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Review Article

# Taper and Relative Parallelism of Abutment Teeth: A Key to Success in Fixed Partial Dentures

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## Abstract

Retention is considered to be one of the key factor that influences long term success of fixed partial denture prosthesis. It is by the virtue of which restoration is prevented from getting dislodged by forces parallel to the path of withdrawal. Taper is one factor that predominantly influences retention of the prosthesis. Also, the parallelism of the axial walls of abutment teeth is fundamental for the accurate placement of a fixed partial denture. It is necessary that abutment teeth for fixed partial denture be reduced adequately to remove any undercut, maintaining a minimum axial taper to ensure optimum retention. Thus this article describes methods to measure taper and assess the relative parallelism of the prepared abutment teeth to ensure long term success of cement retained fixed restorations.

**Keywords:** Taper; Parallelism; Retention; Convergence Angle; Axial Walls

## Introduction

Crowns and fixed partial dentures are the major prosthodontic treatment modalities for past several decades with factors like esthetics, contact points and pontics playing an important role in varying their design. However, one property of cement retained fixed restorations, retention, has been a prime importance in all designs [1-3].

Retention is considered to be influenced by factors such as diameter, height of preparation, luting cement and mainly by one of the operator controlled factors, that is the convergence angle [4]. It is defined as the angle between two opposing walls that equals the sum of the taper (angle between one axial wall and the long axis of the preparation) of two opposing axial walls of a preparation [4]. The length and diameter of the preparations are often limited by the existing dental anatomy of the teeth. Improved retention due to cement depends on mechanical interlocking of cement, surface area of cement coverage, durability of cement and resistance to mechanical breakdown and dissolution [4]. Hence, taper of the preparation is considered to be as a primary variable determining the retention.

Many dental schools and textbooks advocate preparation designs that include an ideal wall taper of 2 to 5 degrees per side for fixed prosthodontics. In addition to serving as a clinical objective, wall taper in this ideal range has been used in numerous laboratory studies where standardized dies or preparations were used to evaluate fixed prosthodontic materials or techniques. The ideal wall taper is based on clinical observation and laboratory research begun by Jorgenson and expanded by Kaufman., *et al.* A strong relationship exists between the retentive force of cemented castings and the convergence angle of machined test dies. As the convergence angle equals the sum of the taper of two opposing preparation walls, thus if opposing walls each taper 2 to 5 degrees, the convergence angle would equal 4 to 10 degrees [5]. The size of the convergence angle is one of the factors which decides the magnitude of axial (Jorgensen, 1956) and non-axial forces which can be tolerated without resulting in loosening of the crown (Hegdahl and Silness 1977). The size of the angle is likewise important for determining the vertical discrepancy (margin discrepancy) between the cervical crown margin and the finishing line of the preparation as well as the area of the exposed luting material between the crown and the tooth in the seated restoration (Silness and Hegdahl, 1970) [6]. Some researchers have reported that a smaller convergence angle or degree of taper is associated with greater retention of complete veneer crown. In previous studies, many researchers have suggested 2º - 7º of taper or 4º - 14º of convergence angle in order to obtain maximum retention [1,7,8].

The primary goal, while preparing teeth for single crowns or abutment of fixed dental prostheses, is to establish a common path of placement that allows for unobstructed insertion of the restoration in conjunction with an optimum convergence angle of 2.5 to 6.5 degrees in order to decrease stress concentrations [7,8]. Failure to achieve a common path of placement and the presence of undercuts, if taper is not provided adequately in the preparations will force the dental technician to make a choice: 1) ask the clinician to repeat the preparation and impression steps or 2) leave the margins open to compensate for bypassing the undercuts. Open margins may eventually lead to microleakage, which further cause many significant biological effects on the restored tooth like the recurrence of caries, pulpal pathology, hypersensitivity, discolouration and marginal breakdown leading to failure of the prosthesis [9].

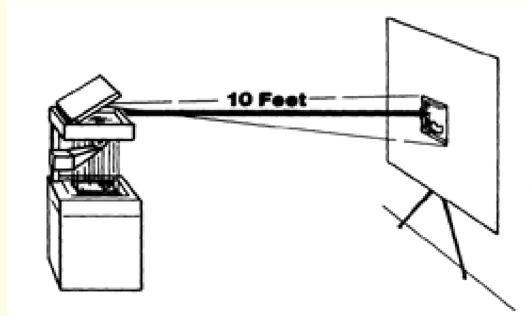

**Figure 1:** Silhouettes projected on overhead projector.

This article describes various methods to measure taper for crowns and relative parallelism between the abutment teeth as they ensure long term success of single crowns and fixed partial dentures.

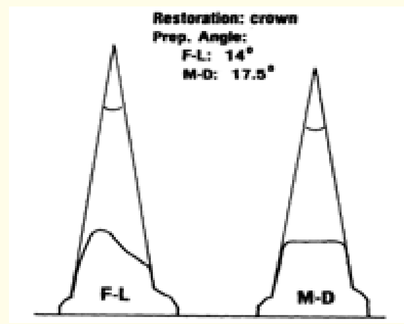

**Figure 2:** Convergence angle working sheet.

### Methods to measure taper

Researchers have proposed many methods to measure abutment convergence angles, however a single method has yet not been standardized. The most commonly used technique was the tracing method using a protractor.

1) Ohm and Silness (1978) described a technique in which measurements of convergence angles were taken from stone dies produced on the basis of tray impressions. The measurements were made in a Reichert MeF microscope. Using incident light the external contour line of the preparation was projected, enlarged 4 times, onto the ground glass screen of the microscope. The glass screen was covered with a transparent resin foil on which the contour line was traced with a fine line ink marker and convergence angle was measured [6].

2) Norlander (1988) described a technique in which the convergence angle of the preparation was determined by projecting the faciolingual and mesiodistal silhouettes of the die obtained from impression with an overhead projector (Figure 1). The die was positioned and stabilized with clay over the lens to record the outline of the appropriate side. The sharp image focused on paper was traced. Lines were drawn parallel to the traced axial walls in the gingival one third and extended until they met to form an angle above the tracing [5].This angle was measured with a protractor to give the convergence angle (Figure 2).

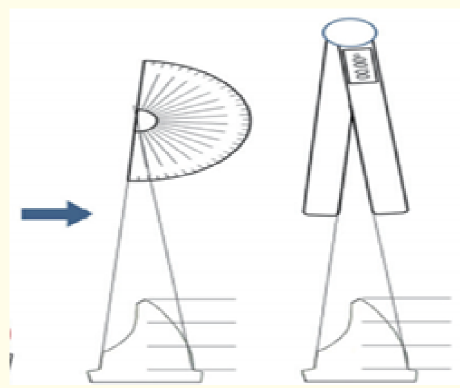
**Figure 3 (A and B):** After tracing the images following the magnification of the pictures, the abutment occlusal convergence angles were measured using a drawing protractor and a digital protractor.

3) Computer-aid design (CAD) system: Recently, few researchers have emphasized on measuring the abutment convergence angle more accurately using a computer-aid design (CAD) system. Initially with the help of tracing method, the axial wall of the cervical third of the abutment was traced, followed by the extension of the tangential lines in order to measure the convergence angle with the aid of drawing protractor or a digital protractor (Figure 3A and 3B), but when measuring the convergence angle with a CAD system, it is not necessary to extend the tangent lines of the axial walls to evaluate the angle as the occlusal convergence angle can be easily measured through a virtual convergence of the two tangent lines (Figure 4) [10].

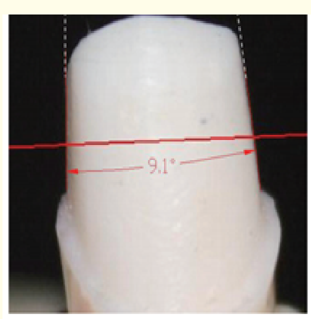

**Figure 4:** The two tangent lines (red solid lines) are mesio-distally established to the cervical third of the abutment. The software virtually extends the tangent lines to converge (white dashed lines) and calculates the angle between the tangent lines.

Thus, there is no particular rule for measuring the abutment convergence angle. The accuracy and reliability of the measured values may be questioned as they are dependent on the observers or measuring methods employed. The traditional method of a tracing using a protractor is likely to show less accuracy and reliability as the convergence angle is read manually by the person. However, measuring convergence angle with CAD system is an easy and reliable method but is quite expensive.

### Methods to assess relative parallelism of abutment teeth

When multiple abutments are being evaluated for a common path of placement; use of mouth mirror, photographic mirror and dental periscope were described in previous literature.

### Mouth mirror

In this technique while evaluating multiple abutments for a common path of placement, the mouth mirror is to be centered over 1 abutment and moved to the next without changing the angulation of the mirror [1]. Preparations needs to be viewed with 1 eye closed because undercuts may remain undetected with binocular vision.

### Drawbacks

a) This technique has the prerequisite of maintaining angulation of the mouth mirror constant as each abutment is evaluated for undercuts relative to opposing axial walls.

b) As the number of abutments increases and the distance between them increases, it becomes difficult to determine whether a common path of placement exists or not [11].

### Photographic mirror

Mirrors that are designed for use in taking intraoral pictures allow multiple abutments to be viewed at the same time. Viewing the implant abutments (Figure 5) with one eye by using an intraoral photography mirror reveals non-parallelism of the axial walls of the abutments. Either an angled abutment must be used or the axial walls of the solid abutments must be modified. Multiple preparations confined to 1 quadrant or sextant may be viewed with a buccal photography mirror, whereas an occlusal photography mirror provides a better view of multiple preparations in an entire arch [9].

### Drawbacks

a) This technique requires the preparations to be viewed with a single eye centered over one abutment and shifting to the next without moving the mirror.

b) Examining the undercut areas relative to the opposing axial walls is difficult as the operator does not have any guideline to move the eye from over one abutment to another [12].

**Figure 5:** Occlusal view with intraoral photography mirror.

Peter D. O'Meeghan and Donald A. Behrend (1983) described a simple technique using an acrylic resin base with a guide pin made from paper clip wire. With pliers or fingers, the pin is bent at its base for the desired line of insertion. Guide pins used as a visual guide to the line of the bur, abutments were prepared. If tapered diamond points or burs are used and their central axes aligned to the guide pin, the resulting preparations will have about 6 degrees of total taper [13].

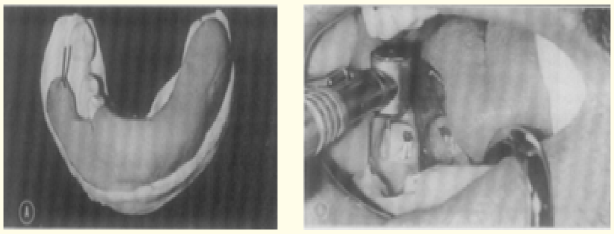

**Figure 6 (A and B):** A: Baseplate with guide pin for fixed partial denture in mandibular posterior segment.
B: Guide pin in mouth.

### Dental periscope

It is constructed by using 3 plain mirrors (A, B and C) angulated at 45° to a main metal framework (M) (Figure 7A and 7B). Mirrors A and B are made to face mirror C. Mirror C is attached to eyepiece. The device when placed in patients mouth, mirror A is placed over the most posterior abutment and the slideable assembly with mirror B is centered over the anterior abutment preparation. For examining posterior teeth, B is removed with the help of handle H. The occlusal image of posterior abutment preparation which is formed on A acts as an object to C. The image formed can be viewed into eyepiece outside patient's mouth. When B is reseated an occlusal image of anterior abutment is visible through the eyepiece in similar manner.

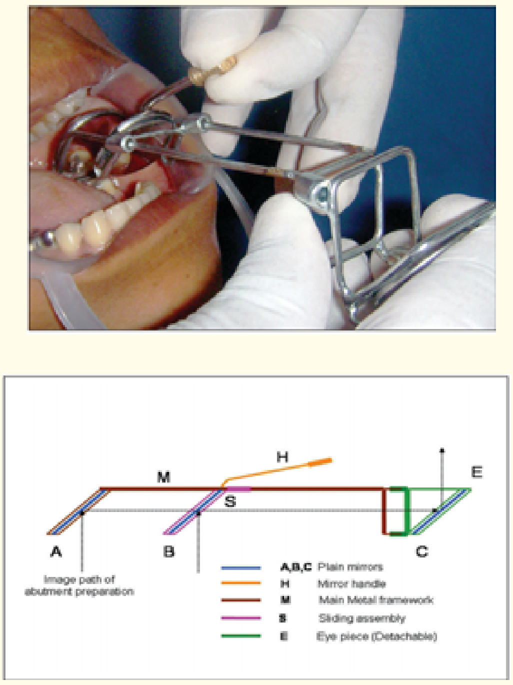


**Figure 7 (A and B):** A: Dental periscope. B: Schematic representation.

### Drawbacks

a) Sufficient light illumination is required [11].

Rafat I farah (2016) described a chairside technique to verify the parallelism of fixed partial denture abutments. It facilitates a simple and accurate extraoral preparation assessment. Preparation undercuts are detected prior to making the definitive impression. Casts required for this technique are fabricated using polyvinyl siloxane impression material. This technique makes use of class II (< 1mW) laser module attached to dental surveyor

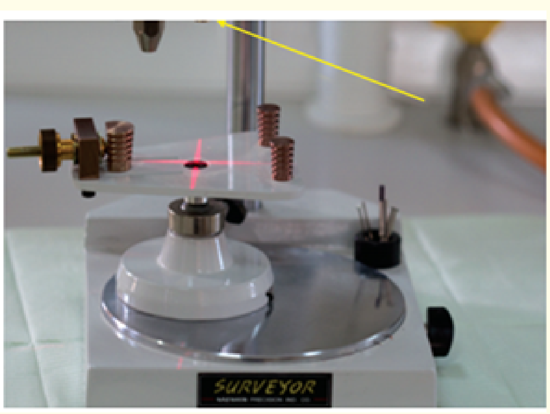


**Figure 8A:** Laser module fixed to dental surveyor.

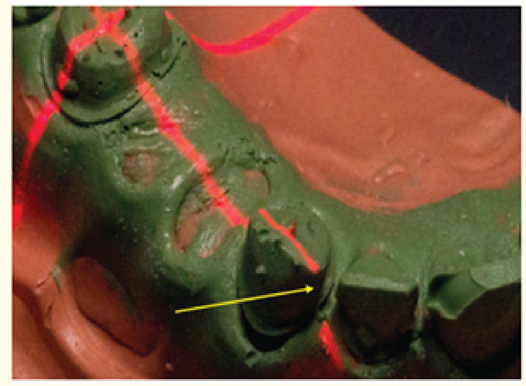

**Figure 8B:** Non-continuous laser line on one of the axial walls indicating undercut.

### Drawbacks

a) This technique required frequent pouring of the polyvinyl siloxane cast until there is continuous laser line on all of the prepared abutment teeth making it a time consuming procedure [9].

## Discussion

As a cast metal restoration or ceramic restoration is placed on the preparation after the restoration has been casted in its final form the axial walls of the preparation must taper slightly in order to permit the restoration to seat properly. It has been theorized that more nearly parallel opposing walls of the preparation, the greater would be the retention. The most retentive preparation should be one with parallel walls. However, parallel walls are impossible to create in mouth without producing preparation undercuts which further prevents complete seating of the restoration. Thus walls of the preparation are tapered in order to allow their visualization, prevent undercuts, compensate for inaccuracies in fabrication process and permit more nearly complete seating of restorations during cementation.

The result of the study conducted by Ohm and Silness (1978) [6] showed that for vital teeth the mean size of the convergence angles varied between approximately 19 and 27° and for endodontically treated teeth, the mean values varied between about 12 and 37°. The values both for vital and endodontically teeth are considerably larger than those usually recommended for the preparation of teeth for artificial crowns. Norlander., et al. analyzing 208 preparations done by 10 dentist reported a low of 17.3 degrees for premolars and a high of 27.3 degrees for molars with an overall mean of 19.9 degrees [5]. Findings by the clinical research on dental students, intern dentists, and professional dentists showed a clinically acceptable tooth inclination angle of 10 - 24º which was relatively larger than the recommended theoretical value [14-16]. Thus it is being observed that there is increased tendency to over taper the preparation that must be vigilantly guarded against in order to produce preparations with least possible taper and the greatest possible retention. Study by Jorgensen and kaufman., *et al*. also established that retention decreased as taper increased. Tooth preparation should be kept minimal as it adversely affects the retention of the prosthesis. Mack had suggested that minimal taper of 12 degrees was necessary to ensure absence of undercuts [17]. Also, in previous studies, many researchers have suggested 2º - 7º of taper or 4º - 14º of convergence angle in order to obtain maximum retention [1,7,8].

## Conclusion

Thus it is important for the clinician to accurately measure the amount taper and so the convergence angle of the preparations in fixed partial dentures, and also ensure parallelism of abutment teeth which facilitates the common path of insertion for the prosthesis.

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