Tooth Preparation Theory
Application to Custom Abutment Design
GUIDING PRINCIPLES TO SUCCESS

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Introduction

The concepts of tooth preparation have been developed and modified over the past century as changes in instrumentation and materials have dictated. The principles of retention, resistance form, taper and surface roughness have been studied thoroughly and a set of guiding principles have been developed. These principles, as they are applied to the design of custom implant abutments, will be presented.

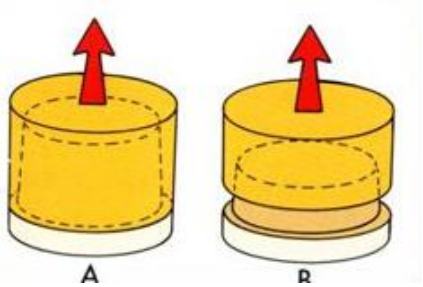
Among the many benefits of a custom abutment is that they can be designed to duplicate the shape and form of prepared natural teeth. Specific advantages include:

- Crown retention and resistance form
- Emergence profile design
- Margin placement
- Ease of cement cleanup
- Correct positioning of preparation form

Principles

The two primary principles in preparation design are Retention and Resistance Form which are very interrelated and often inseparable qualities.

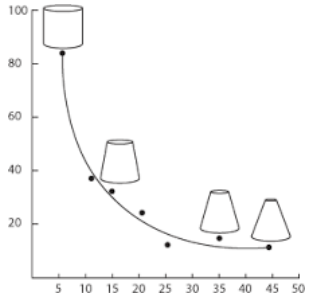
Retention Form – is the ability of the preparation to impede removal of the restoration along the path of insertion.



There are four factors which affect retention;

1) *Taper* – The ideal taper of each axial wall is between 6° and 8°, for a total taper of the form ranging between 12° – 16°. As the amount of taper increases, the retention of the form drops significantly. This factor is probably the most important when designing an abutment, and is much easier to do on a computer than in the mouth.

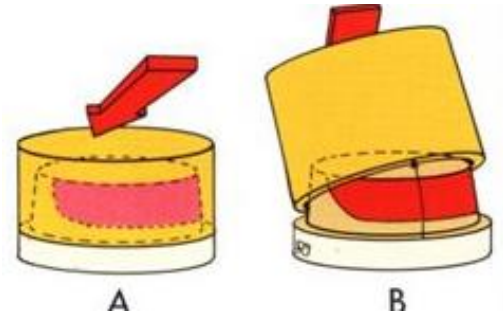
2) *Total Surface Area* – In general, the more surface area, the better. This is affected by the size of the tooth as well as the addition of boxes or grooves in the preparation form.



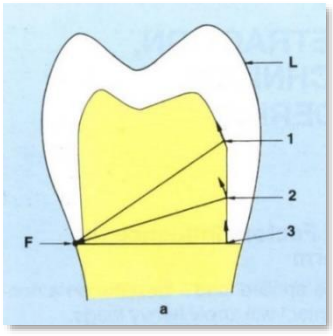
3) *The area of cement under shearing forces* – Dental cements are much stronger in shear, and weaker in tension. Designing a preparation form with more parallel opposing walls will restrict the path of draw of the restoration. This creates greater shear forces upon the cement while reducing tensile forces.

4) *Surface Roughness* – Since titanium is not normally capable of being chemically bonded, cements utilizing adhesion are used to retain abutment-supported restorations. Oilo and Jorgenson showed that using dies with a 10^{o} taper, a surface roughness of 40um was 2x as retentive as one with a 10um surface roughness. Although sandblasting can create an adequately rough surface, the resulting darkening effect on the titanium surface can create unfavorable esthetic issues with all-ceramic restorations. This darkening can be avoided if a "grooved" surface is created on the axial walls in the milling process. The figure below illustrates this "grooved" surface as machined by our Versamill 5-axis Dental Machining Center.

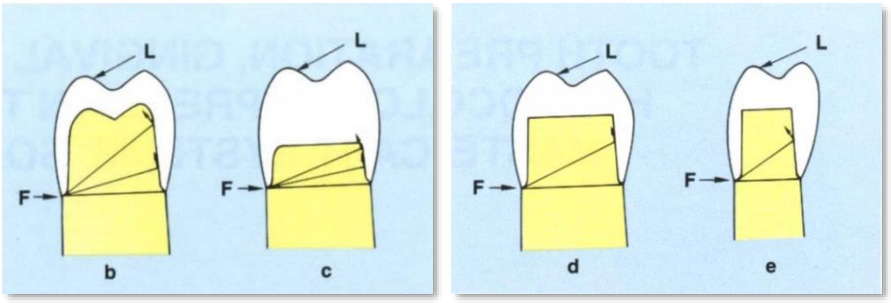
<u>Resistance Form</u> – is the ability of the preparation to prevent dislodgement of the restoration by forces applied apically, obliquely, or horizontally. This can be a difficult concept to visualize.



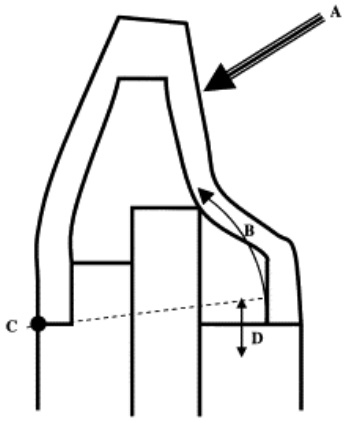
Noting the illustration: When a load (L) is applied to the occlusal surface of the restoration, it wants to "tip" or be dislodged and the restoration will want to rotate around a fulcrum point (F). The only thing preventing this dislodgement is the shape/taper of the opposing axial wall. Note the direction of the resulting forces on points 1, 2, and 3. Whenever the <u>shape of the opposing wall</u> is at a 90^{o} angle to a line drawn to the fulcrum, there is very little resistance (1, 3). This occurs frequently with over-tapered prep forms. Note, however, that at point 2, there is adequate preparation form to resist this tendency for the restoration to tip. Hence it is at this point on the prep that *resistance form* has been created.



The height and width of the preparation form will significantly affect resistance form. The taller, narrower the form, the more resistance form is present. The shorter, wider the preparation form, the less resistance form is present. Ideally, axial walls should be a minimum of 4mm tall.



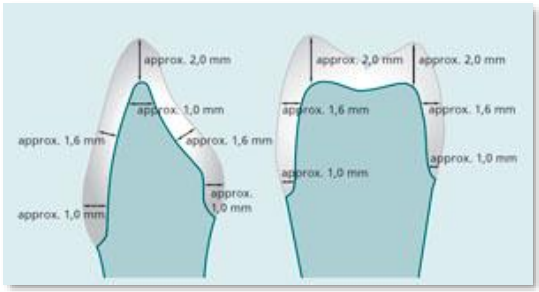
Anterior teeth – These principles of retention and resistance form are especially critical when dealing with anterior teeth. Due to the anatomy of anterior teeth, the lingual surface provides relatively little surface to create the desirable features discussed above. It is therefore critical to create an adequate lingual surface (1.5mm – 2.0mm) while accurately maintaining the proper taper relative to the facial surface.



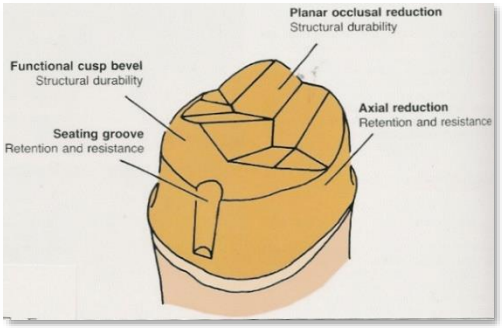
<u>Emergence Profile, Margin Placement, and Ease of Cement Cleanup</u> – The contours of the sub-marginal area of the abutment and the final placement of the margin are critical to healthy tissue response, esthetics, and cement clean-up. Whether the clinician is attempting to specifically shape the surrounding supporting tissues or simply transitioning from the round interface of an implant to the proper contours of a tooth at the level of the cervical tissue, the emergence profile of an abutment should be smoothly contoured, avoiding sharp undercuts and areas that will be difficult for the patient to maintain. Ideally the margins should be placed within 1mm of the gingival tissue to allow for easy access by the clinician to facilitate cement removal while maintaining specific esthetic requirements.

Criteria

In addition to applying the above principles to preparation design, it is important to consider the amount of clearance/reduction necessary for the final restoration. Specific numbers vary depending upon materials, however, the illustration below provides a general guideline. In addition, it is vitally important to provide *functional cusp reduction* (or 2nd plane reduction).



This additional 30° – 45° reduction is provided on the occluso-buccal surfaces of both maxillary (for esthetics) and mandibular posterior teeth (for material thickness). In addition, the maxillary anterior teeth should also demonstrate a 2nd plane reduction on the facial-incisal surface to prevent the dreaded "headlight" effect of the restoration substructure.



Summary

The fabrication of high-quality, custom titanium abutments requires efficient application of the biomechanical concepts of tooth preparation and finely tuned, robust milling strategies that consistently produce complete and highly accurate results.

Applying Principles During Digital Design

Based upon the 3Shape platform, the following is a possible sequence of design steps for custom abutments:

1) Parametric Mode

(Buccal View)

a. Margin placement (Distal, Buccal, Mesial)
b. Sub-gingival geometry (Mesial, Distal)
c. Reduction/Clearance/Axial wall height
d. Set Gingival Contour (ant/post)

(Mesial View)

e. Margin placement (Lingual)
f. Sub-gingival geometry (Buccal, Lingual)
g. B-L Angulation

(Occlusal View)

h. Abutment Rotation/Set Top Cap And Margin Shape

(Buccal View)

i. Set Path of Insertion
j. Set Axial Wall Taper
k. Re-check Margin Geometry

2) Sculpt Mode

a. 2nd Plane Reduction (Mesial View)
b. Retention Groove (Occlusal View)

3) Additional special modification (if necessary)

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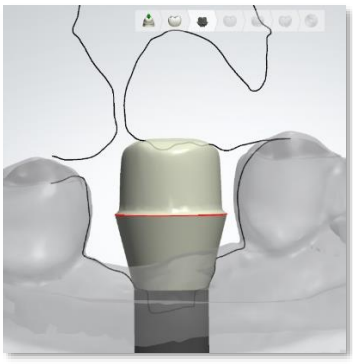
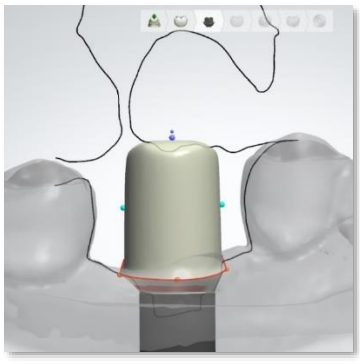
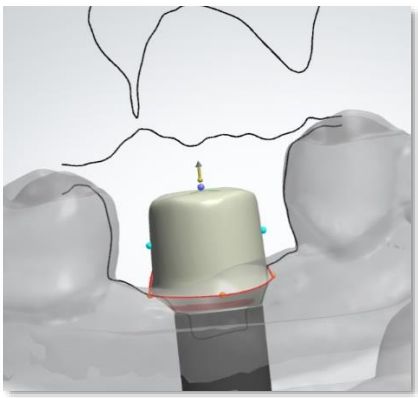
1. Custom Abutment - Initial Presentation



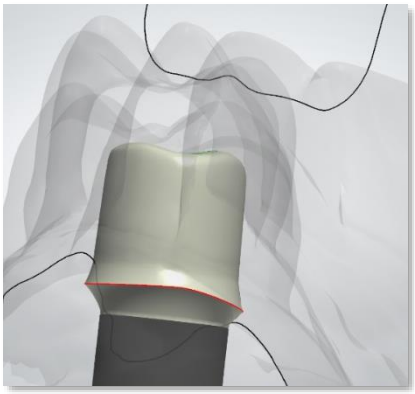
2. Set Margins – Distal, Buccal, Mesial



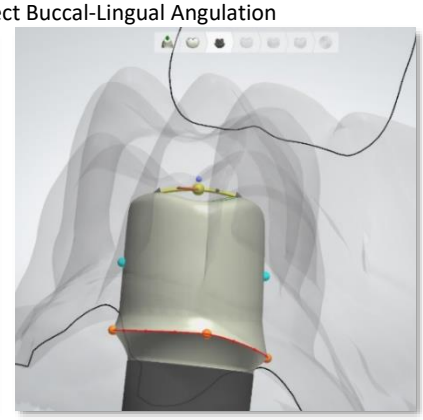
2. Set Height



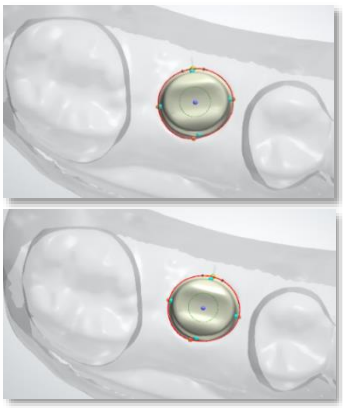
4. Set Lingual Margin



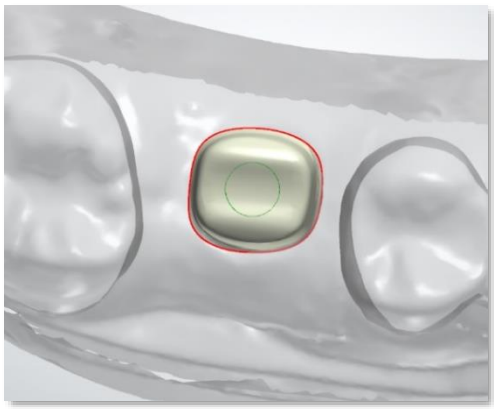
5. Correct Buccal-Lingual Angulation



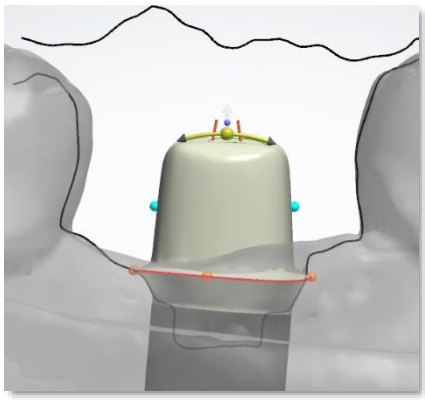
6. Correct Rotational Orientation



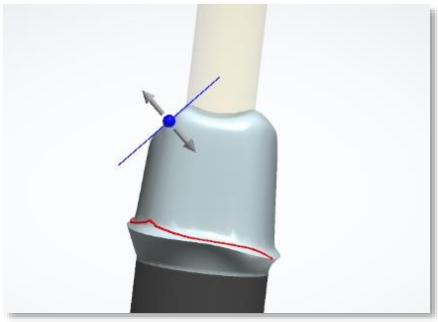
7. Set Top Cap and Margin Geometry



8. Set Path of Insertion and Axial Taper

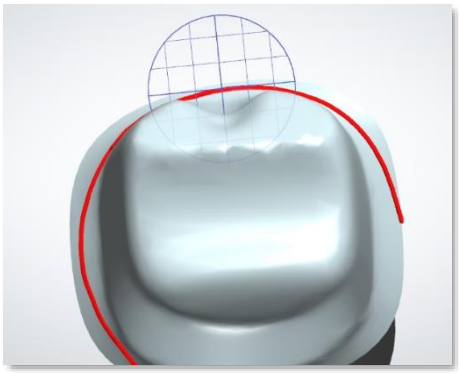


9. Sculpt Mode: Second-Plane Reduction

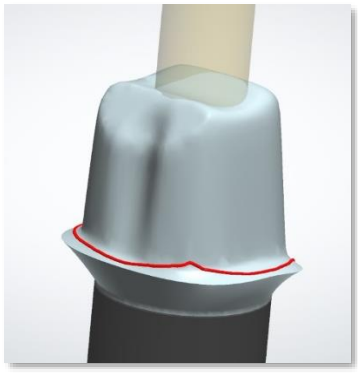


Shorter=less taper / Taller=more taper

10. Add Retention Groove



11. Final Restoration



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