WHEN TO PLACE A POST AND HOW:
A Scientific Approach to a Clinical Question

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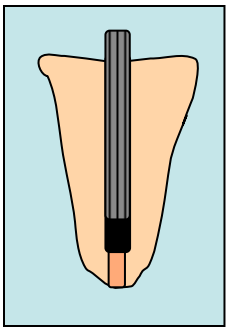
I. WHAT IS THE PURPOSE OF A POST?

It has never been shown that endo teeth are more brittle than vital teeth.
- One study showed resistance to fracture is the same for vital and non-vital teeth.
- BUT, endo teeth seem to have a lower moisture content.[1]

Posts do NOT reinforce roots.
Posts WEAKEN ROOTS, by removing dentin.



But...
A posted canal is stronger than an empty canal.[2]
- It is critical to utilize all of the prepared post space with the post. Empty space apical to the post can cause the post to become loose. It can also cause the root to fracture.

So...
The purpose of a post is to RETAIN THE CORE.

The root retains the post.
The post retains the core.
The core retains the crown.[3]

WHEN DO WE NEED A POST?
→ When we need to retain the core.

Does this tooth need a crown?
- How wide was the endo preparation?
- What does the facial look like? (Are there fractures?)
- Why was the endo needed?
- How old is the patient?

[1] Helfer AR, et al: Determination of the moisture content of vital and pulpless teeth. Oral Surg Oral Med Oral Pathol 34:661, 1972.
[2] Hunter et al, 1989
[3] Henry & Bower, 1977

In general, ANTERIOR teeth with minimal access preparations and intact marginal ridges do NOT need crowns.

Anterior teeth that are not crowned should NOT receive posts.[4]

But…
What happens if we don't crown an endo tooth that needs it?

- Aquilino & Caplan studied patients who had endo teeth.
- Non-crowned teeth were lost 6 times more often than crowned teeth.[5]

Some researchers studied patients with minimally prepared premolars. (Cusps were not weakened.)
- Half were crowned; half received composites.
- Crowns "did not enhance the clinical performance" of the teeth in a 3-year period.[6]

But…
Was 3 years long enough?

A study of molars that had endo but no crown revealed the following:

1 YEAR survival was 96%
2 YEAR survival was 88%
5 YEAR survival was **36%**

They classified the amount of tooth structure remaining, with 5 year survival:

1. Like a Class I lesion; at least 2mm surrounded. 78%, 5 year
2. Like a Class II; at least 2mm on at least 2 walls. 45%, 5 year
3. Less than 2 walls had a thickness of 2mm 18%, 5 year

They also found that composite-treated teeth performed better than amalgam-treated teeth.[7]

[4] Sorensen & Martinoff showed no improvement in prognosis with posts present. 1984
[5] Aquilino & Caplan, 1982
[6] Manocci et al, 2002
[7] Nagasiri & Chitmongkolsuk, 2005

In general, endo-treated posterior teeth should be crowned.
EXCEPTIONS *might* be lower premolars and first molars with:

- Conservative access cavities,
- Intact marginal ridges, AND
- Absence of excessive occlusal forces.[8]

Maxillary premolars with 2 or 3 surface amalgams have a high incidence of fracture.

- Endo-treated upper premolars with previous sizable restorations should be crowned.
- One author concludes that "amalgam, especially in MOD cavities, is an unacceptable material for restoration of endodontically treated posterior teeth…"[9]

Even if we have a conservative access, we need to consider a post in cases of:

- big access or big instrumentation
- horizontal cracks on the crown
- heavy function[10]

WHAT IS THE PURPOSE OF A POST?

- To retain a core

So…
WHEN DO WE NEED A POST?
→ When we need to retain the core.

- Gordon Christensen recommends a post when less than half of the tooth crown remains.[11]

Posts are not needed in molars if the crown prep (in natural tooth) is 3 to 4 mm in length.[12]

- If one cusp is missing, we might consider a post.[13]

Another consideration…
A post could interfere with our ability to retreat the endo.

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[8] Rosenstiel, Contemporary Fixed Prosthodontics, 4th Ed, 2006
[9] Hanson, 1990
[10] Christensen, 2004
[11] JADA 2004
[12] Kane, JJ et al, 1990
[13] Rosenstiel, Contemporary Fixed Prosthodontics, 4th Ed, 2006

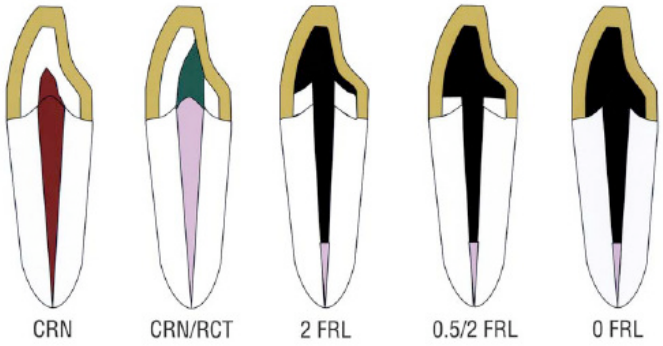
II. **HOW MUCH TOOTH DO WE NEED?**

ANSWER: 2 mm all the way around the tooth. (FERRULE)

If you have 2mm of natural tooth all the way around, the actual type and design of the post does not matter as much.[14] [15] [16]

One study looked at extracted teeth with:

1. a crown
2. endo and a crown
3. endo, cast post and core with 2mm ferrule, and a crown
4. endo, cast post and core with 2mm B & L, 0.5mm M & D, and a crown
5. endo, cast post and core with NO ferrule, and a crown



- No ferrule group was the least resistant to fracture.
- The 2/0.5 ferrule group was less resistant to fracture than the first three groups.
- This means a 2mm ferrule is optimal.
- It also means the posted tooth was as strong as the non-posted teeth.[17]

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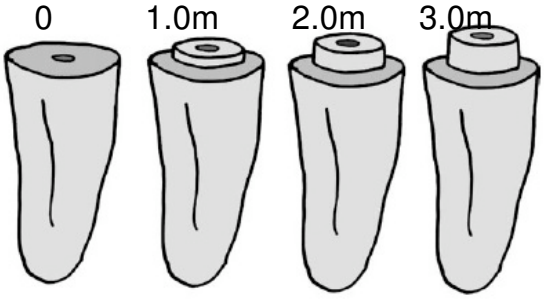
[14] Assif et al, 1989
[15] Milot & Stein, 1992
[16] Rosenstiel, Contemporary Fixed Prosthodontics, 4th Ed, 2006
[17] "In vitro fracture resistance of endodontically treated central incisors with varying ferrule heights and configurations" – Tan et al, Journal of Prosthetic Dentistry, 2005

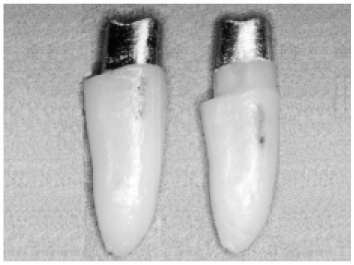
Another study featured extracted teeth with no ferrule and with 1mm, 2mm and 3mm ferrule.

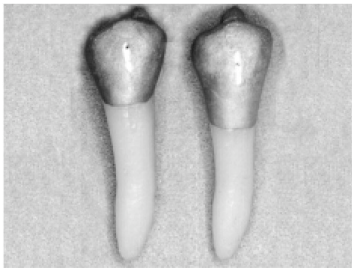


2mm ferrule was stronger than 0 or 1mm.
3mm ferrule was the **most** resistant.

So…
We need at least 2mm of tooth structure.[18]

What do we do if we don't have 2mm?
- One study took extracted premolars and simulated no ferrule and crown lengthening with a 2mm ferrule.

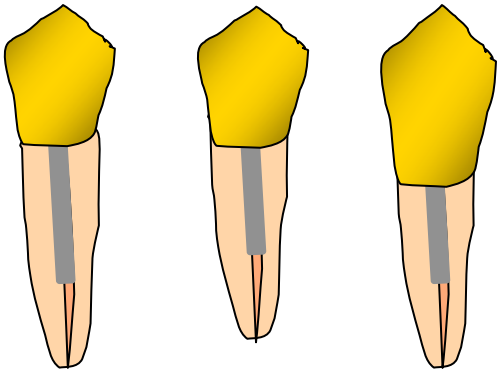




- The ferrule, crown-lengthened teeth needed a **smaller** load to fracture.
- The crown lengthening altered the crown-to-root ration unfavorably.[19]

[18] "Effect of a crown ferrule on the fracture resistance of endodontically treated teeth restored with prefabricated posts" – Perreira et al, Journal of Prosthetic Dentistry, 2006
[19] "Effect of crown lengthening and ferrule placement on static load failure of cemented cast post-cores and crowns" – Gegauff, Journal of Prosthetic Dentistry, 2000

A better option might be forced orthodontic extrusion.



Tooth on left represents no surgery and no ferrule.
Tooth on right represents surgery to obtain ferrule.
Center tooth represents ortho extrusion to obtain ferrule.

- While this also alters the root length and changes the crown-to-root ratio, the crown is NOT lengthened, so the crown-to-root ratio is not as unfavorable as a crown-lengthened tooth.[20]

III. **WHAT POST QUALITIES ARE BEST?**

LENGTH OF THE POST

It is best to leave 5mm of gutta percha.
- to avoid disturbing the apical seal
- curves and lateral canals occur in the apical 5mm. [20]

The absolute minimum is 3mm. [20]

RETENTION
- LONG posts are more retentive than SHORT posts. [20] [21] [22] [23]

FRACTURE RESISTANCE
- SHORT posts are more likely to cause a root to fracture.
- LONG posts resist fracture better because *stress concentration* is lowered.[24]

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[20] Rosenstiel, Contemporary Fixed Prosthodontics, 4th Ed, 2006
[21] Standlee et al, 1978
[22] Kurer et al, 1977
[23] Cooney et al, 1986
[24] Standlee and Caputo, 1992

- One group studied endodontically treated teeth that were extracted because of vertical root fractures (VRF) or suspected VRF.
    - 62% of teeth with VRF's had posts.
    - *70% of the posts did not extend past the coronal one-third of the tooth*.[25]

So, HOW long is long enough?

- Retention seems adequate with ⅔ root length.[26]
- Resistance to deflection is greatest at ¾ the root length.[27] [28]

But, can we always get posts that are that long?
- Often, 5mm gutta percha cannot be retained with a post ¾ the length of the root (or even ⅔ length of the root).[29]
- The solution might be make the post as long as possible, while still leaving 3mm of Gutta Percha.

- The post should be at least the same size as the height of the crown.[30]

- Others say ½ the length of the root in bone is enough.[31]

- MOLAR posts should not exceed 7mm in length.[32]
    - DISTAL CANAL OF LOWER MOLARS
    - PALATAL CANAL OF UPPER MOLARS

- If placing a second post in a MOLAR, try to avoid:
    - the MB canal on upper molars (root curvature and concavities),
    - the ML canal on lower molars. (not uniform)[33]

- Try to avoid:
    - the DISTAL surfaces of the MESIAL canals in mandibular molars (thin walls).
    - the M & D surfaces of the BUCCAL canals in maxillary molars. (easy to strip) [32]

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[25] Fuss et al, 2001
[26] Hunter et al, 1989
[27] Johnson & Sokumura, 1978
[28] Leary et al, 1989
[29] Zillich, 1984
[30] Henry & Bower, 1977
[31] Stern & Hirshfeld, 1973
[32] Abou-Rass et al, 1982
[33] Tilk et al, 1979

- Many authors recommend removing the Gutta Percha with HEAT, and not rotary instruments. Rotary instruments can be used to clean the walls, and to prepare a post space. This not only preserves dentin, but also helps avoid perforations.

PERFORATIONS
Kuttler et al studied extracted MOLARS:
- Do not use a gates glidden larger than #3 in a molar. (Don't use a gates glidden #4 in a molar.)
- After endo, some furcation areas are already less than 1mm in thickness.
- Length is more important than width.
- 7mm post in distal of mandibular molars and palatal canal of maxillary molars.[34]

PERFORATIONS produce a distinct, round radiolucency with borders.

FRACTURED ROOTS produce a diffuse radiolucency with an oval "tear-drop" shape.

<u>WIDTH OF THE POST</u>

- Post diameter should not be greater than one-third the root diameter. Root concavities are not always easy to see on radiograph.[35]

- Peters et al found that if fitted correctly, longer thicker posts were a little less likely to fracture as long as parameters were not exceeded.[36]

- Larger diameter posts require higher tensile strengths to break the cement seal and pull them out of the roots of extracted teeth.[37]

- Trabert et al found that longer NARROW stainless steel posts absorbed less energy.[38]

- A wide post generates more stress when it is SHORT.

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[34] Kuttler et al, 2004
[35] Tilk et al, 1979
[36] Peters et al, 1983
[37] Johnson & Sakumura, 1978
[38] Trabert et al, 1978

- Post *length* is more important than *width* in generating stresses. Medium to wide posts should be avoided if the post is short (causes too much stress.)[39]
- A *thicker* post actually stresses a tooth more, since it is sitting in a *thinner* tooth. Since length is more important than width, going for a wider post is not worth the risk of fracture.[40]

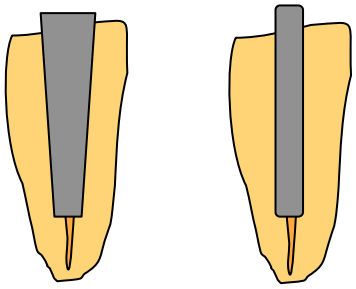
TEXTURE OF THE POST

- Serrations, roughening, & grooves increase retention.[41] [42] [43]
- Serrated posts are 30-40% more retentive than smooth posts.[44]

SHAPE OF THE POST

Categories of posts:
1. parallel
2. tapered
3. threaded (screw)

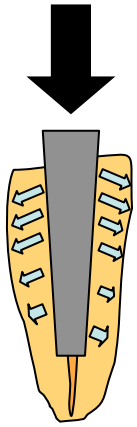
RETENTION
- The *most* retentive post is the THREADED (screw) POST.[45] [46] [47]
- The *least* retentive post is a TAPERED post. A PARALLEL post is more retentive than a tapered post.[41] [46] [47]
- In one study, on average, it took about 4½ times the tensile strength to pull out a parallel post than it did to remove a tapered post from a tooth of similar diameter.[48]



[39] Hunter et al, 1989
[40] Rosenstiel, Contemporary Fixed Prosthodontics, 4th Ed, 2006
[41] Colley et al 1968
[42] Ruemping et al, 1979
[43] Wood, 1983
[44] Henry & Bower, 1977
[45] Kurer et al, 1977
[46] Standlee et al, 1978
[47] Ruemping et al, 1979
[48] Johnson & Sakumura 1978

RESISTANCE TO FRACTURE

- SCREW posts are the most likely to fracture a root.
- In that study of teeth extracted for vertical root fractures, 67% of those teeth had SCREW posts.[49]



- TAPERED posts are more likely to fracture teeth than PARALLEL posts.
- TAPERED posts have a wedging effect and show the highest shoulder stress concentrations.[50]

- Smooth-sided parallel posts generate the greatest apical stresses.[50]
- Serrated parallel posts distribute forces on both sides of the post.[50]
- Serrated parallel posts place the root under less stress than other posts.[50]

But, this all depends on having:
- adequate length
- vertical adaptation (using all of the post space we created)
- a round canal:
    - max central
    - max 1st molar
    - mand 2nd premolar
    - db canals of max molars

SUMMARY
The ideal post is:
- at least as long as the crown.
- not wider than 1/3 root diameter.
- serrated, rough, or grooved.
- parallel.

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[49] Fuss et al, 2001
[50] Standlee et al, 1972

IV. **WHAT POST TYPES ARE BEST?**

CUSTOM CAST POST
ADVANTAGES:
- fit to the canal
- good for oval canals

DISADVANTAGES:
- time-consuming (extra visit)
- costly
- requires removal of tooth structure (undercuts, bulk)

- As much coronal dentin should be retained as is possible, to minimize stress which can fracture the root.[51] The amount of remaining tooth structure (crown and root) is the single most important factor in success and prevention of root fractures.[52]Cast posts require removal of coronal and radicular tooth structure.
- If PARALLEL posts are more retentive and produce less stress, cast posts should be parallel. We can accomplish this using parallel post drills, instead of Gates Glidden burs.
- When Cast Posts fail, they often fail catastrophically (root fracture).

The Split Shank threaded post ("FLEXIPOST")
- This redesigned threaded post is split 2/3 down the shaft. On cementation, the split section flexes, to lessen stress on the root.
- Because the coronal 1/3 is NOT split, there is a lot of stress at the neck of the root. This causes a WEDGING EFFECT.[53]
- When they fail, the root fractures.
- Standlee & Caputo deduced that this is no better than a SCREW POST with respect to the potential for catastrophic failure.

PREFABRICATED POST: STAINLESS STEEL
ADVANTAGES:
- easy to use
- strong
- inexpensive

DISADVANTAGES:
- can fracture the root (rigid)
- not esthetic
- nickel allergy
- can corrode[54]

[51] Henry & Bower, 1977
[52] Rosenstiel, Contemporary Fixed Prosthodontics, 4th Ed.
[53] Standlee & Caputo, 1992
[54] Christensen, 2004

PREFABRICATED POST: TITANIUM

ADVANTAGES:
- not allergenic
- does not corrode

DISADVANTAGES:
- not as strong as steel
- can fracture root (rigid)
- not esthetic[54]

PREFABRICATED POST: CARBON FIBER

ADVANTAGES:
- can bond easily
- flexible
- can be removed

DISADVANTAGES:
- not strong - not esthetic[55]

- In a 2-to-3 year study of over 200 C-Posts in vivo, there were NO incidences of dislodgment OR root fracture.[56]

- One study showed that fracture resistance was lower than cast post/core control, but failures almost always resulted in fracture of the core and not the root.[57]

- In another study, the fracture resistance was similar to parallel and tapered metal posts. Metal posts fractured roots 50% of the time. None of the carbon posts fractured any roots.[58]

PREFABRICATED POST: GLASS FIBER (silica)

ADVANTAGES:
- can bond easily
- can be removed
- high tensile strength
- flexible
- esthetic[59]
- elasticity similar to dentin
- flex under load[60]

DISADVANTAGES:
- not strong

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[55] Christensen, 1996
[56] Fredriksson et al, 1998
[57] Martinez-Insua et al, 1998
[58] Dean et al, 1998
[59] Christensen, 2004
[60] Bateman et al, 2003

- Bonding reduces the wedging effect of the canal in the root.
- Can use a shorter, thinner post. This conservation of tooth structure lowers the chances of root fractures.[61]
- Bonding might mean that the shape (parallel vs. tapered) might be less important for retention.[62]

- THE RULES ARE CHANGING!!! We can reduce less root structure:
    - Shorter Posts
    - Narrower Posts
    - Use existing canal anatomy (less risk of fracture or perforation)

- Some researchers found that fiber posts were much less resistant to stress than bonded metal posts. But, the fiber posts had NO root fractures.[63]

- In another study, parallel fiber posts were more retentive than tapered fiber posts. (SEM showed more resin cement attached to the parallel posts.)
- Quartz fiber post was more rigid.
- Light transmission was incomplete.[64]

- "Light-transmitting" fiber posts had the same depth of cure as posts that do not transmit light. At this point, it would not be advisable to use a cement that is not self-cured or dual-cured.[65]
- Fiber Posts can be removed easily in cases where endodontic retreatment is necessary.[66]

<u>PREFABRICATED POST: CERAMIC</u> (zirconia)
ADVANTAGES:
- esthetic
- very strong / rigid

DISADVANTAGES:
- expensive
- difficult to bond
- difficult to remove
- can fracture roots[67]

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[61] Pontius & Hutter, 2002
[62] Qualtrough et al, 2003
[63] Newman et al, 2003
[64] Teixeira et al, 2006
[65] Roberts et al, 2004
[66] Cormier et al, 2001
[67] Christensen, 2004

- When Zirconium Oxide posts are bonded with a resin cement, the bond between ceramic and resin is weak. This would diminish the retention of the post.[68]

- Bonded metal paraposts had better retention than ceramic posts, regardless of how they were cemented. Silanated ceramic posts cemented with resin had greater retention than those posts cemented with glass ionomer. Sandblasting the posts had variable success.[69]

- Some researchers bonded TITANIUM, QUARTZ-FIBER, GLASS-FIBER & CERAMIC posts on extracted canines.[70]
    - Titanium had the lowest resistance to fracture, followed by Silica and Zirconia. Quartz was the most resistant.
    - TITANIUM & CERAMIC posts resulted in catastrophic root fractures.
    - NONE of the QUARTZ or GLASS fiber posts resulted in root fractures. Those teeth could be salvaged & restored.

SUMMARY
- CAST POSTS remove a lot of tooth structure.
- STAINLESS STEEL POSTS can corrode.
- TITANIUM POSTS are weaker than steel.
- CERAMIC POSTS do not bond well.

ALL of the above can fracture roots.

- CARBON FIBER POSTS bond well, but are black.
- GLASS FIBER POSTS bond well.
- QUARTZ FIBER POSTS are stronger than glass.

NONE of the above render a tooth unrestorable after failure.

V. **WHAT CEMENTS ARE BEST?**

<u>CUSTOM CAST POST & CORE</u>
Cement does not show any significant difference.

<u>PREFAB METAL POST</u>
There is no significant difference between traditional cements.

BUT, when you BOND a metal post...

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[68] Hedlund et al, 2003
[69] Purton et al, 2003
[70] Akkayan & Gulmez, 2002

Standlee & Caputo[71] showed that bonded metal posts are very retentive.
- They assessed Boston Post (bis-gma) & C+B Metabond (4-meta)
  - C+B was more retentive.
- They also reported that composite resin–cemented posts are as retentive as screw posts.

- Metal posts could be sandblasted to add to retention & resistance.
PROBLEM: How would you remove it if you had to?

FIBER POSTS (carbon, fiber or quartz)
- A resin cement should be used.
- It should be self-cure or dual-cure until we have posts that truly transmit light.

CERAMIC POSTS (zirconia)
- A resin cement should be used, along with a silanating agent.
- We need to develop a ceramic post that more reliably bonds to the canal.

VI. **WHAT CORE IS BEST?**

AMALGAM
- Bonding the amalgam prevents microleakage at the root level.
- **BUT**, should we place amalgam into the canals? (can we get it out?)

COMPOSITE RESIN
- THE STANDARD FOR ENDO TEETH, whether we are crowning immediately or later.
- Restoring prepared teeth with amalgam does not increase fracture strength. (Preps with no restoration were just as strong as amalgam.)[72]
- Fracture resistance was increased with composite, even if dentin was not bonded.[72]
- MOD's on endo premolars: mean force of fracture was significantly higher for etched comp than for amalgam.[73]

[71] Standlee & Caputo, 1992
[72] Bakke et al, 1985
[73] Troppe et al, 1985

- In a study of amalgam & composite in endo teeth:
  - Teeth with composite were as strong as untreated teeth.
  - The authors say amalgam is okay if the prep is small. If it gets bigger, composite is better, since composite is as strong as an untreated tooth, regardless of size of prep.[74]

- What if we are not crowning the tooth NOW?
→ Composite is preferred over amalgam in an endo tooth until it is crowned, especially if it is 3-surfaces.[75]

- One study showed that amalgam cores and composite cores had the same resistance to fracture.
  BUT…
  When composites fractured, the tooth was still restorable.[76]

- "It is concluded that amalgam, especially in MOD cavities, is an unacceptable material for restoration of endodontically treated posterior teeth if used without cuspal overlays." [77]

VI. **WHAT GIVES A CORE RESISTANCE?**

Retention applies to VERTICAL loss of a crown.
Resistance applies to LATERAL loss of a crown.

The ratio of the crown prep height to the buccolingual tooth dimension gives an idea of resistance.[78]

- The ratio should be no less that 0.4.
- For molars, that usually means the prep height should be 4mm.
- For premolars, the prep height should be 3mm.

What features can we add to increase resistance?

- Grooves and boxes can increase resistance.[79]
- *Interproximal* grooves are more effective than *buccal and lingual* grooves.[80]

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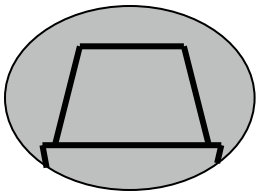
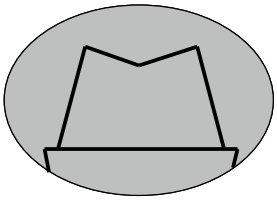
[74] Oliveira et al, 1987
[75] Scurria et al, 1995
[76] Pilo et al, 2002
[77] Hansen et al, 1990
[78] Goodacre et al, 2001
[79] Reisbick & Shillingburg, 1975

- Total Occlusal Convergence (taper) affects resistance.[81, 82]

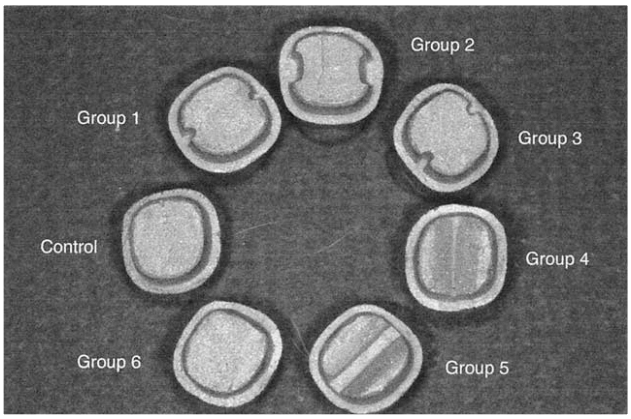


- Occlusal inclined planes can increase resistance.[83]



- Occlusal isthmuses can increase resistance.[83]

Proussaefs et al milled ivorine teeth with a 20° taper. They prepared groups with interproximal grooves, buccal and lingual grooves, interproximal boxes, inclined occlusal planes and occlusal isthmuses. For the last group, they went back and reprepared the gingival 1.5mm with a 4° taper (total occlusal convergence of 8°.) They made crowns and measured the force needed to remove the crowns.



The group with the altered Total Occlusal Convergence was the ONLY group that significantly altered the resistance form.[84]

- While the features listed above have been documented to increase retention and resistance, they appear to be of no use if the taper of the crown preparation is excessive.
- Grooves, boxes, isthmuses and inclined planes are more useful for a short crown prep with a total taper closer to 10°.

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[80] Woolsey & Matich, 1978
[81] Weed & Baez, 1984
[82] Wiskott et al, 1996
[83] Zuckerman, 1988
[84] Proussaefs et al, 2004

SUMMARY:

- A post is indicated only when it is needed to retain a core.

- A ferrule of at least 2mm is critical to prevent loss of post or fracture of the tooth.

- For retention and fracture resistance, posts should be long, parallel and rough/serrated.

- While metal posts are stronger, fiber posts (carbon, silica or quartz) generally do not cause catastrophic fractures that cannot be retreated.

- Bonding a post gives the best retention and resistance to fracture.

- Composite resin cores render an endodontically tooth more resistant to fracture. When resin cores fail, the tooth can usually still be restored.

- Molar crown preps should be at least 4mm tall.

- Resistance features can be useful in short crown preps *only* if total occlusal convergence (taper) is not excessive. Repreparing an overtapered preparation is the most effective resistance feature.