Effect of Low Power Magnification on Total Occlusal Convergence Angles in Crown Preparation

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ABSTRACT

Purpose: The purpose of this study was to compare the total occlusal convergence angles of crown prepared teeth with low-power magnifying dental loupes and without dental loupes.

Materials and methods: Three different typodont maxillary teeth (incisor, premolar, and molar) were prepared with x2.5 dental loupes and other prepared without dental loupes. A total of 96 were made, 48 with dental loupes, 48 without dental loupes. Teeth were admitted for evaluation of the buccolingual and mesiodistal convergence angles of each prepared tooth with AutoCAD digital software.

Results: The average buccolingual and mesiodistal total convergence angles for crown-prepared central incisors with dental loupes were 14.73 degrees and 14.94 degrees without dental loupes. In premolars were 16.18 degrees with dental loupes and 17.74 without dental loupes. In molars were 18.55 degrees with dental loupes and 19.18 without dental loupes.

Conclusion: There is no statistically significant difference between crown-prepared teeth with 2.5X dental loupes and other crown-prepared teeth without dental loupes.

Keywords: Crown, Fixed prosthodontics, Magnification, Total occlusal convergence angles

Introduction

Development in restorative dentistry places significant demands on the restorative dentists to work with a high level of visual acuity. A simple efficient way to achieve the better vision is by magnifying the area of interest. The use of magnification in dentistry has been advocated for many years. Many advantages have been reported for using magnification in clinical practice such as reducing diagnosis ambiguity, enhancing the clinical outcome, ensuring the maintenance of better posture, reducing visual stress, and decreasing musculoskeletal pain. Beside the clinician-centered benefits, magnifications could be beneficial in educational purposes. Robinson et al. 2001 showed that the use of magnification is an effective method in undergraduates’ education by using video magnification for pre-clinical teaching of crown preparations. Maggio et al. concluded that dental magnification loupes significantly improve students’ performance during preclinical dental teaching. Moreover, a study conducted by Leknius et al. 1995 revealed that dental students who used dental magnification in fixed prosthodontics procedures tended to have fewer errors than students who not use magnification. However, the disadvantages of dental magnifications are a psychological dependency, eye readjustment to normal vision after using dental magnification, considerably high cost, and relatively prolong learning curve.

The most common magnification devices that have been introduced in dentistry are loupes, surgical microscopes, and recently endoscopes with a wide range of magnification. The more sophisticated delicate procedures the high magnification power is required. Therefore, the high power of magnifications more frequently used in endodontics. In tooth preparation and other prosthodontics works the common magnification used is x2.5.

Tooth preparation has specific geometrical characteristics to provide essential retention and resistance. The most significant factor that contributes to the retention and resistance is total occlusal convergence (TOC). TOC has been defined as the converging angle of two opposite axial walls. While taper refers to the inclination of one wall of preparation to the long axis of a tooth (Fig. 1).

Fig. 1: Total occlusal convergence (TOC) is the angle formed between two opposing axial walls (red color), while taper is the angle formed between one axial wall with the long axis of tooth (green color)
Theoretically, parallel axial walls provide maximum retention and resistance. However, it is difficult to achieve this parallelism without undercut creation. Many studies showed a significant relation between total occlusal convergence and the retention and resistance of restoration on the prepared tooth. The optimal total occlusal convergence ranged from two degrees to 5.5 degrees. Other studies concluded that clinically achievable TOC range from 6 to 24 degrees.

This study measured the TOC angles on crown-prepared teeth aided by x2.5 dental loupes and crown-prepared teeth by naked eyes. Even though many studies have discussed the application of dental loupes on several dental procedures, there was no single study correlate the relation between dental loupes and total occlusal convergence angles for crown-prepared teeth. The goal of the study was to test the null hypothesis that there would not be a significant difference between TOC angles of crown-prepared teeth aided by dental loupes and without dental loupes.

**Materials and Methods**

This cross-sectional study was conducted at College of Dentistry, Prince Sattam-bin Abdulaziz University (PSAU), crown preparations were done by staff members in the phantom lab on typodont plastic teeth (Columbia model, Long Island City, New York, United States). The participants were asked to prepare three typodont teeth (Columbia model, Long Island City, New York, United States) as shown in Table 1. All other teeth were placed in the artificial jaws and mounted in the phantom head in the dental simulation units. The hand-pieces and burs were also standardized. Indirect visualization by dental mirrors was provided. Total preparation teeth were 96 (48 prepared teeth without dental loupes, and 48 prepared teeth with x2.5 dental loupes).

Custom-fit die bases were fabricated by light cure acrylic resin (Zermack, Padua, Italy) and marked to ensure the reproducibility of die positions (Fig. 2). Three bases were made for each tooth. Then, custom-fit die bases enabled the insertion and removal of the rest of the specimen in the accurately identical position every time.

Images were captured by a digital camera (Canon; EOS D700) with a macro lens (Canon EF 100mm f/2.8 Macro USM USM Fixed Lens for Canon SLR Cameras), which is mounted on a mini tripod and wireless remote control (Canon RC-6) at a distance 30 cm from the base. A black background was set up to increase the contrast between the background and the tooth. For each tooth, four pictures were taken in different standardized positions.

The images were transferred into a computer and AutoCAD 2017 for Mac software (version: 4.4.2) was used to measure the mesiodistal (MD) and buccolingual (BL) convergence angles. The two angles were measured by the mean of two opposing standardized positions. Measurement was including the gingival portion of tooth preparation due to its effectiveness in retention and resistance (Fig. 3).

Paired (samples) t-test was used to assess if the means of the TOC angles for the crown-prepared teeth with dental loupes were statistically significantly different from crown-prepared teeth that were not aided by dental loupes.

Next, two analyses were carried out for each teeth type (incisors, premolar or molars). First Paired t-test was used to assess if the mean TOCs of Buccolingual crown-prepared teeth aided by dental loupes were statistically significantly different from crown-prepared teeth that were not aided by dental loupes. Then, the same test was repeated to

| Artificial teeth          | Dental loupes | Without dental loupes | Total number of prepared crowns | Type of tooth preparation         |
|---------------------------|---------------|-----------------------|----------------------------------|-----------------------------------|
| Maxillary right central incisors | 16            | 16                    | 32                               | Full ceramic crown preparation    |
| Maxillary right first premolar | 16            | 16                    | 32                               | Porcelain fused to metal crown preparation |
| Maxillary right first molar | 16            | 16                    | 32                               | Full metal crown preparation      |

Fig. 2: Custom-fit bases marked to ensure reproducibility of the tooth and die position

Fig. 3: Measuring total occlusal convergence
Effect of Low Power Magnification on Total Occlusal Convergence Angles in Crown Preparation

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assess if the mean TOCs of mesiodistal crown-prepared teeth aided by dental loupes was statistically significantly different from crown-prepared teeth not aided by dental loupes.

RESULTS

Each side and tooth analyzed separately, the results Table 2 indicate that the mean TOC angles of buccolingual (BL), and mesiodistal (MD) of incisor teeth were not statistically significantly different between incisor-prepared with dental loupes and without dental loupes ($p = 0.7462$, and $p = 0.9418$, respectively). In premolars, the results also indicate that the mean TOC angles of crown-prepared premolar teeth with dental loupes was not statistically significantly different from crown-prepared teeth without dental loupes for both BL and MD sides ($p = 0.9151$ and 0.12, respectively). In molars, the results indicate that the mean TOC angles of crown-prepared molar teeth with dental loupes was not statistically significantly different from crown-prepared teeth without dental loupes for both BL and MD sides ($p = 0.7680$ and 0.2051, respectively).

The average BL and MD convergence angles for crown-prepared central incisors with dental loupes were 14.73 degrees and 14.94 degrees without dental loupes. Among premolars were 16.18 degrees with dental loupes and 17.74 without dental loupes. Among molars group were 18.55 degrees with dental loupes and 19.18 without dental loupes.

DISCUSSION

Because no significant differences were found between convergence angles in each group of crown-prepared teeth, the null hypothesis was confirmed. In the previous study, magnifications were extensively discussed in endodontics and periodontics. In restorative dentistry, few studies have addressed the effect of magnifications, they discussed the magnification effect on iatrogenic damage to the adjacent tooth surface, geometrical shapes, and ergonomic benefits. No single study was found that discussed the effect of magnifications in total occlusal convergence for crown-prepared teeth.

Magnification of x2.5 provides a multiple quadrant field view focus. This is adequate for most restorative procedures and is the recommended magnification for new users. At magnification x3.5 or higher, the view filed becomes increasingly restricted until the only single tooth is seen, this makes high magnification unsuitable for all restorative works. In crown-prepared teeth, the clinician must see the abutment and adjust teeth to avoid any unnecessary damage. Thus, x2.5 is the recommended magnification for crown-preparation. In this study, standardized x2.5 dental loupes were used by all the participants during the crown preparations.

Several techniques have been described for evaluating total occlusal convergence for crown-prepared crowns. Light projection and silhouette tracing, projected photograph negatives, and three-dimensional laser scanners. In this study, the AutoCAD software for the evaluation of the photographs was utilized which has been previously used by Ghafoor et al., and Al Ali et al.

Although several studies have acknowledged that ideal TOC angles are rarely achieved. Parker et al. mentioned that the minimal acceptable average convergence angles are 29-degree for incisors, 33 degree for canines, 10 degree for premolars, and 8.4 degree for molars. Also, Goodacre et al. recommended 10 to 20 degrees as an ideal TOC. Other studies reporting TOC angles are summarized in Table 3. In this study, the total occlusal convergence

Table 2: Means TOC angles for crown-prepared teeth

| Type of teeth | Side | Aided by dental loupes | Not aided by dental loupes | p  |
|---------------|------|------------------------|---------------------------|----|
| Incisors      | BL   | 19.83 (17.98–21.69)    | 20.16 (18.91–21.41)       | 0.75 |
|               | MD   | 9.63 (7.64–11.62)      | 9.72 (8.44–11.00)         | 0.94 |
| Premolars     | BL   | 17.33 (14.99–19.66)    | 17.25 (16.01–18.48)       | 0.91 |
|               | MD   | 15.02 (12.28–17.75)    | 18.22 (14.82–21.62)       | 0.12 |
| Molars        | BL   | 17.46 (15.82–19.09)    | 17.80 (16.24–19.37)       | 0.77 |
|               | MD   | 19.64 (18.2–21.08)     | 20.55 (18.70–22.39)       | 0.20 |

Table 3: Summary of average TOC angles in the literature review

| Study/ Year   | Tooth type | Preparation crown types | Total occlusal convergence in degree (SD) | Operator                   |
|---------------|------------|-------------------------|------------------------------------------|----------------------------|
| Marghalani,   | Premolars  | Metal ceramic           | 10.49 (3.95)                             | 5th year dental students  |
| 2014.40       |            |                         | 11.11 (4.79)                             |                            |
| Yoon, 2014.15 | Incisors   | Full ceramic            | 20.4                                     | 3rd and 4th year dental    |
|               | Premolars  | Metal ceramic           | 12.4                                     | students                  |
|               | Molars     | Full metal              | 16.3                                     | GDPs and Specialists       |
| Al-Dwairi,    | Molars     | Metal ceramic           | 29.8                                     | Post-doctorate students    |
| 2015.52       |            |                         | 24.7                                     | and staff members          |
| Janine,       | Incisors   | Metal ceramic           | 19.61 (12.50)                            |                            |
| 2016.43       | Premolars  | Metal ceramic           | 12.0 (10.64)                             |                            |
|               | Molars     | Metal ceramic           | 14.26 (6.95)                             |                            |
angles for crown-prepared central incisors with dental loupes were 14.73 degrees and 14.94 degrees without dental loupes. Among premolars were 16.18 degrees with dental loupes and 17.74 without dental loupes. Among molars group were 18.55 degrees with dental loupes and 19.18 without dental loupes. These results are fall in the ideal range because of the participants of this study were experienced staff members. In compared to other studies, most of the participants were students.\textsuperscript{11,12}

This study has some limitations, and teeth preparation was performed on artificial teeth. Therefore, the variable of patient compliance, accessibility, and soft tissue were not present. Then, the convergence angles achievability could differ from clinical situations. Hopefully, future studies may consider more clinical sample size, and reporting other aspects of crown-prepared teeth.

**Conclusion**

This is *in vitro* study comparing TOC values of crown-prepared teeth with x2.5 dental loupes and without dental loupes among three different teeth found that there was no significant difference between crown-prepared teeth with x2.5 dental loupes and without dental loupes.

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