resistance and retention values of crowns when compared to crowns with no grooves [2], while Lu *et al.* suggested that the addition of two grooves can further increase the resistance [4]. Moreover, Bowley [5], Elvin *et al.* [6], and Rajkumar *et al.* [14] noted that the addition of grooves can significantly increase the resistance of crowns.

The results of this study showed that the addition of grooves to the specimens resulted in better resistance when compared to the specimens with no grooves. The mean level of force required to remove the crown was the highest for the crowns with box-shaped grooves ( $27.97 \pm 1.08$  kgF), followed by those with V-shaped grooves ( $6.15 \pm 0.22$  kgF), those with half round grooves ( $1.77 \pm 0.22$  kgF), and the crowns with no grooves ( $0.95 \pm 0.13$  kgF). The results therefore support the notion that the increasing the surface area of the tooth has an impact on the resistance [1]. The crowns with no grooves required a mean force of 0.95 KgF to become separated from the tooth, which could be caused by the crown sliding or rotating during testing.

In this study, the data distribution was not normal, which may be due to the relatively low sample size and the variability of the data. The data variability was high, since there were differences in both the surface area and the form of the grooves. Box-shaped grooves cause the master model and the crown to interlock; hence, the compression force required to remove the dental crown was higher. This study showed that there were differences between the groups, which may be due to the differences in surface area between the groups. The crowns with the smallest surface area (i.e., no grooves) exhibited the lowest resistance value. The crowns with box-shaped grooves had the largest surface area and thus the highest resistance value.

#### 4. Conclusion

This study determined that there exist differences in terms of the resistance of dental crowns on conical and small molar teeth between crowns with no grooves and those with grooves. Of the three types of grooves investigated in this study, the box-shaped grooves exhibited the best resistance, followed by the V-shaped grooves and the half round grooves. Future studies should investigate in more depth the force that can remove dental crowns, since the force that occurs inside the mouth is hugely complex. This study can help to guide clinicians in choosing the most appropriate form of grooves when constructing crowns for small and conical molar teeth.

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