

Short Note

Rotational Tendencies and Their Influence on Surveying and Designing of Removable Partial Denture: Theoretical Considerations with Literature Review**

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Abstract

Background Aims: Rotational tendency is an important factor that determines the way in which all kinds of removable partial dentures (RPDs) behave during function. However, a literature review revealed lack of comprehensive quantitative presentation about the problem. The purpose of this article was to investigate this assumption and explain the importance of rotational tendency using diagrammatic as well as mathematical evidence.

Materials and Methods: The presented diagrams and mathematical equations were used to explore different aspects related to the function of RPDs such as the way in which the guiding planes behave and interact with the tilt of the cast (decided path of insertion) to govern their retentive and stress breaking potential as well as other aspects related to RPD service. New evidence that supports considering zero tilt during RPD designing is also presented in the context of this article.

Results and Conclusions: Rotational tendency is an important factor that influences the way in which RPDs function. The study approached the topic in a quantitative way and prescribed simple mathematical formulas that can be used in assessing different treatment plans. Accounting for this during RPD, surveying and designing steps should contribute to the quality improvement of this still applicable dental service. In addition, the quantitative approach carries the potential of increasing the predictability of the outcome when different factors related to RPD designing are manipulated.

Clinical Implications: It is extremely important to consider the interactions that take place between the inclination of the desired path of insertion and the retention, stabilizing and stress breaking potential of the different RPD components.

Keywords: Removable partial denture, designing, surveying, guiding plane, zero tilt, path of insertion, rotational path of insertion, stress breaking, dislodgment, retention.

(J Med J 2013; Vol. 47 (1):80- 92)

Received

August 24, 2011

Accepted

May 10, 2012

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** This study was supported by a grant for dental research (125, 2005-2006) from the University of Jordan, Amman, Jordan.

Introduction

Due to the dual nature of their support, distal extension removable partial dentures (RPDs) are considered to have rotational movements during function. Rotational movements happen when the original force is applied off the center of resistance and tend to occur about a fulcrum which is a dominant point of contact between the rigid framework and a rigid tooth surface in most cases.¹⁻⁶

When the force is seating in nature, the fulcrum of rotation tends to be the closest rigid contact, while an unseating force will have the fulcrum of rotation at the furthest dominant contact.¹⁻³ Due to the existence of multiple contacts between the framework and the remaining teeth and due to the presence of other rotational components in perpendicular planes, fulcrums of rotation are usually converted into axes of rotation that will determine the final way in which the prosthesis tends to rotate.¹⁻³ Those tendencies in distal extension RPDs were discussed thoroughly in many references and became dogmas that influenced both the design of indirect retainers and the way in which stress breaking mechanisms should be planned.^{1,2,7-10}

However, the rotational tendency seems to be an inherent property of all intraoral prostheses, including removable partial dentures.¹¹⁻¹³ This fact is caused by the unilateral nature of the transient forces that act on the prosthesis during function. It is the exception to have a resultant force with trajectory acting directly through the center of resistance of the supporting or retaining elements. Most of the time, the resultant force will be off the center of resistance and rotational tendency will be created.¹⁴⁻²⁸

Nevertheless, purely translational movements, like when a single path of insertion and removal exists, can still happen. This is caused by nullifying all the rotational components of the original force through strategic contacts between the prosthesis and the tissues that support and stabilize it.^{1,2,29}

The purpose of this article was to investigate the significance of rotational tendencies and to clarify their implications on the function of guiding plane surfaces, retainers, and stress breaking mechanisms. The article will focus on the importance of those rotational tendencies, their interaction with the prosthesis, and the way that the RPD design should be tailored to account for them. Furthermore, the interaction between the tilt of the cast on the dental surveyor and the efficiency of RPD components during function will be explored in light of rotational tendencies.

Many references advocate that surveying should be done first at the zero tilt and then an alternative tilt will be chosen to be the path of insertion and removal of the prosthesis. According to this alternative, tilt axial recontouring of the abutment teeth should be accomplished inside the patient's mouth.^{1,2,29-34}

The zero tilt is the orientation of the cast on the swiveling table of the dental surveyor when the analyzing rod is perpendicular to a plane that is parallel to the mean orientation of the occlusal planes of the teeth, or to be more precise perpendicular to a plane that is leveled at the occlusal planes of the abutment teeth involved in the RPD design.^{1,2,29-34} Related to the article's subject, the importance of considering the zero tilt surveying in RPD designing will be discussed in light of the presented rotational tendencies.

Dislodgment Scenario

Dislodgment of the RPD may be caused by the pull of sticky food acting on the occlusal surfaces of artificial teeth, the push of the surrounding soft tissues on some of the RPD components, or the action of gravity on maxillary RPDs.^{1,2}

Any force acting off the center of resistance of the prosthesis tends to cause dislodgment on the side closer to the point of force application.³ Therefore, the dislodgment movement will have an inherent rotational tendency about an axis of rotation passing between the retentive components being the most distant from the point of force application on the other side of the center of resistance.

In Figure 1, there is a modified Kennedy class III partially edentulous arch. When chewing sticky food on the right side, that side tends to dislodge. The retainers on the left side will not be challenged by the dislodging force and will stay in place and therefore act as an axis of rotation around which the retainers on the right side will move during this dislodgment scenario. Since the vertical locations of the retentive tips on the right and left sides are more or less at the same level, this will make the dislodging retentive tips to be at the same level as the axis of rotation.

The direction of the initial dislodgment of each retainer will be the junction between two planes, each of them perpendicular to a line drawn from each respective center of rotation (retainer on the other side) to the dislodging retainer. The result will be that the retainers on the right side dislodge vertically in a direction parallel to the analyzing rod when the cast is mounted on the surveyor according to the zero tilt. The same result will be revealed when the dislodging force is acting on the anterior or left edentulous spans.

Of course, dislodgment will be affected by the direction of the original force applied on the prosthesis. Usually the prosthesis tends to dislodge under the pull of sticky food when the mandible is opened during each masticatory cycle.³⁵ This dislodging force tends to be the highest at the beginning of opening when the two opposing occlusal surfaces are still glued and trying to separate from each other.³⁵ It is logical to consider the direction of pull to be dictated by the direction of separation between the two contacting occlusal surfaces.³⁵ Literature review about the early direction of mandibular opening during function revealed the following. The direction of the mandibular opening was explored in both the frontal and the sagittal planes. In the frontal plane, it was shown that the early direction of mandibular opening was more vertical than the late direction of mandibular closure. However, it was shown that the early direction of the opening can be variable and in many cases, it was inclined either towards the working side or the nonworking side.²⁰⁻²⁸

In the sagittal plane, translation of both the working and the nonworking condyles during opening was superimposed on the terminal hinge opening which led to a reduction of the backwards movement that accompanies terminal hinge opening.³⁶ The resulting direction of movement of the lower occlusal plane in relation to the upper ranged from backwards, vertical, or even forwards. But there was an agreement that it was anterior to the direction of closure.^{24-28,37,38}

The inter-individual and intra-individual variability found in the literature may reflect the influence of many factors on the actual direction of the mandibular opening.^{24-28,37,38} The degree of deviation in relation to the perpendicular on the occlusal plane (zero tilt) may be close to the amount of tilt that is usually adopted when partially edentulous models are surveyed.^{1,2,29-34} This fact may undermine the assumption that the importance of the zero tilt actually comes from the fact that it represents the common path of dislodgment.

On the other hand, rotational tendencies will be relatively independent of the direction of the original force simply because the horizontal force components will be dissipated through contact between minor connectors and vertical teeth surfaces which of course will contribute to retention through the generation of friction force.⁴⁰ What remains is the vertical force component acting unilaterally on the working side off the center of resistance of the prosthesis.

Therefore for the retainers to be effective in preventing unilateral dislodgment during function, they need to be engaging undercuts according to the zero tilt. Undercuts according to the zero tilt can be engaged either by the flexible retentive clasp tip or by the rigid minor connectors or reciprocal components that were allowed to be placed in the undercuts according to the zero tilt through changing the tilt of the cast on the surveyor.^{1,2} By changing the tilt in an appropriate direction, undercuts according to the zero tilt can be exposed above the new survey line and therefore can be engaged by rigid minor connectors or reciprocal clasp arms.^{1,2}

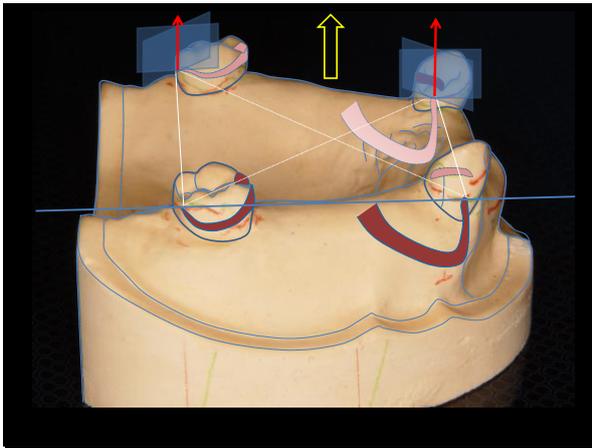


Figure (1): Kennedy Class III Modification II partially edentulous upper arch. When a dislodging force (yellow arrow) is applied on the right artificial teeth, the direction of the dislodgment of the adjacent retainers will be dictated by their positions in relation to the retainers on the other side (left) because they are the retainers that will stay in place and act as the centers for this rotational dislodgment. The direction of dislodgment for any retainer will be the junction between two planes (transparent blue planes) each of them perpendicular to a line drawn from each respective center of rotation to the tip of the retainer. Since the retainers are located more or less at the same level vertically, the direction of dislodgment will initially be very close to the zero tilt (vertically upwards). The same tendency will also be seen when the dislodging force is applied to the anterior or to the left artificial teeth.

The rigid minor connectors or reciprocal components might be more efficient in preventing minor vertical dislodgment movements during function.^{1,2} Of course, this depends on the intimacy of the contact between the two surfaces and on other geometric factors.⁴¹

In comparison, retentive tips of the flexible clasp arms will not be forced to deflect and generate enough reaction force unless some vertical movement happens first, so it is expected that the prosthesis will be allowed some degree of vertical movement with each dislodging scenario which is proportional to the amount of dislodging force, stiffness of the clasp, and the angle of cervical convergence.^{40,42,43}

In conclusion, for a clasp assembly to be retentive during function, undercuts according to the zero tilt should always be engaged by rigid minor connectors and reciprocating clasp arms or by the flexible tips of retentive clasp arms.

On the other hand, undercuts according to the alternative tilt cannot be engaged by the rigid components and should only be engaged by the retentive clasp arms which will prevent dislodgment according to the adopted path of insertion and removal of the prosthesis.

In Figure 2 we can see a Kennedy class I partially edentulous arch. In this case, if a dislodging force is acting on the right artificial teeth, the right clasp will be activated. In the sagittal plane, a couple of forces will be created that tend to rotate the prosthesis in a clockwise direction; this will activate the indirect retainers located anteriorly. The result will be that the indirect retainer on the left side will be activated and an axis of rotation with the left retentive clasp tip will be formed. The retentive clasp assembly on the right side will dislodge by rotating about this axis. Again, because the right retentive tip is located more or less at the same vertical level as the axis of rotation (especially if the indirect retainer on the other side is a lingual rather than an incisal rest), the dislodgment movement will be parallel to the zero tilt analyzing rod and the same rule mentioned above will apply.

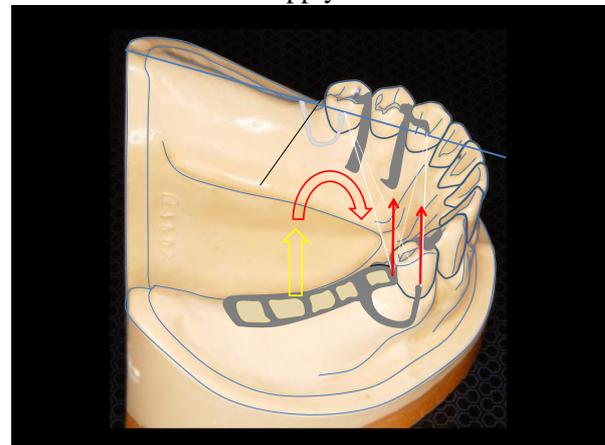


Figure (2): Kennedy Class I lower arch. This figure shows the same tendency for the dislodging retainer to move vertically upwards even in cases that have only one retainer on the other side. The dislodging force acting on the right artificial teeth will activate the closest retainer first. This will create a couple of forces that will affect a clockwise rotation of the RPD and consequently the activation of the anterior indirect retainers. The left clasp with the left indirect retainer will form an axis of rotation for this dislodgment movement around which the right clasp assembly will move vertically upwards as in the Figure 1 case.

Cross Arch Stabilization

In addition to their retentive function, retentive clasps also have a cross arch stabilizing function when a vertical force is applied on the opposite side.^{1,2} In Figure 3 when a vertical seating force is applied on the right side, some of the occlusal contacts are expected to happen buccal to the inter-rest axis of rotation. This tendency increases as the edentulous span becomes longer and involves a curve in the dental arch.

The off axis vertical forces will cause a rotational tendency of the prosthesis with the clasp assemblies on the left side moving upwards about an axis of rotation passing between the rests on the working side. The closer the vertical location of the left clasps and the right rests are and the longer the distance between the components on the right and the left sides are, the closer the movement of the left clasps will be to the zero tilt.

Therefore as a conclusion, cross arch stabilizing clasps will have an inherent vertical movement close to but lightly buccal to the zero tilt. The offset angle will be related to the ratio between the height difference between the inter-rests axis on one side and the cross arch stabilizing clasp on the other side and the perpendicular distance between them.

For example in Figure 3 for the right molar cross arch stabilizing clasp, if the vertical level difference was 2 mm and the horizontal distance between the inter-rest axis and the clasp tip was 50 mm, the cross arch stabilizing clasp will move vertically upwards with only 2.3 degrees inclination towards the buccal. In the cases of distal extension partial dentures, the axis of rotation distally will be located even more cervical. The more cervical is the axis of rotation, the less the buccal inclination will be, and in some cases, it might even incline towards the lingual (Fig. 4).

Therefore, cross arch stabilizing clasp assemblies will move vertically upwards close to the zero tilt. Also, for clasps or minor connectors to be efficient as cross arch stabilizers, they need to engage undercuts according to the zero tilt.

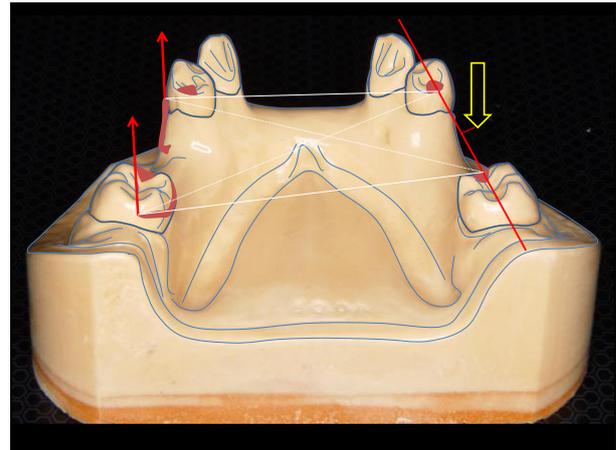


Figure (3): Kennedy Class III Modification II lower arch. A seating force is applied on the right artificial teeth and the occlusal contacts are located labial to the interest axis. In this case, the denture tends to rotate around the closest rigid contact which is the inter-rest axis line. The clasps on the left side will act as cross arch stabilizers and contribute to controlling this movement by their resistance to deflect out the engaged undercuts. The clasps will move vertically upwards with a minor labial offset which increases as the vertical difference in position between the rests on the right side and the clasp tips on the left side becomes more and decreases as the horizontal distance between them increases.



Figure (4): Kennedy Class II upper arch. In this case, if a seating force is applied on the left side, the direction of the dislodgment of the cross arch stabilizing clasps on the right side might be a little bit towards the lingual rather than labial because of the lower position of the support axis line on the right side.

Guiding Planes

Guiding planes are axial surfaces on the abutment teeth prepared parallel to the adopted tilt. Through an intimate contact with the minor connectors, they function to prevent horizontal movements and to limit the translational path of dislodgment of the prosthesis.^{1,2,29} During function, they also work to prevent rotation tendencies.

Figure 5 shows a sagittal view of two guiding plane surfaces. Any dislodging force applied off the center of resistance will cause rotational tendency. Clockwise dislodging rotational tendency will be about a center of rotation located on the most occlusal contact between the anterior guiding plane and the corresponding proximal plate, of course, in the case where no other rigid binding contact exists anterior to the anterior proximal plate, otherwise that component will become the dominant center of rotation.

This clockwise rotation will cause binding of the most cervical part of the posterior proximal plate and the corresponding guiding plane. The cervical part of the proximal plate will approximate the tooth surface with an angle of approximation (θ) which describes the direction of movement in relation to the zero tilt. An approximation angle which has a value of zero describes a purely vertical movement perpendicular to the occlusal plane. The approximation angle depends on the difference in vertical location (according to the zero tilt) between the center of rotation which is the most occlusal contact on one guiding plane surface and the most cervical contact on the other guiding plane surface (h) and on the horizontal separation between them (d) and can be calculated by the following formula:

$$\theta = \text{atan } h/d \quad 44$$

The more the vertical distance and the less the horizontal distance are, the more the approximation angle will be. This will cause a more efficient resistance to the rotational dislodgment.⁴⁵

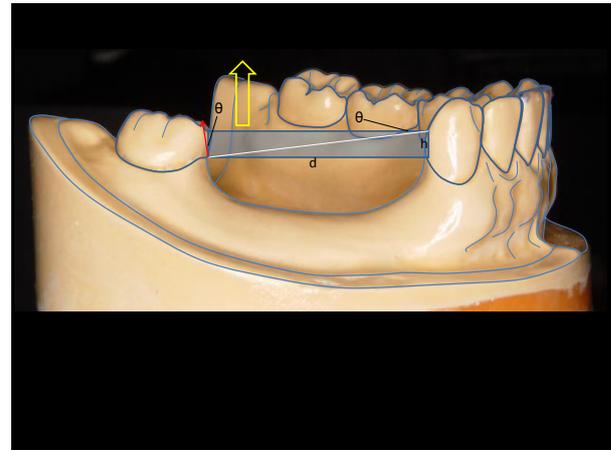


Figure (5): Kennedy Class III lower arch. This figure demonstrates the guiding planes mechanics. When the posterior artificial teeth are about to dislodge the RPD will rotate about the most anterior contact between the RPD and the remaining teeth. For simplicity in this figure only, the anterior proximal plate is presented. In this case, the most upper contact between the anterior proximal plate and the respective guiding plane surface will be the center about which the posterior proximal plane will rotate. The most gingival part of the posterior proximal plate will have the highest approximation angle (θ). The angle can be calculated based on the horizontal separation between the two guiding planes and the vertical distance between the rotating point and the center of rotation. The more cervical the location of the rotating point is in relation to the axis of rotation and the less the horizontal separation between them is, the more (θ) will become and, therefore, the more resistant the posterior proximal plate will be in preventing rotational dislodgment.

In most of the cases the alternative tilt will be different from the zero tilt. The tilt or the orientation of the guiding plane in the sagittal plane can be described as angle (α). If (α) is equal to (θ), then the most cervical part of the proximal plate will move parallel to the guiding plane surface and will not contribute to the prevention of this rotational dislodgment. Any value of (α) equal or more than (θ) will lead to inefficient guiding plane proximal plate contact while any value of (α) less than (θ) will cause the binding of the proximal plate and the guiding plane surface and will lead to the prevention of rotational dislodgment. Therefore, the efficient approximation angle (β) would be:

$$\beta = \theta - \alpha$$

If the value of (β) is positive, binding will happen between the proximal plate and the guiding plane surface while a negative value means that separation will happen. Tilting the cast posteriorly as in Figure 6 will lead to less engagement on the anterior guiding plane surface while binding will increase on the posterior guiding plane surface. On the other hand, tilting the cast anteriorly will cause the opposite effect.

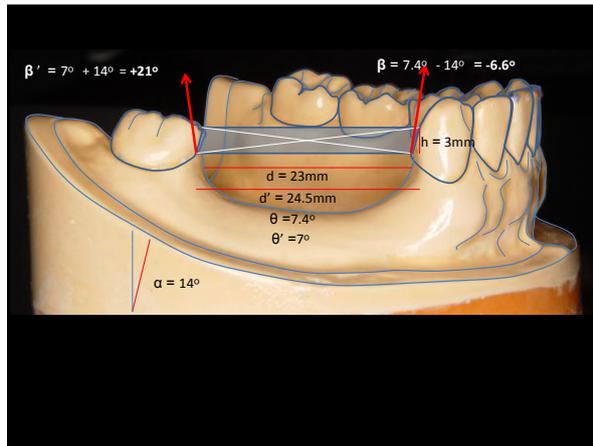


Figure (6): Kennedy Class III lower arch. This figure demonstrates the effect of tilting the cast on guiding plane mechanics. In this case, the cast was tilted posteriorly for 14° (α). Tilting the cast also changed the values of horizontal separation between the most gingival part of each proximal plate and its respective center of rotation (the most occlusal part of the other proximal plate) which is needed to calculate the approximation angle (θ). The efficient approximation angle (β) which will decide the effectiveness of each proximal plate in resisting rotational dislodgment adjacent to it can be calculated by the equation ($\beta = \theta - \alpha$). If (β) is positive, the proximal plate will resist dislodgment on its side while a negative value means that it will not. It should be noted that (α) is negative on the lower proximal plate side and positive on the upper one. Also, all the variants (horizontal distance, vertical distance, and tilt angle) should be measured according to the same coordinate system. In this case, they were measured according to a coordinate system that has the vertical arm of the analyzing rod of the surveyor at the zero tilt as its Y axis and the mean orientation of the occlusal planes as its X axis (zero tilt). Of course, the coordinate system can be rotated to be parallel to the alternative tilt ($\alpha = 0$), but then both the horizontal and vertical distances should be measured according to the new coordinated system to have the same value for (β).

The less the vertical distance between the most occlusal part of one guiding plane and the most cervical part of the other is and the more the horizontal distance between them is, the less the

approximation angle (θ) will be. This will increase the risk of rendering one guiding plane surface inefficient by tilting the cast off the zero tilt. In addition, if this is to be avoided, the tilt (α) should be limited to a value less than (θ) on the corresponding guiding plane surface.

As a conclusion, the zero tilt will be fair in distributing the efficiency of the guiding plane surfaces in preventing rotational tendencies. Also, it will decrease the risk of rendering any of the opposing guiding plane surfaces ineffective.

It is prudent to mention that, for simplicity only, two guiding planes with no other components were projected on the sagittal plane. The problem is three dimensional and usually the guiding plane surfaces are only parallel to the vertical rod on the surveyor. In other words, they are vertically parallel but not parallel as planes.^{1,2,29} Also, each guiding plane can be analyzed into two planes which are parallel vertically but perpendicular horizontally. Each component will contribute to preventing the rotation happening on the other plane. In other words, frontal components of the guiding planes will prevent rotational tendencies happening on the sagittal plane and vice versa.^{1,2,29}

Stress Breaking

The efficient approximation angle equation can be used to analyze any kind of purely rotational movement happening. Besides being useful in predicting the efficiency of the guiding plane surfaces and the need for supplementary retentive clasp arms, they can also be used to determine the block out needed during fabrication to cause an efficient stress breaking mechanism.

In Figures 7 and 8, mandibular first premolars are the primary abutments of distal extension RPDs. RPI systems were used to allow for a stress breaking mechanism that will distribute the load towards the residual ridge distally.¹⁻⁴ Any engagement between the seating proximal plate and the guiding plane surface during mastication theoretically will happen cervically first. This contact will relocate the fulcrum of rotation distally³ and mandate that more abutment tooth

movement within its socket should accompany any tissue-wise movement of the denture base distally, which means a disturbed stress breaking mechanism.

In this theoretical situation, the cast was tilted anteriorly (α) for 15 degrees, and the horizontal distance between the center of rotation at the rest and the most distal aspect of the guiding plane surface was 5 mm.

The question is how far cervical the contact between the proximal plate and the distal guiding plane surface can extend without disturbing the stress breaking mechanism.

During function, the proximal plate part with the an approximation angle (θ) equal to or more than 15 degrees which is the tilt angle (α) (or guiding plane inclination) will bind and disturb the stress breaking mechanism.

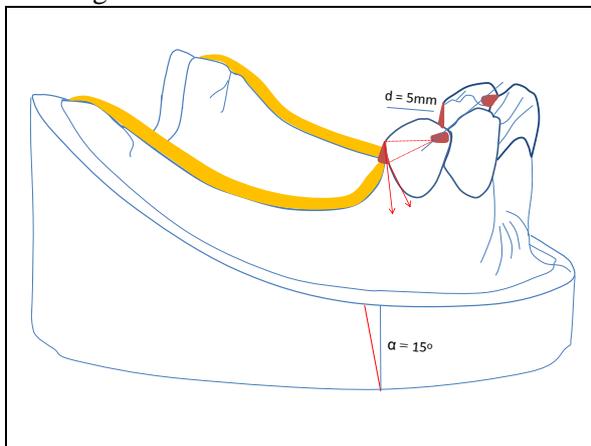


Figure (7): Kennedy Class I lower arch. This figure demonstrates the stress breaking potential of the proximal plate in distal extension RPD. When the force is seating in nature, the prosthesis tends to rotate about the closest rest. The most gingival part of the proximal plate will have the highest approximation angle (θ) and therefore tends to engage, move the fulcrum of rotation distally, and disturb the stress breaking effect of the mesial rest. By adopting an anterior tilt (α is positive) and restricting the gingival extension of the proximal plate-guiding plane contact at the full seating position, this engagement can be avoided and the stress breaking potential won't be disrupted.

The more cervical we go along the guiding plane surface, the more (h) will be and at the same time the less time (d) will be slightly. Since $\theta = \text{atan } h/d$, moving cervically will have the effect of increasing the approximation angle.

At the point where the approximation angle (θ) becomes equal to (α) which is 15 degrees, binding will happen and to avoid this, block out should be done below that point.

According to the following equations:

$$d = 5 - (h * \tan \alpha), \text{ and } \theta = 15/180 * \text{Pi} \text{ so } 15/180 * \text{pi} = \text{atan } [h / 5 - (h * 0.268)]$$

Then (h) will be 1.27 mm, which means that guiding plane areas extending within 1.27 mm cervical to the center of rotation can still be contacted with the proximal plate without disturbing the stress breaking mechanism. Below this point the guiding plane surface should be blocked out to avoid any potential contact during tissue-wise movement. The less the anterior tilt of the cast on the surveyor is, the less cervical the contact may extend, which means that for distal extension RPD for better stress breaking mechanism, anterior tilt should be adopted.

Distal Proximal Plate Retention

In distal extension RPD, retention provided by the proximal plate will be furnished by the most occlusal contact between the proximal plate and the guiding plane surface. This is caused by the fact that the approximation angle for the proximal plate which is rotating about the indirect retainers axis will increase as we go occlusally (Fig. 8).

At the same time the more cervical the indirect retainers are, the more the approximation angle will be. Therefore, in comparison to incisal rests, lingual rests will be more efficient in rendering the occlusal parts of the guiding plane surface binding and retentive during dislodgment (Fig. 8).

On the other hand, in the case where the indirect retainer rest (lingual rest) is located cervical to the most occlusal part of the guiding plane surface, the more the horizontal distance (d) between the indirect retainer and the guiding plane is, the less the approximation angle between the occlusal part of the proximal plate and the guiding plane surface will be, which

means less efficient retention by the proximal plate. The decreased retentive efficiency of the proximal plate will lead to more reliance on the retentive clasp arm to prevent dislodgment of the prosthesis. On the other hand, placing the indirect retainer further anteriorly is known to improve the retentive potential of the clasp by increasing the resistance arm.¹⁻⁴

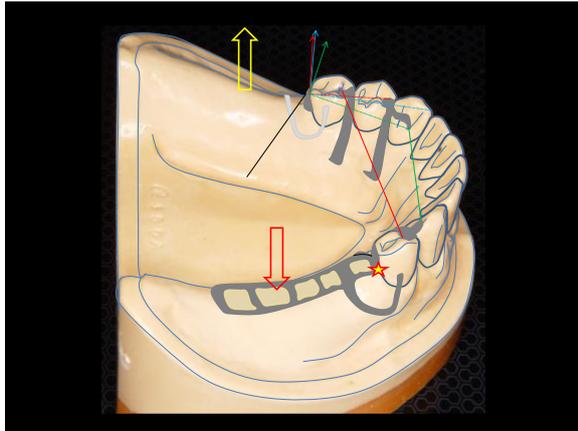


Figure (8): Kennedy Class I lower arch. The right side shows that when a vertical seating force is applied, the most gingival part of the proximal plate-guiding plane contact tends to be the first point of engagement. The left side shows that when a dislodging force is applied, the most occlusal part of the proximal plate-guiding plane contact tends to be the first engaging point. The retentive potential of the proximal plate is affected by the tilt of the cast and the location of the indirect retainers-axis line. Adopting an anterior tilt (α is negative) will increase the retentive potential. The more gingival the indirect retainer, the more the retentive potential of the proximal plate. Among the mesial rest on the first premolar is the lingual rest on the canine or an incisal rest on the canine. The lingual rest seems to have the best retentive potential by moving the axis of rotation cervically (increasing h and therefore θ) and also by increasing the resistance arm/force arm ratio and decreasing the distal base vertical movement/clasp vertical movement ratio.

In the case that the indirect retainer is located occlusal to the proximal plate (occlusal rest), the approximation angle will be negative (separation angle), and binding will happen only when the anterior tilt angle becomes big enough to exceed the separation angle. In this case, placing the indirect retainer further anteriorly will have the influence of reducing the amount of separation and increasing the binding potential caused by an anterior tilt. Also, when the indirect retainers are placed anteriorly, utilization of the anterior teeth instead of the premolars will allow more cervical position of the rests (lingual rest) with an increased retentive efficiency.

Again, the more anterior position will similarly increase the retentive efficiency of the binding proximal plate or retentive clasp arm by increasing the resistance arm/force arm ratio and decreasing the distal base vertical movement/clasp vertical movement ratio.¹⁻⁴

In cases in which the second premolar is the primary abutment for a distal extension RPD, if the primary rest is removed while keeping the embrasure minor connector for reciprocation and stabilization, and at the same time, a mesial rest is placed on the first premolar for support and a lingual rest is placed on the canine for indirect retention, in this assumed design removing the second premolar rest will lead to a reduction of the approximation angle of the tissue-wise movement of the proximal plate, which means more cervical extension and less block out are allowed without violating the stress breaking mechanism. This assumed design might be beneficial in cases where less loading of the second premolar is sought (Fig. 9).

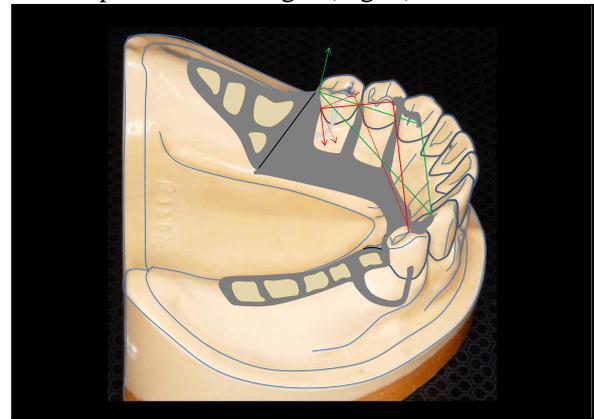


Figure (9): Kennedy Class I lower arch. In this design the primary rest on the left second premolar is removed while keeping the minor connector for reciprocation and stabilization; a mesial rest is placed on the first premolar for support and a lingual rest on the canine for indirect retention. By placing the primary supportive rest further towards the mesial (h increased and θ decreased), the stress breaking potential of the proximal plate will be enhanced. This design is supposed to increase the soft tissue loading and reduce the load on the primary abutment. While removing the rest on the lower second premolar clasp assembly is expected to allow more vertical movement of the clasp, the proximal plate, and the mesiolingual minor connector on the second premolar during function, using an I-bar instead of a C-clasp will cause disengagement rather than engagement and undue loading of the abutment will not happen.

Rotational RPD

The equation $\theta = \text{atan } h/d$ can also be used to determine the situations which would benefit from the rotational path of insertion for an RPD and those that would not.

In Figure 10 an anterior posterior rotational RPD would allow the engagement of the mesial guiding plane surface and then the whole prosthesis would rotate into place about an axis of rotation passing through the most anterior rigid contacts. The advantage of having this rotational movement in comparison to a translational path of insertion would be to allow less preparation on the most distal guiding plane surfaces. However, in some situations seating the prosthesis in a linear path of insertion may need a lesser amount of preparation as compared to a rotational insertion.

In the conventional RPD, all the guiding plane surfaces will be prepared parallel to each other. If the mesial guiding plane surface orientation is to be kept, all the other surfaces should be prepared parallel to it. On the other hand, in rotational RPD, the distal guiding plane surfaces should be prepared perpendicular to two lines extending from the two anterior contact points to the most occlusal guiding plane contact on the corresponding abutment.⁴⁶⁻⁵⁴

In rotational RPD, the inclination of the distal guiding plane can be calculated by the equation $\theta = \text{atan } h/d$, where (h) is the vertical distance between the center of rotation and the most occlusal contact on the distal abutment, and (d) is the horizontal distance between them. In the case where (θ) becomes larger than (α) which is the tilt that is parallel to the anterior guiding plane surfaces, the conventional path of insertion would be more appropriate simply because the rotational RPD will dictate more preparation distally than needed to allow seating.

In other words, the less the difference in vertical position between the center of rotation and the first contact point on the second seating guiding

plane, the more the horizontal distance between them, and the steeper the inclination of the guiding planes on the part that seats first, the more convenient the rotational path of insertion and vice versa.

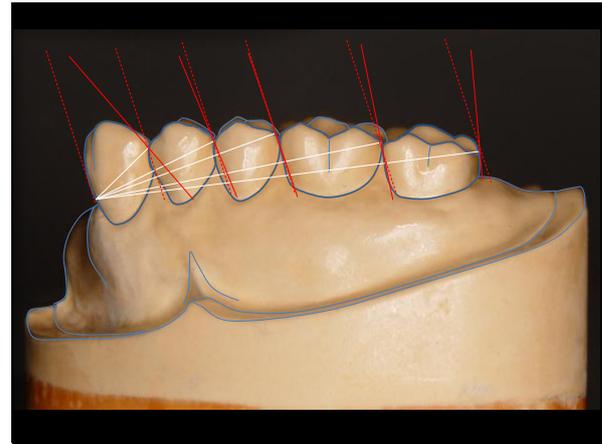


Figure (10): Kennedy Class IV upper arch. With a rotational path of insertion versus conventional design with a posterior tilt of the cast, the dotted lines are parallel to the vertical analyzing rod on the surveyor when the cast is tilted posteriorly to allow engagement of the mesial undercuts on the canines (the tilt is parallel to the inclination of the mesial guiding plane surfaces). The solid lines are perpendicular to lines extending from the center of rotation for a rotational RPD (the most cervical point of the mesial guiding plane surface) to the most occlusal part on the respective embrasure. The solid lines represent the direction in which minor connectors will rotate into their respective embrasures after their first contact with tooth surfaces. These solid lines give an indication about the amount of preparation needed for a rotational RPD design and can be compared with the dotted lines that represent the amount of preparation needed for a conventional RPD design. Rotational design will dictate less preparation for the posterior minor connectors in cases with deeper undercuts on the mesial surfaces of the canines (a more positive) and more distal location of the posterior minor connectors. Rotational RPD design is supposed to be without a labial flange, which will guarantee a more occlusal location of the center of rotation (which is the most anterior contact between the prosthesis and the tissues) and therefore less preparation posteriorly. In the case where a labial flange is needed for esthetic reasons, a conventional RPD design might be a better choice.

Conclusions

In this article, it was shown that rotational tendencies are very important factors that influence the way in which all types of RPDs may behave during function. Therefore, it is prudent to consider it during surveying and

designing of RPDs. Even though the concept was presented through a limited number of examples, the equations and the approach can be manipulated to account for different situations.

Acknowledgment

I want to express my deepest gratitude to my previous Professor Dr. Takashi Ohyama for his everlasting inspiration.

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أهمية ميول الدوران في تحديد طبيعة عمل الأطقم الجزئية المتحركة عند المضغ

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الملخص

الأهداف: يعد ميول الدوران عاملا مهما في تحديد طبيعة عمل الأطقم الجزئية المتحركة عند المضغ. وبالرغم من ذلك، فإن البحث في الأرشفة لم يبين وجود معالجة كمية شاملة للموضوع. الغاية من هذا البحث هي التأكد من صحة هذا الادعاء وتوضيح أهمية ميول الدوران باستخدام براهين توضيحية ومعادلات رياضية.

المواد وخطوات العمل: الأمثلة التوضيحية والمعادلات الرياضية المقدمة تم استخدامها للبحث في أوجه مختلفة ذات علاقة بطبيعة عمل الأطقم الجزئية المتحركة مثل: تفاعل أسطح الإرشاد مع ميلان خط الإدخال لتحديد قدرتها على المحافظة على ثبات واستقرار التركيبة عند الاستعمال، وقدرتها على فصل الجهد لتوزيع الحمل، بالإضافة إلى أوجه أخرى ذات علاقة بطبيعة عمل الأطقم الجزئية المتحركة عند المضغ. تحوي المقالة أدلة جديدة تدعم مراعاة الميل الأفقي للأمثلة (الموديولات) خلال عملية التصميم للأطقم الجزئية المتحركة.

النتائج: تبين أن ميول الدوران عامل مهم في تحديد طبيعة عمل الأطقم الجزئية المتحركة عند المضغ. استطاع الباحثون تحليل الموضوع بطريقة كمية وتقديم بعض المعادلات الرياضية البسيطة التي يمكن استعمالها لتقييم خطط العلاج المختلفة، آخذاً ذلك بعين الاعتبار خلال عملية التخطيط والتصميم أنه قد يمكن تحسين نوعية العلاج، بالإضافة إلى ذلك، فإن من شأن المعالجة الكمية أن تزيد من القدرة على التنبؤ بنتائج العلاج نتيجة تغيير عوامل مختلفة ذات علاقة بتصميم الأطقم الجزئية المتحركة.

الخلاصة: من المهم جدا اخذ التفاعل الحاصل بين ميل خط الإدخال والثبات والاستقرار والقدرة على فصل الجهد لمكونات الأطقم الجزئية المتحركة المختلفة.