Improved Dental Surveyor Tools for Finding Retentive and Reciprocal Arm Action Zones of Circumferential Clasps

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Abstract: - The limitations of the undercut measuring gauge found in dental surveyors restrict precise positioning of the retentive arm of a clasp from its initial contact with the tooth surface above the survey line (suprabulge area) to its final resting position in the undercut area. Presently, the available dental surveyors feature three distinct measuring undercut gauges specifically designed to assess only the depth of the infrabulge area. There is a clear necessity for new gauges that can assess both the undercut depth areas and the suprabulge areas, as this would be crucial for accurately marking the action zone of the retentive arm and the reciprocal action zones to counteract the spring-action mechanism of the retentive arm, thereby reducing the torque on the abutment during the placement and removal of removable partial dentures, as well as during various oral functions. A device with a simple design, consisting of a metal disc whose diameter matches each of the three standard gauge measures (0.25, 0.5, and 0.75 mm), is proposed. This device can be easily made to determine the clasp's activation zone. It is suitable for all types of dental surveyors.

Key-Words: - Dental surveyor, undercut gauge modification, undercut measurement, suprabulge marking, infrabulge.

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1 Introduction

A removable partial denture (RPD) is a device designed and configured to replace partially missing teeth and related structures in partially edentulous patients. It comprises various components that are interconnected to create a unified structure and incorporates both retentive and supportive means [1]. The holding-in-place components are called direct retainers or clasps. The direct retainer (DR) or the clasp is a simple system of retention and support for a removable partial denture. It has different forms but all share the same principle of functioning and components in general [2]. The main components of the clasp are the retentive arm (RA), reciprocal arm or support (REA), and rest (R). Each part is designed for a specific function. The rest prevents vertical movement of the RPD toward the ridge and participates in horizontal stability in favor of protection of the supporting tissues [Fig.1]. The retentive arm works to provide retention by engaging an undercut using its flexibility as a spring [1], [2]. The reciprocal arm intends to counteract the force applied by the retentive arm during function, thus clinically reducing the irritant strains on the periodontium of teeth.

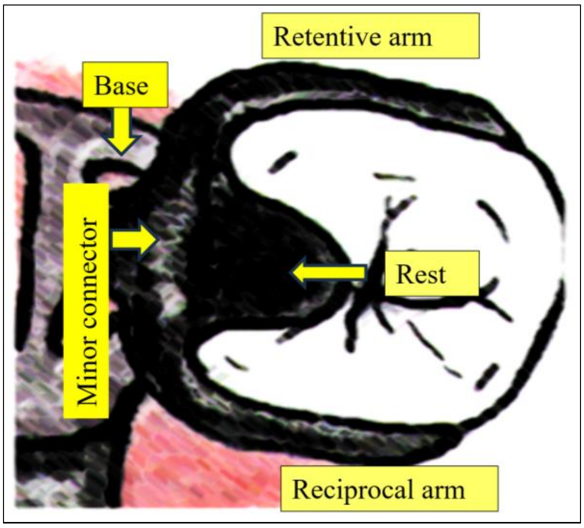

Fig. 1: The circumferential clasp components

The clasp's three components are attached to the saddle or base via a main bar, which serves as the minor connection [Fig.1]. This arrangement allows the clasp to operate as a retentive means and force transmitter for both the abutment tooth and the base of the partial denture. Clasps are classed as occlusal or gingival based on how they approach the abutment teeth. The circumferential clasp engages the undercut of the tooth in the cervical third from the occlusal direction [1],[2],[3].

A spring-action mechanism is frequently employed to achieve the retentive force of a circumferential clasp due to the flexibility of the RA and engagement of the undercut. Cast of a particular Co-Cr alloy, the retentive arm is fashioned in a half-round or semi-elliptical shape in section and gradually reduced in size by one-third until it reaches the tip of the arm, which contacts within the undercut, providing it elasticity and the qualities of a simple spring. Additionally, it is deflected by a hard reciprocal arm [Fig.2]. It makes the RA more adaptable when working. Otherwise, no retentive force could be produced.

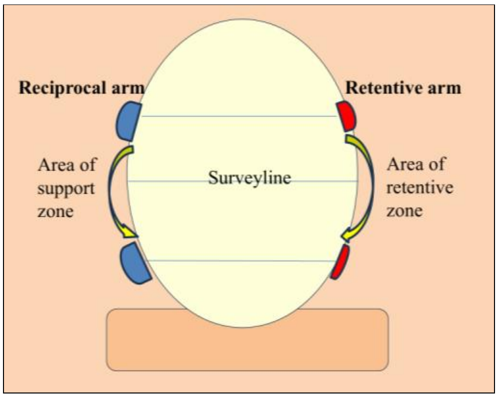

Fig. 2: The retentive and reciprocal (support) zones. Reciprocal arm is hard enough to help RA be act as spring action

2 Problem Formulation

The fundamental principle of clasp design and operation is that a reciprocal arm should counteract the retentive arm when it first makes contact with the tooth surface [1],[2],[3],[4]. Repeat this process until the retentive arm terminal's final rest position encounters the undercut region while the rest is seated in a predetermined spot on the occlusal tooth surface [Fig.2]. When this procedure is not carried out, the tooth is subjected to a harmful torque that causes the abutment to come loose with every movement of the partial denture during oral function, as well as when the RPD is removed and reinserted [1],[2],[3]. The zone of clasp function is the area on both sides of the abutment teeth, and a surveyor should plot and trace it so that the practitioner can correctly design the clasp's configuration [Fig. 2].

The surveyor is a mechanical device used in prosthetic dentistry to determine relative parallelism, mark the survey line or circumference of the teeth, detect the location and depth of undercut areas on the teeth and alveolar ridges, and modify the prosthesis's path of insertion as needed [Fig.3] [4]. However, dental surveyors and accompanying tools are unable to locate the first contact between the retentive arm and the tooth surface at the same time as reciprocal arm contact on the opposite side of the abutment, which is required to activate and equalize the retentive force during RPD insertion and removal [2],[4]. [Fig. 4].

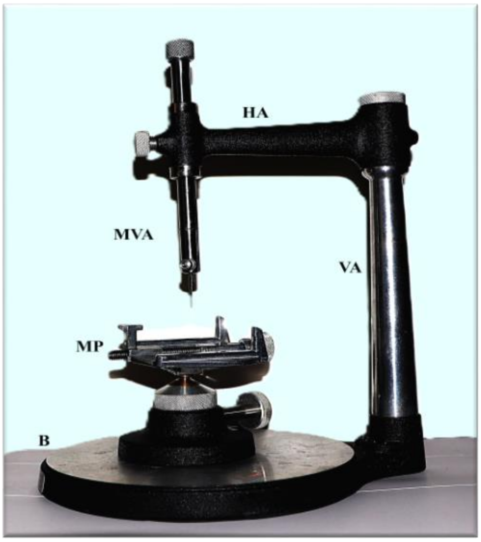

Fig. 3: The classical surveyor main components VSA; vertical axis, HA; horizontal axis, MVA; movable vertical axis, MP; movable plate, B; base of surveyor

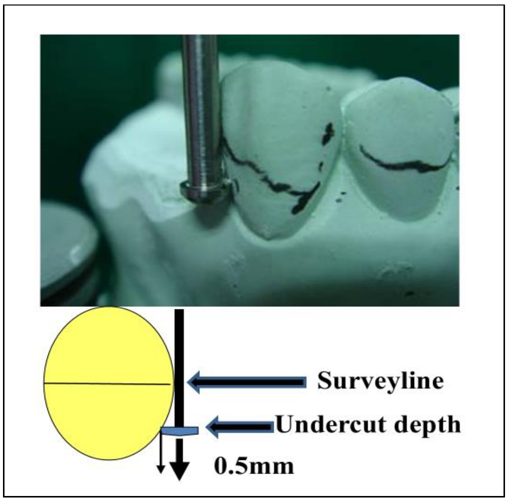

Fig. 4: The main functions of a surveyor; tracing of surveyline and locating the undercut depth

2.1 Analysis of the clasp design and its basic function

The circumferential clasp is configured to retain the partial dentures using the abutment tooth as anchorage when the patient wears the prosthesis. The first contact occurs between the clasps and the teeth before the partial denture settles down inside the edentulous area [1],[2].The clasps hypothetically work in the way that the retentive arm, when it comes into contact with the designated tooth surface (buccal or, palatal, and lingual), should be instantaneously opposed by the reciprocal arm and continues until it reaches the rest position whereas the RPD is well seated, rests in place and clasps components in their designated locations on the supporting tooth [Fig.5].

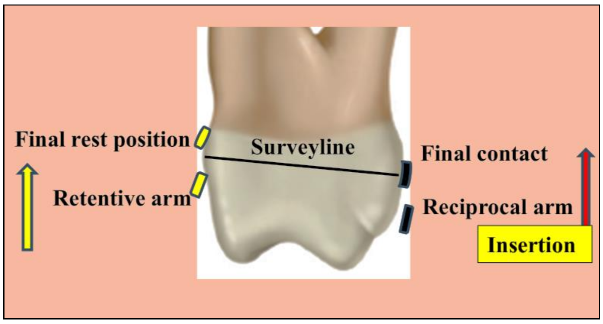

Fig. 5: The typical design and positioning of circumferential clasp retentive and support components along the surveyline, from RPD insertion and initial clasp contact with the tooth surface to rest position. Because of this setting, the retentive arm begins to put pressure on the teeth, while the reciprocal arm stays uninvolved. With continuous insertion, the force gradually increases until it exceeds the survey line, then drops until it reaches its rest position. Because of the support arm's disadvantaged posture, the retentive force never becomes neutral. As a result, a correction is needed to reduce or eliminate the impact on the tooth.

The retentive arm's resiliency and spring feature produce a force against the tooth when reflected; this force continues to rise until the arm crosses the maximum contour of the tooth, at which point it decreases gradually following the inclined surface of the tooth below the survey line toward the undercut area to become null in the final rest position [Fig.5] [2]. The support or reciprocal arm is designed to be rigid and non-flexible to provide resistance against retentive force, and it sits over or above the survey line. Because of this feature, the action continues consistently during daily oral function, and the force is negated if the retentive arm and reciprocal arm are well-aligned and facing each other, which rarely occurs in nature due to the shape of the teeth [Fig. 5]. However, if the tooth circumference is sufficiently broad, it reduces the retentive force effect, as in the case of molars [5]. In nature, the placements of retentive and reciprocal arms do not completely oppose each other due to the dissimilar and unsuitable curvature of the tooth surfaces, as seen in [Fig.5], and [Fig.6]. Because of this faulty location, the long axis of the abutment pivots around the apical axis, increasing torque on the tooth and supporting tissues, especially since ordinary people are able to produce thousands of force units through opening and closing movements during normal oral activities such as swallowing, speaking, breathing, and eating [6]. As a result, in some clinical settings, small changes to the tooth surface of the support area may be necessary to optimize clasp function and the overall longevity of the abutments and residual teeth.

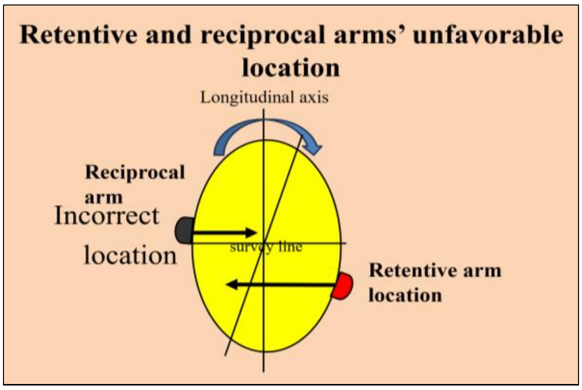

Fig.6: The arrangement of the two opposing components of the circumferential clasp, in relation to the direction of force application, creates a leverage effect. This configuration of the retentive arm and support is therefore unfavorable for teeth health.

2.2 The description of the inappropriate location of the clasp components

In nature, the position of the retentive and reciprocal arms on abutment teeth is never mechanically or physiologically optimal [Fig. 5]. To reduce tooth rotation, the ideal position is as low as feasible at the center of the fulcrum line [1], [2], [3], [1], [2], [3], [7]. This concept cannot be realized without teeth preparation. Minor or major tooth modifications are indicated when the retentive and reciprocal arms need to be placed as close to each other as possible [Fig. 7].

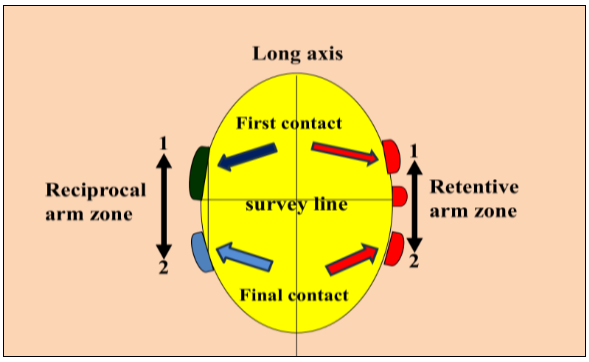

Fig. 7: An illustration of the abutment section reveals the anticipated ideal location of the circumferential clasp, as well as the working action of the clasp's retentive and support components during RPD placement and removal (1 to 2 points).

2.3 Objectives of the study

The aim of this article is to present a comprehensive theoretical and logical analysis based on extensive clinical and laboratory difficulties about the optimal circumferential clasp configuration and operation. Second, to aid in the proper placement of the clasp and action, a little device is studied and thoroughly explained. It can be combined with any dental surveyor's standard undercut gauge to determine the zone of the retentive area above the survey line, and thus the corresponding active zone of the reciprocal arm.

3 Problem Solution

The clasp unit's anchoring feature is the primary factor influencing RPD retention. As previously stated, a detailed analysis and understanding of the circumferential clasps' function and side effects on the supporting teeth is required to resolve some significant yet critical design difficulties. The dental surveyor is the only tool for creating the clasp and determining the proper location and depth of its components [1],[2],[3],[4]. The technological issues with regularly used dental surveyors and their equipment should be solved by modifying these devices to give the required functionality. The newly created tools should have a common form that can be utilized on different brands of analogue surveyors to provide identical job duties and setups. These shared properties make it easier to design and manufacture universal gauges that improve usefulness.

3.1 Identify the technical shortage of the surveyor tool

To achieve the best force-balanced configuration of the circumferential clasp, the clasp's retentive arm should be designed so that its applied force is continuously annulled by a reciprocal arm located on the opposite side from the first contact with the abutment when crossing the contour of the tooth circumference until it reaches and settles in the rest position. During RPD construction, the initial step in tracing the design is analyzing the patient's dental cast or model. To coordinate such activity between the retentive and reciprocal arms, the dentist or technician must either place the survey line in a regular, even spot on the proximal, buccal, palatal, or lingual surfaces of the tooth according to the required clasp placement [Fig. 8], or the patient should be prescribed tooth surface modification or tooth crowning [Fig. 9]. To investigate the positions of the retentive and reciprocal arms, do a preliminary survey of the primary cast to record the line of contour and the ideal location of the retentive tip in the appropriate undercut depth. The depth of the undercut is measured using a simple gauge. The gauges come in three different depths: 0.25, 0.5, and 0.75 mm. Each gauge consists of a horizontal disc with a specific diameter and a shank or mandrel that is held by the surveyor's vertical axis [Fig. 3] and [Fig. 10]. However, this gauge can only measure the depth of the undercut area below the survey line.

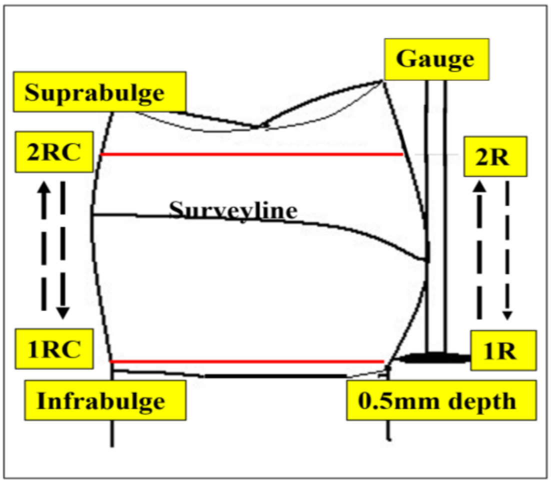

Fig.8: This is a schematic representation of the existing surveyor's technical inability to locate the first touch of the retentive arm (2R) and reciprocal arm (2RC), as well as the rest position of the reciprocal arm (1RC), opposing the retentive arm action range on the other side (2R to 1R).

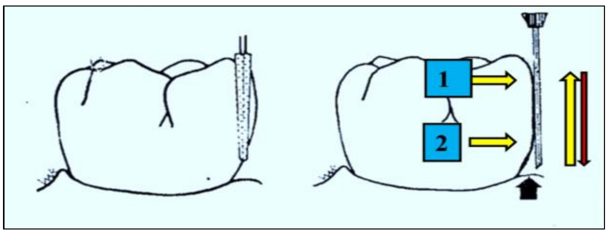

Fig.9: Tooth preparation using operative procedures to correct the supporting zone (1-2) opposite to the retentive arm zone

Fig. 10: The standard undercut gauges and additional tools employed by surveyors to prepare the partially edentulous arch for the subsequent stage in the forming and casting of the metal frame for removable partial dentures (RPD).

3.2 Technical description of the new gadgets

Two devices were developed to determine the initial contact of the future retentive arm with the tooth surface above the survey line. The first type is similar to the original gauge, but the measuring horizontal disc is set someplace on the gauge's shank, making it easier to indicate the suprabulge area. The first version comes in three sizes, like the original gauges: 0.25 mm, 0.5 mm, and 0.75 mm. The second type features a small metallic disc that corresponds to commercially available gauges with varying undercut depth discs, which are fixed to a short metal sleeve. This design can be freely moved and inserted onto the shank of the original gauge when the practitioner intends to measure the suprabulge area of the abutment [Fig. 11] and removed when the infrabulge region is determined.

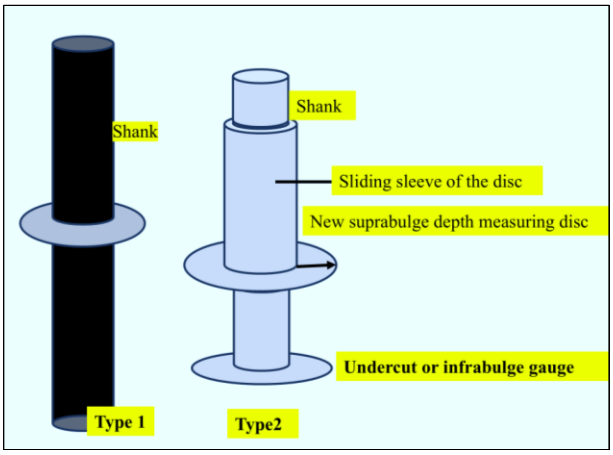

Fig.11: The diagram above depicts two types of suggested supra- and infrabulge depth measuring gauges: Type 1, a single-piece gauge, and Type 2, an extra piece to modify an existing gauge. Type 1 is used alone to measure the infrabulge depth area in mm and should be added to the surveyor's gauge set. Type 2 is an additional piece intended to be used in conjunction with the regular undercut gauge to measure the suprabulge and infrabulge areas.

3.3 How to use the new gadget to record the retentive and support zones

The steps of recording the active, retentive, and supporting zones begin by selecting the path of insertion and fixing the model orientation on the surveyor. Then, the surveyline is recorded on the teeth to be used as abutments. The undercut depth using a classical gauge is measured on the RA side of the tooth, and the record is considered correct when two contact points are reached, one inside the undercut area and the other at the surveyline [Fig. 12]. The contact point at the undercut area is marked using a pencil (0.5 mm ϴ) for further work. The prescribed suprabulge disc of equal depth to the standard gauge is mounted on the same gauge shank and put above the survey line in the suprabulge area; when the disc touches the tooth surface and the shank with the surveyline, a pencil is used to indicate the location. This point shows the first RA contact with the tooth above the survey line [Fig. 13]. The next step of surveying is to duplicate the two positions to the palatal or lingual surface of the tooth as shown in [Fig.14] using the same device with the adopted parts.

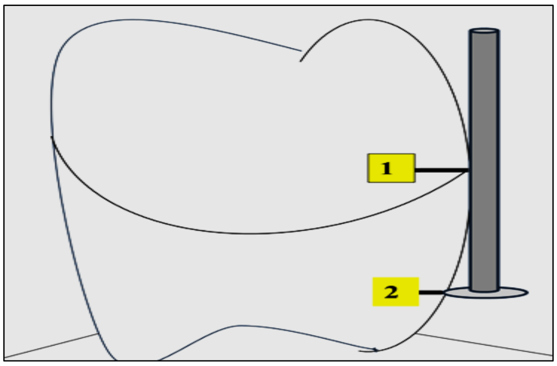

Fig.12: Measurement and marking the location of the undercut area, point 1; contact between the shank and the surveyline should be coupled with point 2 which shows the undercut depth of the tooth

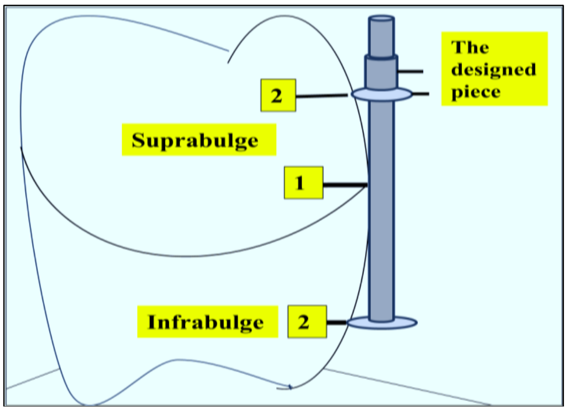

Fig.13: When the UC gauge's shank hits (point 1 or the surveyline) and its disc contacts the tooth surface at the undercut area (point 2), the depth is appropriately determined. The suprabulge area is then marked with the newly recommended piece, which has the same UC depth as the RA (point 2). The two markings (infrabulge 2 and suprabulge 2) represent the maximum and lower limits of the retentive action zone during oral activities.

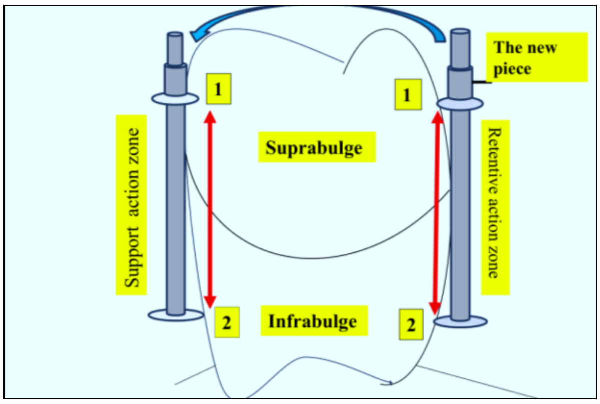

Fig. 14: After measuring the undercut depth, the undercut gauge is shifted to the palatal or lingual tooth side (the left side of the figure) to precisely define the reciprocal arm or support's action zone boundaries at 1 to 2 places.
1. Initial clasp component contact; 2. Final clasp component contact with the tooth. The red arrows indicate the zone of action expansion during clasp activity within the patient's mouth.

The clasp exerted maximum force during typical RPD insertion and removal. The other sort of force is produced during regular oral operations such as mastication, swallowing, and speech. The forces created during oral function are less intense than the first type, but they occur often. The maximum force was applied when crossing the surveyline, but only on a limited basis when inserting and removing the RPD.

3.4 Discussion

The biomechanical features and organization of the stomatognathic system components, like teeth, muscles, bones, and surrounding tissues, are very complex. Tissues that support and anchor teeth to the sockets of the alveolar bone are a complex biological and mechanical entity that is represented by periodontal ligaments and specially composed and configured bone. They are innervated by a complete set of protective systems of different receptors, making prediction of force intensity and direction extremely difficult to understand regardless of the type of test used. [8], [9]. The concept provided in this article reduces the impact of clasps on the abutment's teeth from the start of action to the rest position, decreasing torque on the abutment to the greatest extent possible. It is based on extensive clinical experience teaching, testing, and treating patients who required oral rehabilitation using removable partial dentures (RPDs). The traditional circumferential clasp configuration is not novel, and much opinion and research has been done but resides in the same context of retentive force measurement and distribution around the abutment teeth [1], [2], [5], [7], [9], [10], [11], [12], [13]. However, no prior research has been completed to determine the effect of tooth morphology on clasp design, function, and force distribution, as well as how to reduce fulcrum effects by enhancing the circumferential clasp component's design on the abutment teeth. Even when some researchers repeated their twentieth-century analysis. Finding the first contact point between the retentive arm and the clasp's tooth surface is crucial for prolonging the life of the teeth and removing or reducing the torque created by the clasp's spring mechanism. As a result, one effective technique for counteracting the effect of the retentive arm is to ensure that the opposing reciprocal arm always makes contact with the opposite tooth surface at the same time. Implementing this notion is difficult due to the teeth shape and standard undercut gauge design. To fix the above issue and enable dental surveyors to take a more active role in bringing this idea into practice, a new tool has been developed and presented. This instrument can identify the required convergence point above and below the surveyline by using an undercut gauge of the traditional design. The dentist or the technician can utilize and construct it with ease. High-precision laser measurement equipment is proposed as part of a study of similar but more advanced and user-friendly technology. Suprabulge and infrabulge measurements should be accurate to

± 0.001 mm, whether suggested or made. The gadgets are intended to operate with any manual dental surveyor. Further research on this topic may include improving the arrangement of bar clasps and investigating the effects on abutment teeth in short and long free-end saddles. A new clasp design and shape will be studied in a future study by application of this concept.

4 Conclusion

The classical neutral function of the circumferential clasp is extensively discussed and analyzed. As a result, this concept requires extra measuring tools that allow the dental surveyor to precisely determine and mark the zone of clasp function. Two simple gauges were designed and presented to help apply the neutral function concept of clasp retentive action on the abutment.

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