A THEORETICAL ANALYSIS OF THE MECHANICS OF THE THOMPSON DOWEL SEMIPRECISION INTRACORONAL RETAINER

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A theoretical analysis of the mechanics of the Thompson dowel semiprecision intracoronal retainer

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The Thompson dowel semiprecision intracoronal retainer has been used by dentists for over 40 years. While the design features have been reported in the literature,[1-5] the reasons for its success have not been explained. Koper[6] recently published a summary of the literature and clearly delineated the design features and minimum dimensions. When Morrison[3] analyzed the use of precision attachments in 1962, he said, ". . . the intracoronal attachment has remained a symbol of *better dentistry* for the past forty years."

THE THOMPSON DOWEL

The Thompson dowel is custom-made for each abutment for a removable partial denture, and it fits into a specially designed recessed well in the restoration on the abutment tooth (Fig. 1). The system is claspless, which is one of its advantages. Primary retention is effected by a circular boss (metal projection) carried on a lingual snubber arm of the partial denture that fits into a recess on the lingual surface of a restoration on the abutment teeth (see Fig. 4). The retainer is stress-broken to allow displacement of the denture base toward the ridges. The prosthesis rotates about an axis which passes across the arch at right angles through the well areas of the abutments (Fig. 2). An important feature is that the dowels are free to rotate out of the recessed wells without any binding action on the walls of the recesses that would stress the abutment teeth. Ideally, the retaining metal projection should be placed in line with the axis of rotation so that it, too, may rotate without being displaced from its retentive recess. Such displacements would cause premature wear of the recess lips and torque the abutments.

Thompson[2] assumed that the axis of rotation was in the mid-well area of the dowel, while Knowles[4] and later Koper[6] more accurately thought it to be in line with the inner shelf line of the retaining abutment (Fig. 2). The basic design currently used is essentially the same as advocated by Thompson,[2] although many refinements of modern technology have been incorporated.

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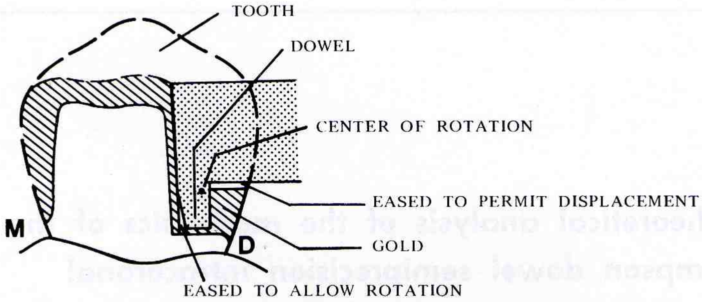


Fig. 1. A mesiodistal section through the abutment restoration with a dowel in position. Note the center of rotation and the parts of the dowel that are eased (relieved) to allow stress-broken displacement of the denture base. Support is obtaind by contact of the foot of the dowel with the floor of the well.

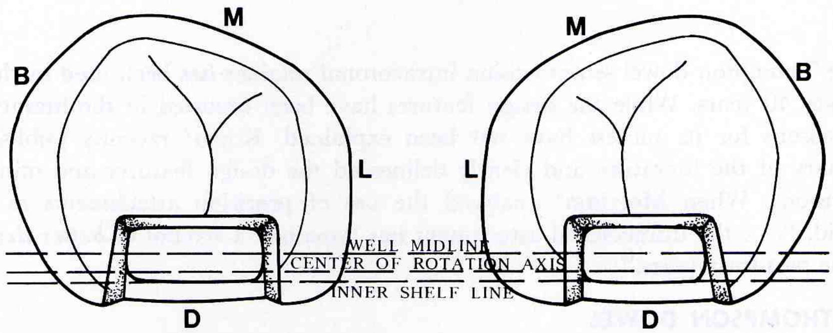


Fig. 2. An occlusal view of abutment teeth that shows the well, its midline, the inner shelf line, and the position of the axis of rotation.

Indirect retention is effected by contact of the dowel with two surfaces—the distal wall of the well below the shelf and the upper part of the axial wall of the well above the eased area of the dowel (Fig. 3). Bracing is provided by contact of the occlusal portion of the dowel with the buccal and lingual walls of the recess and also by the snubber arm (Fig. 4). Support is provided by the base of the dowel as it rests on the floor of the well (Fig. 1).

OBJECTIVES OF THE ANALYSIS

The purpose of the analysis is to determine the (1) location and ideal placement of the rotational axis, (2) ideal position of the retentive recess, (3) optimal easing of the dowel, (4) placement of the occlusal bevel and its limits, and (5) effect of different levels of bilateral well shelves.

Rotational axis. The center of rotation has been found from geometrical drawings and calculations and also by the use of the hinge-axis locating system described by McCollum and Stuart[7] for gnathologic purposes. The latter was applied to working models of the dowel using scaled enlargements of the current design concepts.[6]

Examination of the working diagram (Fig. 5) shows that the rotational center

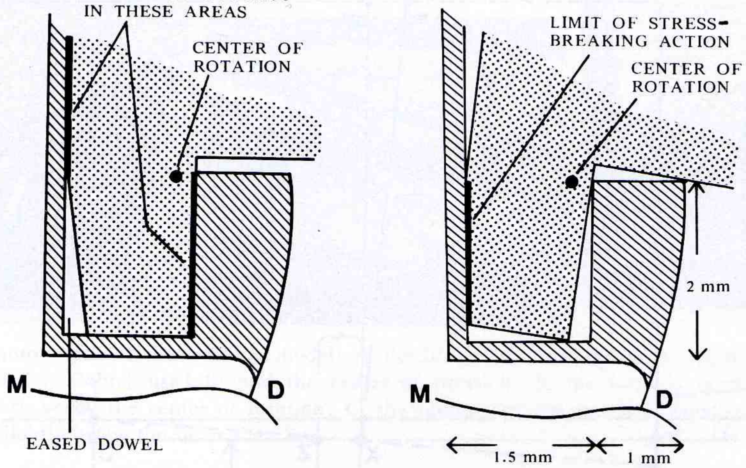


Fig. 3. Mesiodistal sections through the dowel in the rest and rotated positions indicate where indirect retention is obtained and how rotation is limited by the degree to which the dowel is eased (relieved).

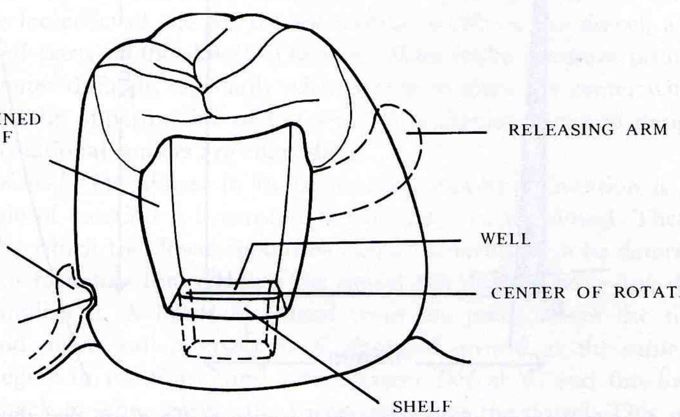


Fig. 4. A distoocclusal view of the abutment restoration indicates where bracing is obtained from the well, the walls of the recess, and the snubber arm.

is approximately at the intersection of the "shelf line" *(YZC)* and the maximum rotation or "tilt line" *(AXC')*. They cross at *X,* the center of rotation. With the minimum dimensions of 2 mm. for well depth (maxillary*) and 1 mm. for shelf width, as suggested by Koper,[6] the center of rotation has been found by experiment to be 0.19 mm. in from the shelf (Fig. 6), not 0.5 to 0.75 mm. as used formerly. It is also important to note that it is not coincident with the inner shelf line.

There is a slight error in determining the center of rotation because of the coronal

*In mandibular teeth, the minimum depth is 1.5 mm.; greater retention is required in the maxilla.

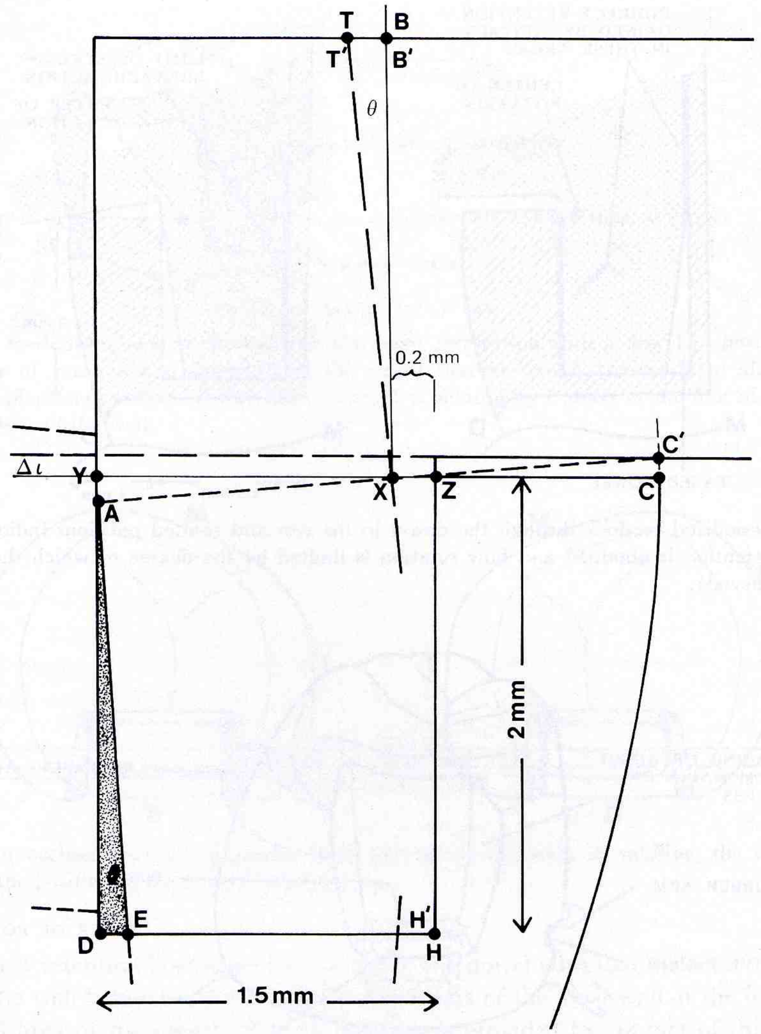


Fig. 5. A scale drawing of the mesiodistal section of the dowel that shows the position of the center of rotation at *X*—the intersection of *YXC* (the shelf line) and *AXC'* (the tilt line).

displacement of the dowel as it rotates. This occurs because the heel (*H*, Fig. 7) tends to enter further into the well. In the working models (see Fig. 6), the effect of this action is to displace the center of rotation slightly apically below the inner shelf line. This effect can be overcome by easing the corner of the foot of the dowel at *H* (Fig. 7). Failure to compensate for this effect will result in a minute torqueing force at the side of the retentive projection whenever the denture base is displaced toward the ridges. It will cause accelerated work hardening of the spring arm and tend to lip the coronal aspect of the recess in the lingual surface of the abutment tooth restoration. These two effects will be more pronounced if the rotational center is incorrectly aligned with the metal projection. Avoiding these errors will result in

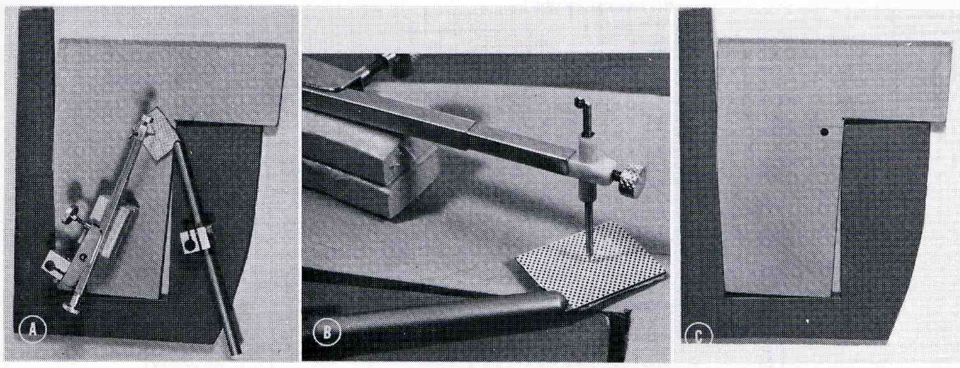


Fig. 6. Photographs of the working model: *A,* the hinge-axis locating system (Denar Corporation, Anaheim, Calif.) used to find the center of rotation; *B,* the location of the pin on a single dot to verify the center of rotation; *C,* the position of the center of rotation within the well and slightly below the inner shelf line.

minimizing wear so that it will occur only during the insertion and removal of the prosthesis.

The position of the rotational center is a function of the separation of the dowel from the shelf, the looseness of the fit, the mesiodistal width of the dowel, and the contour of the eased parts of the dowel. These variables make accurate positioning of the rotational center difficult, especially when trying to align the center with that of the abutment on the opposite side of the arch. It is advantageous to design the dowels so that the rotational centers are coincident.

Easing of the dowel. The dowel in its position of maximum rotation is shown in Fig. 7. The angle of rotation is a constant for all parts of the dowel. Therefore, the exact amount by which the dowel should be eased (reduced) can be determined. Harris[5] mentioned a rationale for reducing the dowel but did not have any definite guidelines to accomplish it. A line will extend from the point where the tilt line (*AXC′*, Fig. 5) and inner wall intersect at *A,* dropped inward at the same angle (θ, the required degree of rotation), and will intersect *DH* at *E,* and this line will be the one to cut back to when easing the inner surface of the dowel. This will remove the part of the dowel that prevents rotation.

Occlusal bevel. An additional design feature of the dowel retainer is a bevel placed on the occlusal outline of the recess in the abutment restoration. The bevel is contacted by a lip on the occlusal edge of the dowel. This design feature is not always used and has not been mentioned in the literature. The rationale of its use is to reduce the potential for food impaction between the dowel and the recess.

In Fig. 8, a line is extended from the center of rotation *(X)* to the occlusal surface, cutting it at *B.* A second line is extended inward and upward toward the occlusal surface at an angle *(*θ*)* intersecting at *T*. As the dowel rotates, the portion of the occlusal surface mesial to *T* will rotate coronally out from the tooth, and the remainder from *T* to the distal edge or outer margin will rotate apically. If the occlusal bevel extends from the middle of the tooth past *T,* it will bind and act as a fulcrum, altering the center of rotation and stressing the abutment.

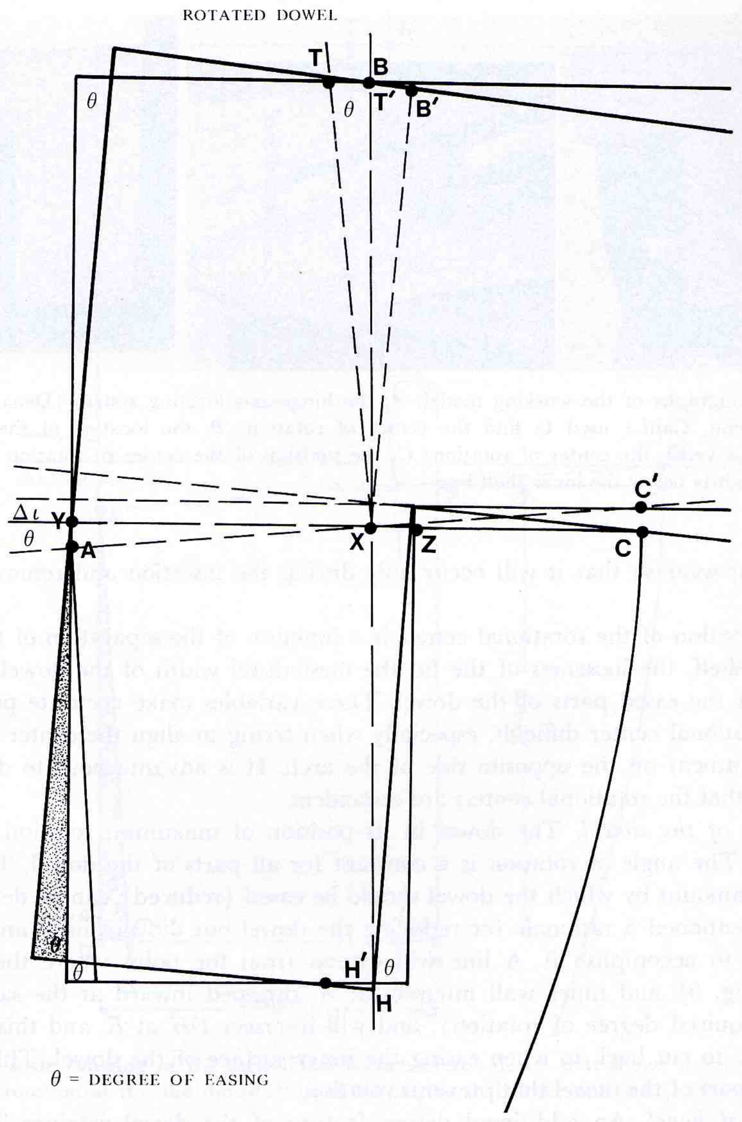


Fig. 7. A scale drawing of the mesiodistal section of the dowel in the rotated position that shows the exact degree to which the dowel should be eased. The shaded area is the part of the cast dowel which should be cut away to permit rotation. The heel *(H)* tends to rotate into the floor of the well when the center of rotation is within the dowel at *X*.

The exact limitation of the placement of the bevel can be determined by using the same angle of maximum rotation through which the dowel may turn. It had been suggested that the bevel be extended to the edge of the normal tooth contour. This is not a favorable design.

Relative position of the heights of the shelves and the effects of nonalignment. Ideally, the centers of rotation should be exactly aligned in both horizontal and

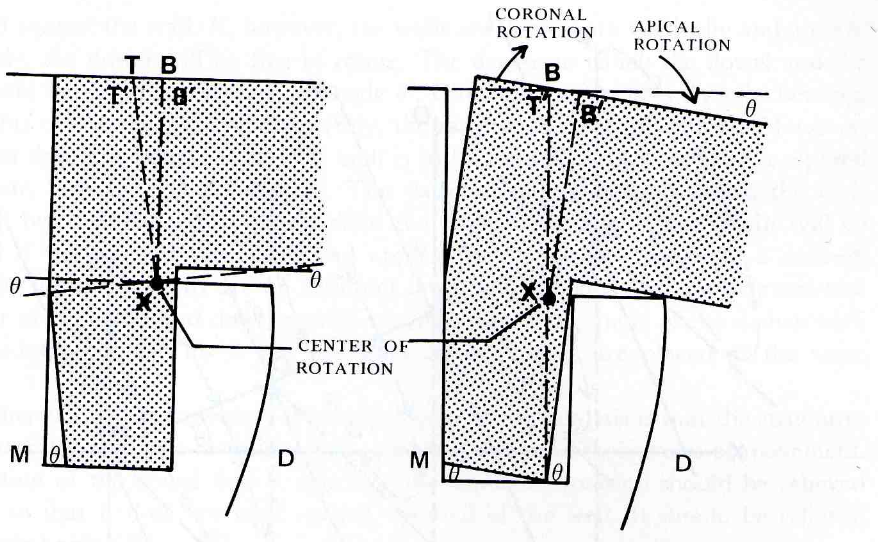


Fig. 8. Mesiodistal sections through the dowel in the rest and rotated positions show that the occlusal surface mesial to *T* rotates coronally, while the occlusal surface distal to *T* rotates apically. An occlusal bevel should not be placed distal to *T*.

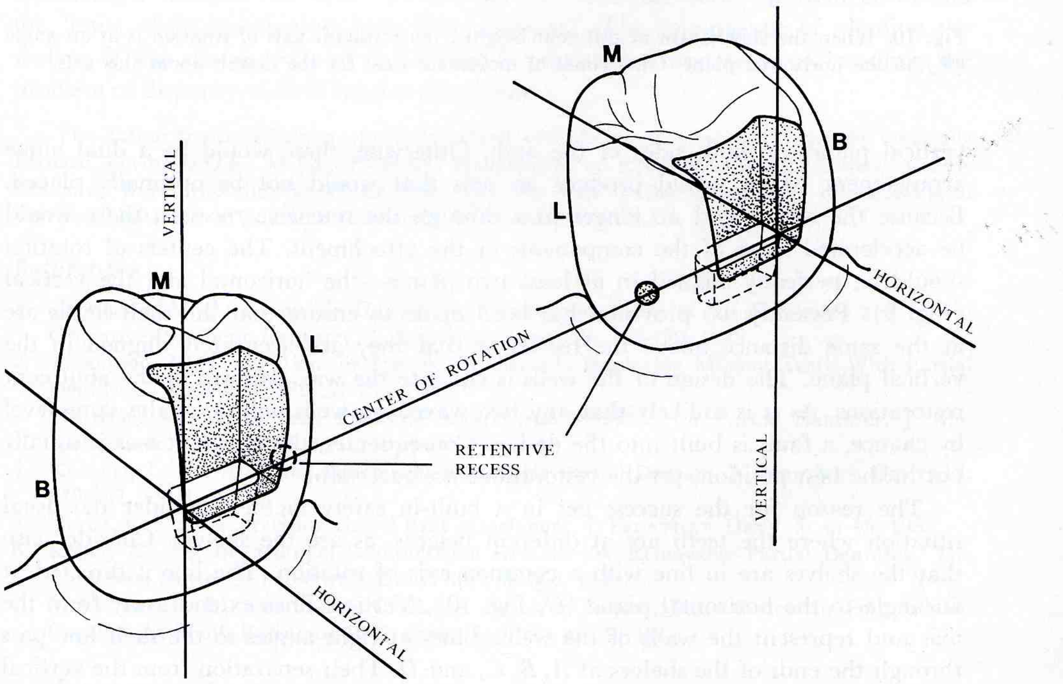
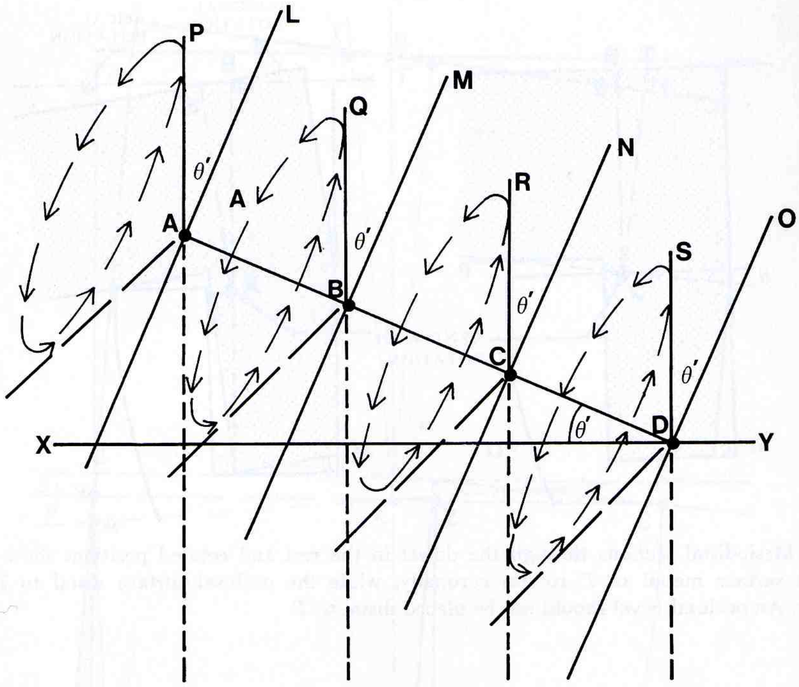


Fig. 9. A view of the distal surfaces of abutment teeth that shows the alignment of the centers of rotation in both horizonal and vertical planes.



A - B
C - D
REPRESENT THE INNER SHELFLINE

Fig. 10. When the shelves are at different heights, the resultant axis of rotation is at an angle (θ') to the horizontal plane. Only cones of movement exist for the dowels about this axis.

vertical planes on both sides of the arch. Otherwise, there would be a dual hinge arrangement which would produce an axis that would not be optimally placed. Because the axis would no longer pass through the retentive recesses, there would be accelerated wear of the components of the attachment. The centers of rotation should be perfectly aligned in at least two planes—the horizontal and the vertical (Fig. 9). Presently, no provision has been made to ensure that the shelf levels are at the same distance above the tissues or that they are accurately aligned in the vertical plane. The design of the wells is cut into the wax patterns of the abutment restorations. As it is unlikely that any two waxed-up wells will be at the same level by chance, a fault is built into the design. Consequently, the resultant axis is usually not in the best position, yet the restorations are successful.

The reason for the success lies in a built-in safety factor. Consider the usual situation where the teeth are at different heights, as are the shelves. Consider also that the shelves are in line with a common axis of rotation. The line is directed at an angle to the horizontal plane (θ', Fig. 10). Vertical lines extend away from the axis and represent the walls of the wells. Lines at right angles to the shelf line pass through the ends of the shelves at *A, B, C,* and *D.* Their separation from the vertical plane is also at the angle θ'. About the centers *A, B, C,* and *D,* there are only cones of movement, and rotary movement of the dowels must be in this path. Rotation of a vertically walled dowel with a vertically walled well is not possible as the dowel will bind against the wall. If, however, the walls are flared both vertically and anteroposteriorly, the dowel will be free to rotate. The degree to which the dowel and the wall should be flared is equal to the angle θ'. Clinically, differences do exist between the heights of the shelves, and frequently, the resultant axis is suboptimal. However, the dowel does not bind, because the well is in fact flared as it is cut with a tapered fissure bur. The flare is 2.5 degrees. The variation of the heights across the arch may well be as little as this angle. When the angle is greater, better results will be obtained if the angle θ' is known and applied to the design. Designing a denture where the abutment teeth are on different levels can be done with confidence, and the taper of the walls and dowel can be made to match the angle of the shelves with the horizontal plane. This is not necessary if the shelves are placed at the same levels.[6]

Another point that is evident from this aspect of the analysis is that the structures below the rotational axis as well as those above it rotate in their cones of movement. The portion of the dowel that is apical to the center of rotation should be relieved laterally so that it does not bind against the wall of the well. It should be relieved at the same angle (θ').

SUMMARY

An analysis has been made of the mechanics of the Thompson dowel retainer. The analysis locates the center of rotation during function and identifies the factors that affect its position. The degree to which the dowel should be relieved to permit unrestricted rotation has been established. The rationale of an occlusal bevel and the limits of its positioning have been analyzed. The importance of aligning the shelves of the dowel wells in two planes is emphasized and ways of handling the problem of disparity of shelf heights are given.

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