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ORIGINAL ARTICLE

A Mathematical Derivation to Prove Reduced Denture Retention in V Shaped Palate

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Abstract The impact of oral health on the quality of life of older individuals have significantly increased over the last few decades. Edentulism substantially affect oral and general health and overall quality of life. Complete denture retention is the resistance to displacement of the denture base away from the ridge which is the main source of psychological comfort for the patient. Special retention problems are seen in patients exhibiting highly tapered steep palatal vault. In these cases a metal base or subsequent bench cure reline procedure would be incorporated into the initial treatment plan. In this article, we have derived a mathematical proof for the clinical experience that reduction in the palatal angle, results in lesser denture retention.

Keywords Retention · V shaped palate · Complete denture

Introduction

Retention stability and support are essential factors in the success of a complete denture. Among the three, probably retention is the 'spectacular' factor [1]—loss of denture retention can immediately impact physiologic needs (like mastication) as well as can have psycho-social impacts (self image, social relations, etc.). Needless to say, retention dramatically increases psychological acceptance of a complete denture [2].

Glossary of Prosthodontics terms, defines complete denture retention as "that quality inherent in the dental prosthesis acting to resist the forces of dislodgment along the path of placement". In other words, it is the "resistance to displacement of the denture base away from the ridge" [2].

Various authors attribute factors such as adhesion, cohesion, interfacial surface tension, gravity, intimate tissue contact, peripheral border seal, atmospheric pressure neuromuscular control and the size and shape of the palatal vault with it [2, 3]. Posterior palatal seal (PPS) is a feature unique to maxillary dentures. It helps the maxillary denture base to maintain tissue contact during base movement or soft palate function, compensates for processing shrinkage of acrylic resin and is an important factor in maintaining retention [2, 4]. This area is "not susceptible to pressure atrophy and therefore allows moderate tissue displacement to maintain the thin fluid film" [2]. Size and shape of the palatal vault is a factor that determines whether the required amount of tissue displacement to ensure a good PPS can be obtained.

Palatal vaults have been classified into three types based on their geometrical features. Class I palates are low and flat. Class II has a medium vault and is considered ideal for complete denture construction. Class III palate, on the other hand are high and often tapered. A tapered, steep and high vault palates, often indicates as 'V shaped' palates presents a special problem in construction of complete dentures. In V shaped palates, the processing shrinkage of resin "may be so severe that no amount of PPS can

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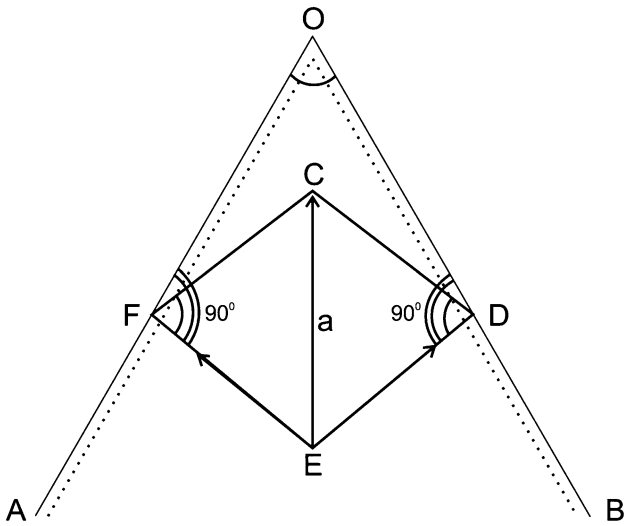
compensate for the resulting deficiency in intimate tissue contact". Construction of a complete denture becomes very difficult in patients with V shaped palatal vaults [1].

The aim of this article is to present a mathematical derivation that can explain the loss of retention in V shaped palates.

Methodology of Mathematical Derivation

AOB is the geometrical representation of a V shaped palate. The dotted lines represent a denture base. The retention of the denture base will be under the influence of the sum total of forces acting on the two halves of the denture base resting on AO and BO. It is the horizontal portion of the hard palate lateral to the midline provides the primary support for the denture.



In the diagram, EF represents a line of force acting perpendicular to AO (the left half of the palate). Adhesion gets most powerful at right angles to the surface. In the direction shown in the diagram (towards the palate). ED represents another line of force acting perpendicular to BO (the right half of the palate). Both lines of forces acting on the two halves of the palate meet at the point E. In order to find out the magnitude and direction of these two lines of forces, we can apply the parallelogram laws of forces in mechanics, which states that "If two forces acting at the point be represented in magnitude and direction by the two adjacent sides of a parallelogram, the resultant will be represented in magnitude and direction by the diagonal of the parallelogram passing through that point.

A parallelogram, EFCD, is constructed with EF and ED as adjacent sides and by drawing lines FC parallel to ED and DC parallel to EF. Since lines EF and ED represent two lines of forces acting on the palate, their resultant force will be represented in magnitude and direction by the diagonal of the parallelogram, EC passing through E. The magnitude of the forces will be represented by the length of the diagonal and the directions of all lines of forces will be towards the palate as shown in the diagram.

The shape of the palate, whether it is more towards U shape or V shape depends on the measure of the angle AOB (smaller angles make it v shaped and larger angles make it U shaped). Geometrically it can be proved as follows:

Angle AOB is directly proportional to the diagonal EC which represents the resultant of two lines of forces acting on either side of the palate. This means smaller the angle AOB lesser will be the retention. (V shaped palate)

In the quadrangle EFOD,

$<EFO = 90°$ and $<EDO = 90°$ (from the above, forces acting are perpendicular) $<FED + <FOD = 180°$ {since $<EFO + < EDO = 180°$, which when subtracted from 360°, (the sum of 4 angles of a Quadrangle)—we will get 180°}. Therefore, $<FOD = 180- <FED$, which means when $<FOD$ decreases $<FED$ has to increase to maintain the sum as 180°

In the parallelogram EFCD,

$<FED = <FCD$ (opposite angles of a parallelogram are equal). If $<FED$ increases, $<FCD$ will also increase,at the same time, $<EFC$ and $<EDC$ will proportionately decrease to maintain 360° (the sum of 4 angles of a quadrangle, here parallelogram EFCD).

Also,by sine rule in trigonometry $<EFC$ is proportional to EC in Triangle EFC {sin rule $- a/\text{Sin A} = \text{b}/\text{Sin B} = \text{c}/\text{Sin C}$}

Therefore it is proved that when $<AOB$ decreases (in V shaped palate), $<FED$ will increase, which causes $<EFC$ to decrease resulting in decrease of diagonal EC (Resultant of forces).

Discussion

Edentulism is a common disability that can include reduced eating and speaking abilities. Deficient retention and stability are among the primary complaints of complete denture wearers [1]. Certain mechanical, biologic and physical factors are necessary to ensure optimal functioning of complete denture [2]. Satisfaction with complete dentures seems to be multicausal [4]. Fisch was among the first to discuss the determinants of retention. A proper design of the tissue, polished and occlusal surfaces of complete dentures permit dentist to incorporate the mechanical, biologic and physical factors of retention [5]. The most common reason for dissatisfaction in complete denture wearers is unsatisfactory retention. The most commonly listed factors of retention include adhesion, cohesion, interfacial surface tension, gravity, intimate tissue contact, peripheral border seal, atmospheric pressure

and neuromuscular control [6]. Retention primarily is obtained by pressure contact of the PPS against the palate through the effect of soft tissue impaction against the denture base at the, junction of the mobile mucosa and attached mucoperiosteum. Adhesion, cohesion and to a lesser extent, viscosity are important in providing an in expansible film between the denture and mucosa. Special retention problems are seen in patients exhibiting highly tapered steep palatal vaults (V-shaped palate). A V-shaped palate allows sliding and therefore retention by adhesion is compromised [7, 8]. This article has attempted to validate retention variation with different angulations of palatal vault mathematically. The derivation here is in total agreement with the previous studies, that clinically proves that a V-shaped palate has lesser denture retention.

Conclusion

Ultimately the success of a denture is determined by the quality of fit of the denture base to the soft tissue beneath it which is determined by several factors which includes the size and shape of the palatal vault. Dental literature contains numerous references to PPS and thereby to palatal vault form. Indeed, retention has been well studied as a clinical phenomenon However, an understanding of the problem from basic science point of view is not given much importance. The paper presented a mathematical derivation that can explain the loss of retention in V shaped palates. This will be of interest to dentists and scholars who are interested in studying the problem from the point of view of physics and material science.

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