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REVIEW

The role of tooth preparation modification on retention and resistance in short abutment

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ABSTRACT

The parameters for the long-term success of fixed dentures are retention and resistance. Fixed denture treatment for short abutments requires modification of tooth preparation to increase retention and resistance. The proximal area of the preparation can be modified to increase retention by adding grooves, boxes, and frustums. To increase resistance, proximal modifications in the form of adding grooves and boxes, and cervical angle of convergence modification can be used. To analyze retention and resistance based on convergence angle and tooth preparation modification on short abutment. In abutment with ideal convergence angle, addition of grooves and boxes will causes the cement-restoration interface to increase. The frustrum-shaped preparation will convert the retention value from the shear strength of the cement material into the compressive strength of the cement material. In abutment with compromised convergence angle, proksimal modification in the form of grooves and boxes, as well as reducing the convergence angles in the cervical region will result in paralleling of axial walls and increase the resistance. In cases of a short abutment with an ideal convergence angle, the highest retention is obtained by modifying the proximal area with a frustum shape. Meanwhile, if the convergence angles are compromised, reducing the convergence angle in the cervical region would be the most effective method to improve the resistance. (IJP 2024;5(1):29-33)

INTRODUCTION

Fixed prosthodontic treatment can provide a great satisfaction for patients and dentists. To achieve the best treatment outcomes, careful consideration is required from the initial patient history, at the stage of treatment, and the follow-up care. Failure in fixed prosthodontics can occur at any time, and the diagnosis and treatment for the failed restoration are usually complex and difficult. Therefore, it is important to know in advance if there are any indications of possible restoration failure. Failure in fixed prosthodontic treatment can be classified into three categories: biological failure, mechanical failure, and aesthetic failure.[1] According to research done by Zavanelli et al (2018), the most common types of mechanical failure are failures caused by loosening of the prostheses (57.14%), followed by fractured ceramics (28.57%), and fractures of abutments (14.29%).[2]

Failure to achieve the ideal preparation form in terms of the occluso-cervical height and the convergence angle of the abutment to support retention and resistance of the fixed restoration can lead to mechanical failure. Fundamental principles for tooth preparation must be followed to achieve predictably successful prosthodontic treatment. The preservation of tooth structure and periodontium, achieving retention and resistance form, maintaining marginal integrity, preserving structural durability, and aesthetic considerations are the principles of tooth preparation.[3,4] Some common causes of short occluso-cervical height of the abutment are caries, trauma, iatrogenic factors, and eruption disharmony.[5]

Clinically acceptable taper range for a preparation recommended by Rosenstiel et al is 5-22°, however, for abutment with an occluso-cervical height of 3 mm, the taper is restricted to a maximum of 10° to obtain an adequate form of resistance.[4] According to a survey by Abdulla et al. (2018), the average convergence angle that

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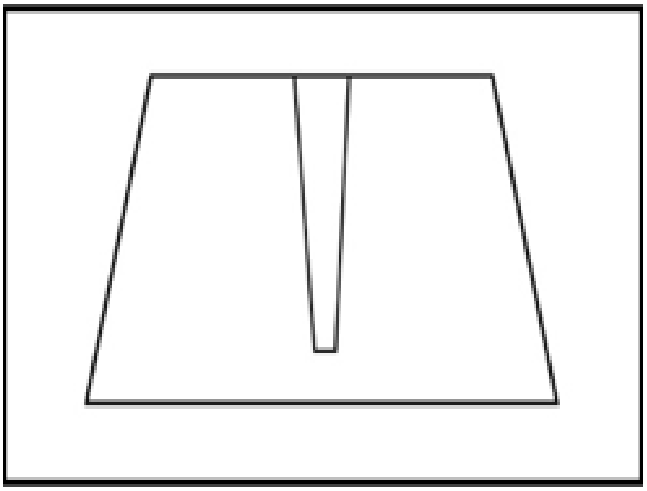

Figure 1. Groove Preparation.

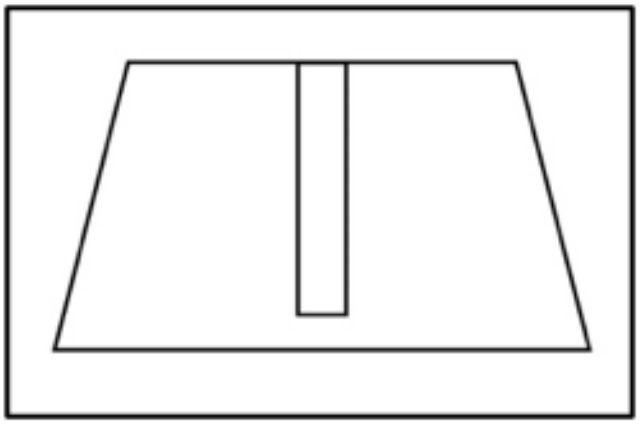

Figure 2. Box Preparation.

Figure 3. Frustum Preparation and The Internal Metal Protrusion.

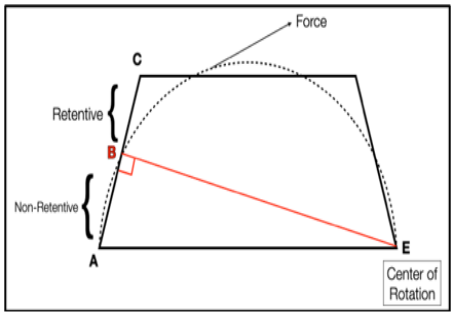

Figure 4. Method Lewis and Owen.

can be achieved by practitioners is 28.6°, which is higher than the recommended limit.[6] A study by Al-Moaleem et al. (2015) also reported that the convergence angle of preparation that can be achieved by specialist practitioners ranged from 22.91° to 38.21°. He concluded that the recommended taper and convergence angle are clinically difficult to achieve.[7] Another study by Ghafoor et al. (2012) reported that the average convergence angle that can be achieved by practitioners is 23.7° ± 8.9°.[8] To overcome the inadequate preparation form, modifications can be made to the tooth preparations in the proximal or cervical area to increase the retention and resistance.

The goal of this article is to determine the role of tooth preparation modification and the correlation between preparation modification and convergence angle in short abutment in increasing the retention and resistance.

LITERATURE STUDIES

According to the Glossary of Prosthodontic Terms, a fixed dental prosthesis is any prosthesis that is securely fixed to a natural tooth or teeth, or to one or more dental implants/ implant abutments; it cannot be removed by the patient.[9]

In order for restoration to last a long time, a preparation must take into account biological, mechanical and aesthetic factors. Biological factors include the health of the tissues of the oral cavity and teeth, avoiding overconturing, supragingival-made margins, harmonious occlusion, and tooth protection against fractures. Mechanical factors include factors that affect the integrity and durability of the restoration. Aesthetic factors, are factors that affect the appearance of the patient.[4]

An ideal preparation form is required to support retention and resistance. Factors can affect retention and resistance in terms of tooth preparation are the convergence angle and the height of the abutment.[3,4]

Short Clinical Crown

Common causes of a short clinical crown are caries, erosion, tooth malformations, dental fractures, attrition, iatrogenic factors at the time of dental preparation, and the presence of disharmony of tooth eruptions such as insufficient passive eruptions and a mesially tipped tooth. The ideal height of the preparation wall for a crown restoration is a minimum of 4 mm.[5,10]

Some methods for dealing with teeth with short clinical crowns include creating the restoration margin in the subgingival area without interfering with the biological width. The biological width consists of 1 mm of epithelial attachment and 1 mm of connective tissue attachment. Any disturbances in the biological width can lead to chronic inflammation, alveolar bone loss, gingival recession, and the formation of periodontal pockets. Chronic inflammation caused by biological width violations can interfere with aesthetics and periodontal health.[5]

Other option when manage a short clinical crown is the use of restoration materials to fill the existing voids, undercuts, and irregularities in the preparation. For non-vital teeth, pre-fabricated post and casting post can be

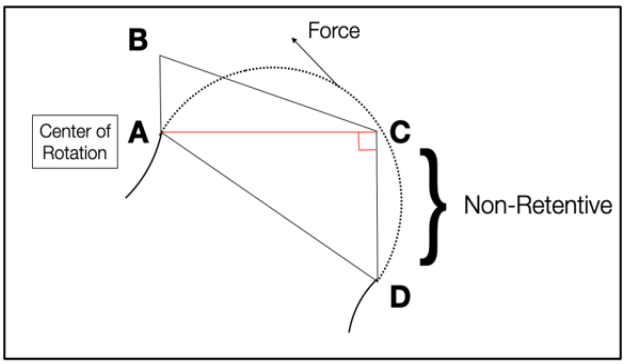

Figure 5. The resistance form of a tilted molar.

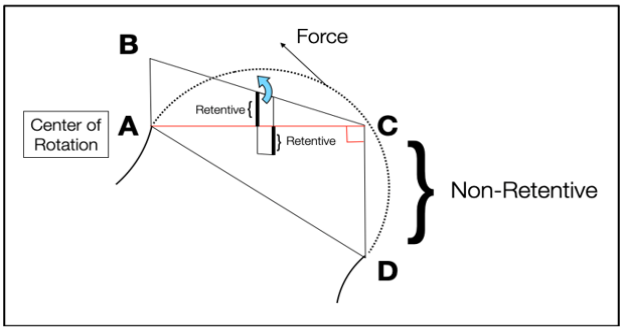

Figure 6. The Resistance Form of a Tilted Molar after Adding Groove.

used. Surgical crown lengthening treatment, can be performed on teeth with short occluso-cervical height, to obtain additional tooth structure, preventing violations of biological width, and for aesthetic reasons, in cases where the gingival contours are not the same, or in the case of gummy smile. Contraindication of this treatment are teeth with fractures that are no longer restored, teeth with a poor crown-root ratio caused by short roots or bone resorption, teeth with exposed bifurcations,and patients with systemic diseases and poor OH, which can interfere with the healing process. Teeth with short occluso-cervical height can also be treated with orthodontic eruption procedure, where the teeth are given a force to pull the teeth upwards. The purpose of this treatment is to maintain bone health, the biological width, and aesthetics. The simplest and most economical treatments for managing teeth with a short occluso-cervical height are endodontic treatments accompanied by the use of a removable overlay denture.[5]

The main factors of retention and resistance are related to the surface area, height of the preparation, the convergence angle, and the surface texture of the prepared tooth. The secondary factor relates to the modification of the preparation in the proximal region or in the cervical region. In the case of a short abutment, preparation modification needs to be done due to the compromised retention and resistance.[5]

Retention

According to the Glossary of Prosthodontic Terms, retention is a quality found in dental prostheses that serves to withstand forces of dislodgment along the path of placement.[9] The magnitude of the dislodging force can influence the retention of a restoration. Generally, this force appears when chewing sticky foods or when chewing gum. This force depends on the sticky consistency of the food, the surface area, and the texture of the restoration. Retention in a fixed prosthodontic depends on the geometric shape of the preparation rather than the adhesion force. Cement is only effective if the restoration has one path of withdrawal. If one of the walls in the preparation is over tapered, the shape of the preparation will not be cylindrical and the cemented restoration material will have more than one path of withdrawal. In such cases, the cement particles will tend to lift away from the preparation rather than slide along the preparation, and the retention obtained is only from the limited adhesion force of the cement.[4]

A taper that is too small may result in unwanted undercuts, while a taper that is too large may result in a lack of retention. The recommended convergence between opposing walls is 6°.Surface area plays a role when the restoration has a limited path of placement. Retention of a restoration depends on the length of the sliding contact between the teeth and restoration. Crowns with tall axial walls will be more retentive than those with short axial walls, and because of the greater diameter, molar crowns will be more retentive than premolar crowns of similar taper.[4]

To reduce retentive failure caused by cohesive failure of the cement, sharp occluso-axial line angles should be rounded to minimize these stresses. Types of preparation can effect the retentive value, retention of a complete crown is more than double that of partial-coverage restorations. Roughening of the internal surfaces of the restoration can increase the retention. The use of air abrasion has been shown to increase retention by 64%. The types of material used for the restoration appear to affect the adhesion with selected luting agents. Base metal alloys such as nickel, cobalt, and chromium have better retention values than less reactive metals with high gold content.[4]

Adding preparation modification in the form of grooves or boxes to increase the surface area between cement materials and restoration is another method to increase retention figure 1 and 2. Further studies have been made by AlShaarani F et al (2019), which reported that preparation modification in the form of proximal frustum with or without internal metal protrusion, can increase the retention of the restoration in case with a short abutment figure 3. The role of the frustum preparation, along with the internal metal protrusion inside the restoration will convert the retention value which is usually seen from the shear strength of cement material into the compressive value of the cement material which have a higher value.[11]

Resistensi

According to the Glossary of Prosthodontic Terms, resistance form is a feature of a tooth preparation that enhance the stability of the restoration and resists dislodgment

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along an axis other than the path of placement.[9] A crown with insufficient resistance form preparation will easily roll off the die, whereas a crown with adequate resistance form will prevent movement.

Retention and resistance form depend on taper. The relationship between taper and retention is in the form of a curved graph, where as the taper gets smaller, the retention will increase. On the other hand, the relationship between taper and resistance is in the form of whether the resistance form is achieved or not achieved in a preparation. The limiting taper value can be determined mathematically with the formula:[12]

The H dan B refer to the height and base of the preparation, the convergence angle is twice this value. The minimally acceptable taper guidelines for preparation for each tooth group can be determined by implementing the formula. The total occlusal convergence were 58° for incisor, 66° for canines, 20° for premolar, and 16° for molars. Hence, resistance form for anterior teeth is much easier to achieve than for posterior teeth, which are shorter and broader with a lower height-to-base ratio. Achieving the required taper for adequate resistance form will be a challenge in posterior teeth. According to Shillingburg, the recommended total convergence angle increases from the anterior teeth (10°) to the posterior molar teeth (22°). Clinically, resistance form is difficult to obtain in molar tooth preparations. Since the most common loose restorations are restorations on molars, preparations made on molars must be done carefully to achieve adequate form resistance.[12,13]

The method for evaluating resistance form proposed by Lewis and Owen is carried out by drawing a perpendicular line on the AC side from the center of rotation E on the opposite margin figure 4. The intersection between the Lewis line and the AC side is point B, and all areas above point B (section BC) are resistive, and all areas below point B (area BC) are non-resistive.[12]

Several methods to increase the resistance form include crown lengthening, shoulder preparation, adding a proximal box or groove, occlusal isthmus, and pins or posts. In the case of tilted molars, the addition of grooves will restrain rotational forces that appear on one side of the groove wall figure 5 and 6.[12]

DISCUSSION

The most common mechanical failure of fixed denture restorations is the dislodgement of a prosthesis, caused by inadequate retention and resistance form in a tooth preparation. Factors that play a role in retention and resistance are the dimension of the teeth and the convergence angle of the preparation.[2,12]

Restoration of a molar with a short occluso-cervical height using a full coverage crown is a challenge in fixed dentures due to the lack of retention and resistance forms in the preparation. Several studies have been conducted to find methods to increase retention and resistance in short occluso-cervical teeth for fixed denture restorations.

In terms of retention, preparation modification that can be done is by making proximal grooves and boxes. According to a study by Vinaya et al. (2015), which aimed to evaluate the retention of full fixed denture restorations in teeth with inadequate height, it was reported that the addition of the proximal groove provides greater retention when compared to proximal boxes.[14] This was further investigated by Shetty et al. (2020), who compared the effect of adding grooves on the retention of fixed dentures in teeth with a height of 3.5 mm, reporting that the addition of two proximal grooves on the mesial and distal sides resulted in higher retention compared to the addition of a proximal groove or conventional preparation.[15] In the study of AlShaarani et al. (2019), which compared the addition of retention of the proximal groove preparation and the proximal frustum preparation on the mesial and distal sides, it was stated that there was a significant increase in retention in the proximal frustum preparation compared to the groove. The proximal frustum preparation is reported to be the preparation modification that can provide the highest retention, but some limitations of the frustum preparation are that it needs more teeth preparation than the groove and box. It is indicated for abutments that have undergone endodontic treatment, abutments with small pulp chambers, and abutment teeth restored with posts and cores. In addition, when manufacturing the final restoration, special skills are needed from laboratory technicians to be able to produce restorations with an internal metal protrusion.[11]

A study to increase the resistance by Proussaefs et al. (2004), who investigated the effectiveness of the preparation modification by comparing grooves and boxes and reducing the angle of convergence of the cervical region in abutments with a height of 2.5 mm and a convergence angle of 20°, concluded that the groove and box preparation were not effective, and that the preparation modification that could significantly increase the resistance was by reducing the angle of convergence in the cervical region.[16]

This is contrary to the study of Lu et al. (2008), who examined the effect of groove preparation on increasing resistance in abutment teeth with a height of 3mm and a convergence angle of 50°, and reported that the addition of two grooves could significantly increase resistance.[17] This was later opposed by Huang et al. (2015), who investigated the effects of proximal grooves and abutment height of a posterior fixed restoration with a convergence angle of 20°, reporting that groove preparation only increased resistance in abutments with a height of 4mm, whereas in abutments with a height of less than 4mm, the addition of a groove had no significant effect.[10]

This was further investigated by Arora et al. (2016) on abutment teeth with a height of 2.5 mm and a convergence angle of 22°, who reported that the proximal groove did not significantly increase resistance. The proximal box preparation modification could significantly

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increase resistance, but the most effective method to increase retention is to reduce the angle of convergence in the cervical region.[18]

CONCLUSION

Short abutments can affect retention and resistance. It is necessary to make modifications to the preparation to overcome these problems. Based on the existing literature, it can be concluded that in the case of short abutments with an ideal convergence angle, the highest retention is obtained by adding the frustum preparation, while for short abutments with a compromised convergence angle, the most effective method to increase resistance is by reducing the convergence angle in the cervical region.

SUGGESTIONS

For achieving the required retention and resistance form, the height of the abutment teeth and the angle of convergence of the preparation play an important role. In the literature that uses groove, box, and frustum preparations with the goal of increasing retention of the short abutment teeth, the convergence angle used is 10°, which is the most optimal angle to obtain the resistance form, but it is still clinically difficult to achieve by clinicians. Regarding the literature related to resistance, there is still conflicting research between authors on the effectiveness of the groove and box preparations in short abutment.

Further in vivo studies are recommended to analyze the role of modified preparations on retention and resistance using samples with a convergence angle that can represent the daily clinical situation found in the dental clinic.

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