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Restoration of Endodontically Treated Teeth

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Lecture 1: Introduction

Learning Outcomes

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By the end of this lecture, you should be able to:

1) Understand the changes in the tooth structure after root canal treatment
2) Discuss the factors that make endodontically treated tooth more susceptible to fracture
3) Discuss restorative options for endo treated tooth (with and without a post)
4) Discuss the function, indication, importance and clinical application of posts
5) Understand and describe the concept of Ferrule and discuss the importance of the ferrule effect
6) Understand the factors that affect the ferrule and the longevity of endodontically treated teeth

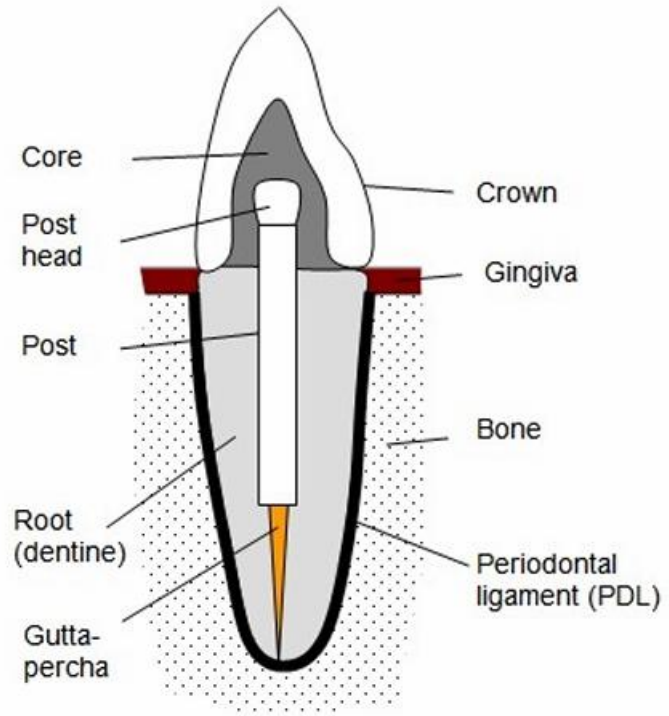
What is Post and Core Restorations

Post (Definition & Purpose)

•A **post** is typically made of **metal** or **fibre-reinforced composite** and is placed into a **prepared root canal** of a natural tooth.

•Together with a **core**, it provides **retention** (and some resistance form) for a **definitive coronal restoration** (e.g., crown).

•Posts may also support **attachment systems** and serve as a foundation for **overdenture post–copings** where indicated.



Pre-fabricated

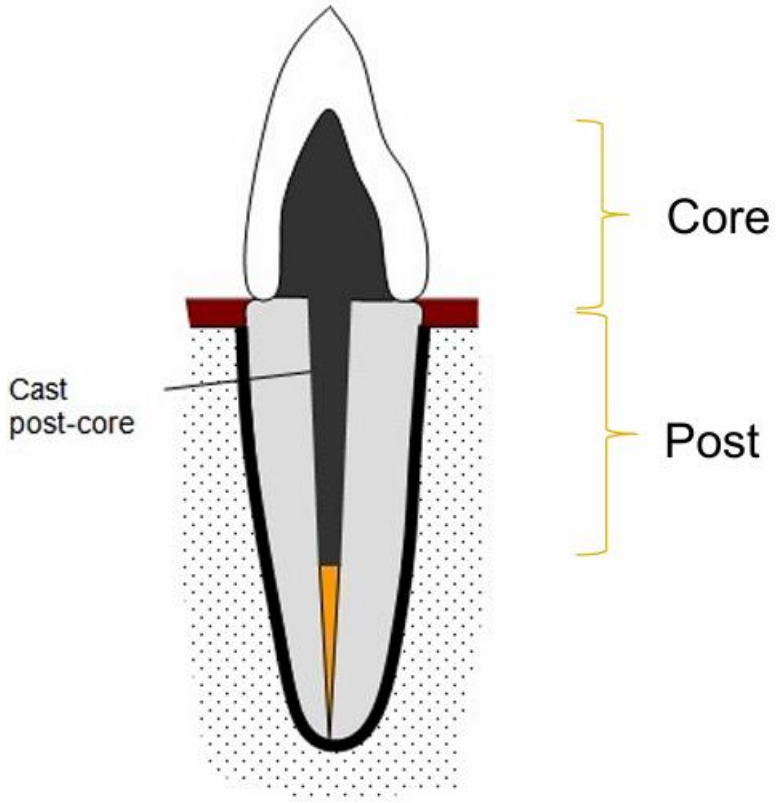
What is Post and Core Restorations

Core (Definition & Role)

A **core** is a **foundation restoration** that replaces missing coronal tooth structure.

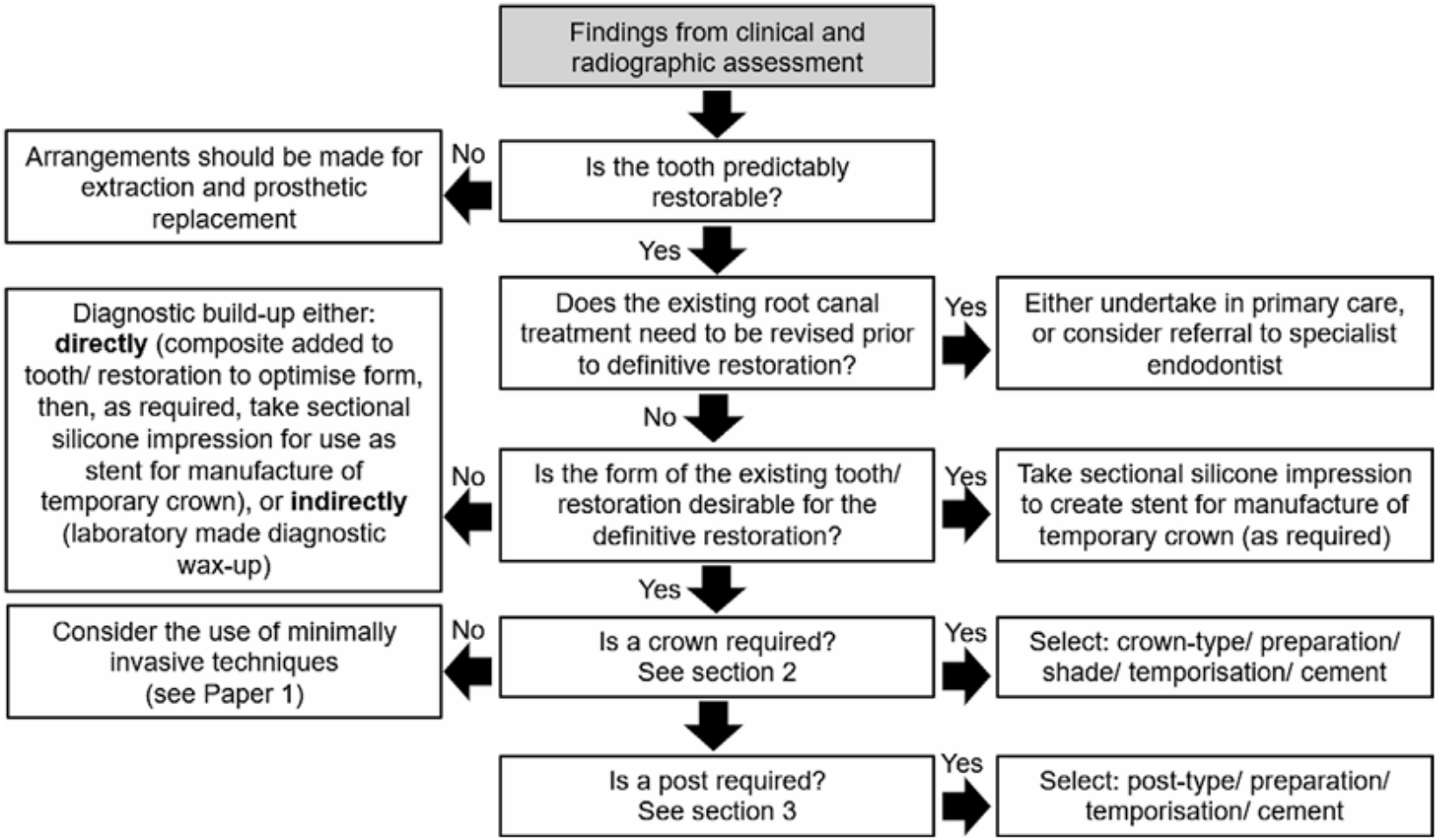
It **rebuilds coronal anatomy** to support the definitive restoration (e.g., crown/onlay) and helps establish **proper form, contour, and occlusion**.

A core may be placed in **vital or endodontically treated teeth** and should provide **adequate retention and resistance form**, while preserving remaining tooth structure.



Cast post and core

Treatment planning process



R. J. R. Smith et al

Fundamental Concepts – Prognosis

- Properly treated, root-filled teeth can function long-term and serve as abutments
- Restoration usually fails before the endodontic treatment fails
- Survival is driven mainly by remaining tooth structure, presence of cuspal coverage, ferrule, occlusal loading and quality of restoration

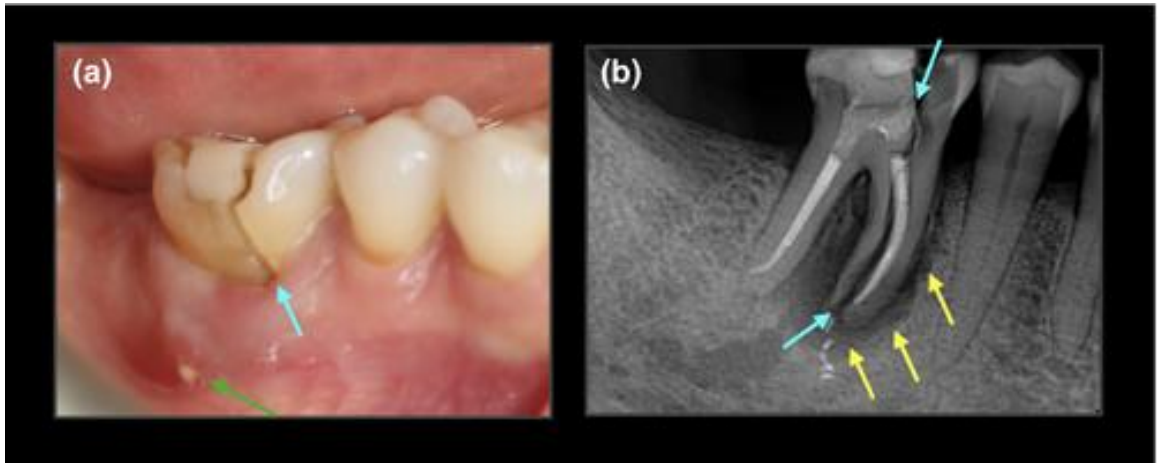
Endodontic Readiness – Biological Criteria

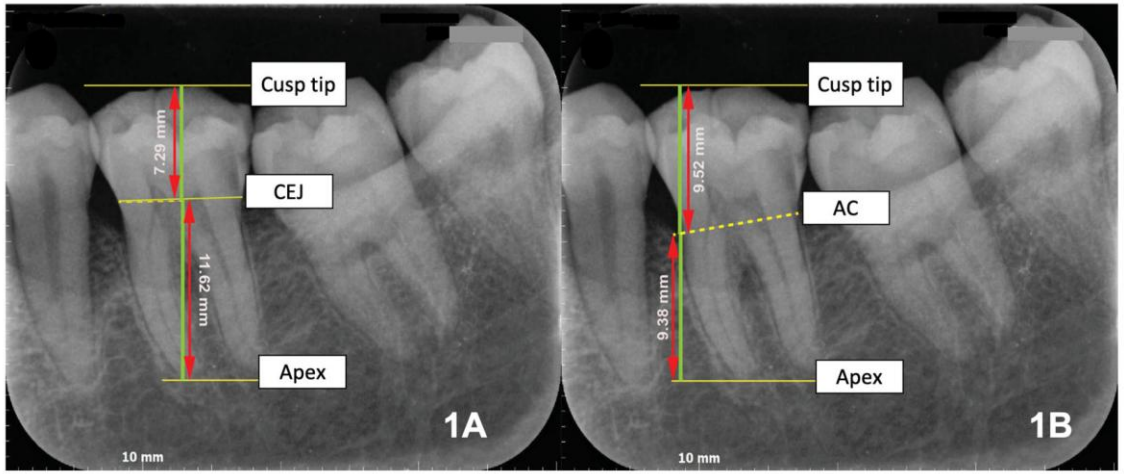
Before definitive restoration, confirm:

- Adequate root canal filling and apical seal
- No sinus tract, exudate or persistent swelling
- No tenderness to percussion or palpation
- Radiographic healing or stability of periapical area
- No unresolved procedural errors compromising prognosis

Periodontal & Structural Readiness

- Evaluate periodontal support and crown-to-root ratio
- Check for mobility and furcation involvement
- Assess presence and height of potential ferrule
- Consider need for crown lengthening or orthodontic extrusion
- Decide early if the tooth is restorable or if extraction/implant is preferable





Role of Tooth Type and Position

- Anterior teeth: often less axial load, but high esthetic and guidance demands
- Premolars: small cross-section, susceptible to fracture, especially maxillary premolars
- Molars: larger roots and pulp chambers, often restored without posts using chamber retention
- Teeth serving as abutments (FDP, RPD) face higher functional demands

Remaining Tooth Structure – Key Predictor

- Height, thickness and number of residual walls strongly influence survival
- Studies show that teeth with substantial dentin height perform significantly better, independent of post type or crown material
- Once remaining wall height is <2 mm, failure risk increases steeply

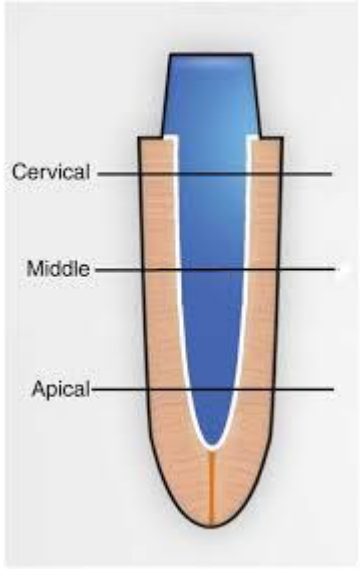
Peri-cervical Dentin – Why It Matters

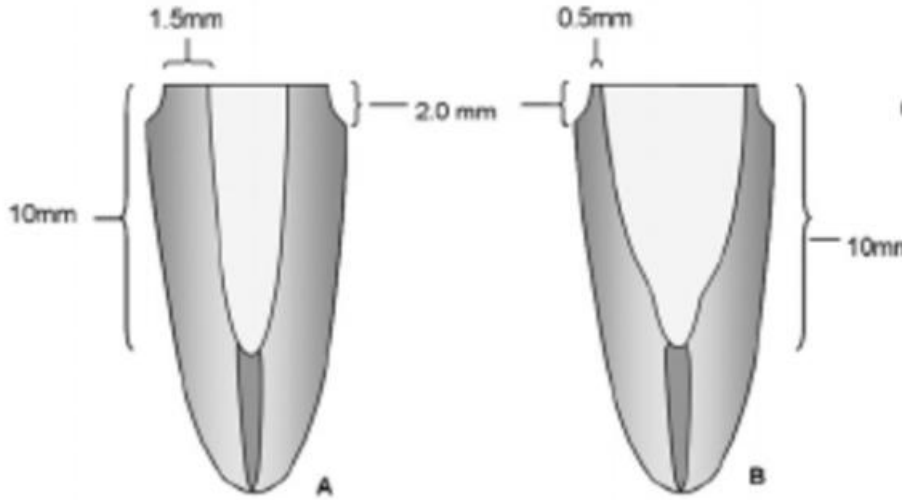
Peri-cervical Dentin: A Critical Stress-Bearing Zone

•The peri-cervical dentin (**~4 mm above and 4 mm below** the crestal bone) is key for resisting **bending and shear** forces.

•**Over-flaring** and aggressive preparation in this region markedly reduce fracture resistance.

•When preparing post space, **remove only what is necessary**—avoid unnecessary enlargement that sacrifices peri-cervical dentin.



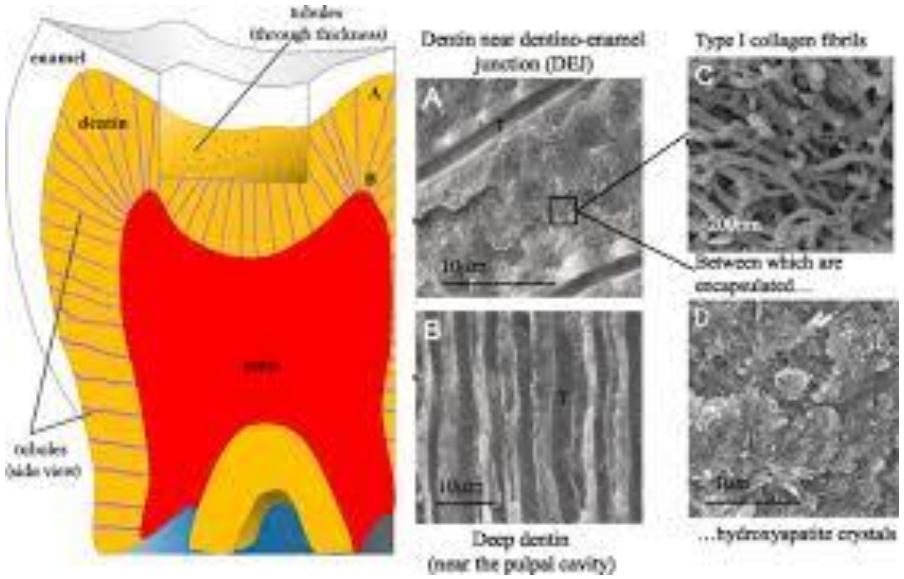


Mechanical Properties of Tooth Structure After Root Canal Treatment

- Common belief: endodontically treated teeth are weaker because dentin becomes ‘brittle’.
- Many experimental studies show minimal change in dentin hardness/elastic modulus after RCT and dehydration.
- Clinically, fracture risk rises mainly due to tooth structure loss (caries, restorations, access) and altered load paths.
- Therefore: treat ETT as structurally compromised and restore to protect remaining dentin.

Why Dentin Properties Vary (Even Without RCT)

- Dentin is not uniform: tubule density and orientation (crown, cervical or root) affecting stiffness and toughness.
- Age and sclerosis change dentin behaviour (often more mineralised and less compliant in some regions).
- Moisture influences toughness; dehydration can reduce toughness, but impact is usually secondary to structural loss.
- Procedures (instrumentation, irrigants, post preparation) can affect surfaces—preserve dentin and minimise over-preparation.



The Main Biomechanical Problem After Root Canal Treatment

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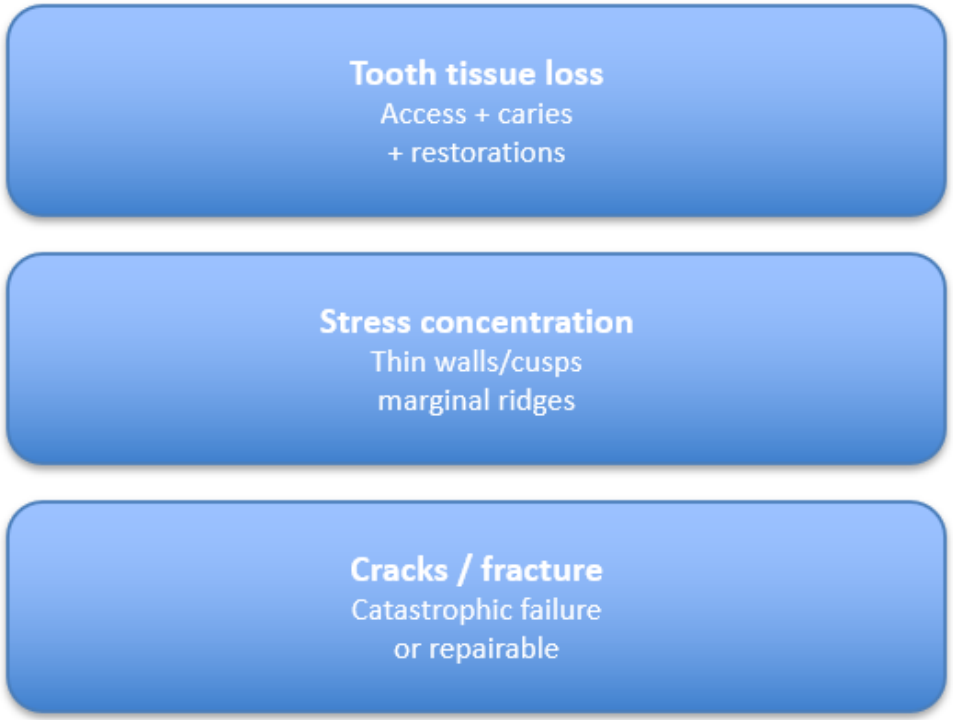
Tooth Structural Loss is the Main Biomechanical Problem

- Major contributors: caries + existing restorations + access cavity + loss of marginal ridges/cusps.
- Thin cusps and walls become stress concentrators → cracks initiate and propagate.
- Goal of coronal restoration: redistribute forces and protect weakened tooth structure.



Biomechanical Principles

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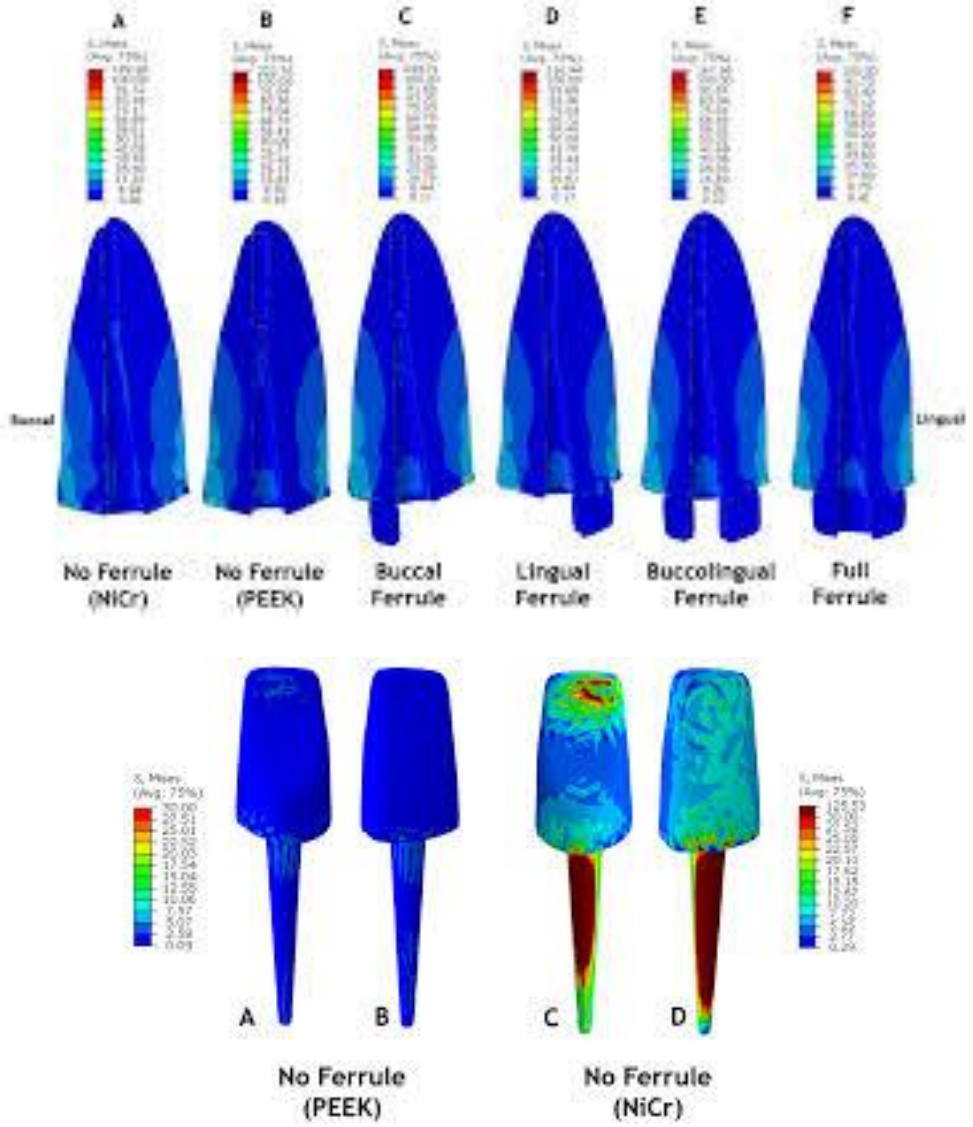
Predictors of Survival: Peri-cervical Dentin, Residual Walls & Ferrule:

- Preserve peri-cervical dentin (≈4 mm above and below the bone crest): critical for resisting bending and shear.
- Remaining wall height/thickness/number strongly predict survival — often independent of post type.
- When remaining wall height is <2 mm, failure risk rises steeply.
- A circumferential ferrule (often ~1.5–2 mm) improves fracture resistance and reduces catastrophic failures.

Biomechanical Principles

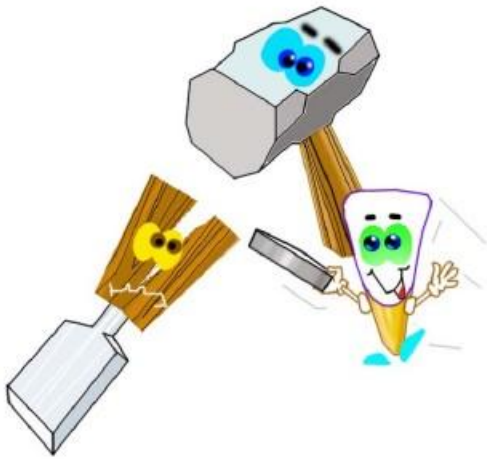
Stress Distribution:

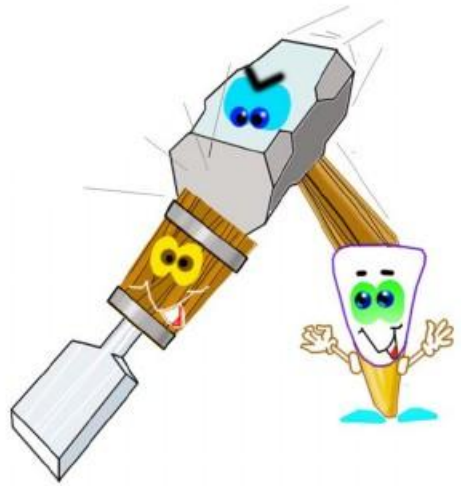
- Finite element/photoelastic studies: cervical dentin often carries the highest stress under vertical loading.
- Posts may shift some stress apically under vertical load; under oblique load they may not reduce overall stress and can increase apical stress.
- Key principle: posts retain the core — they do not automatically ‘strengthen’ roots.
- Prioritise ferrule, conservative post preparation, and occlusal risk management.



FERRULE

General definition: a ring or cap, typically a metal one, which strengthens the end of a handle, stick, or tube and prevents it from splitting or wearing

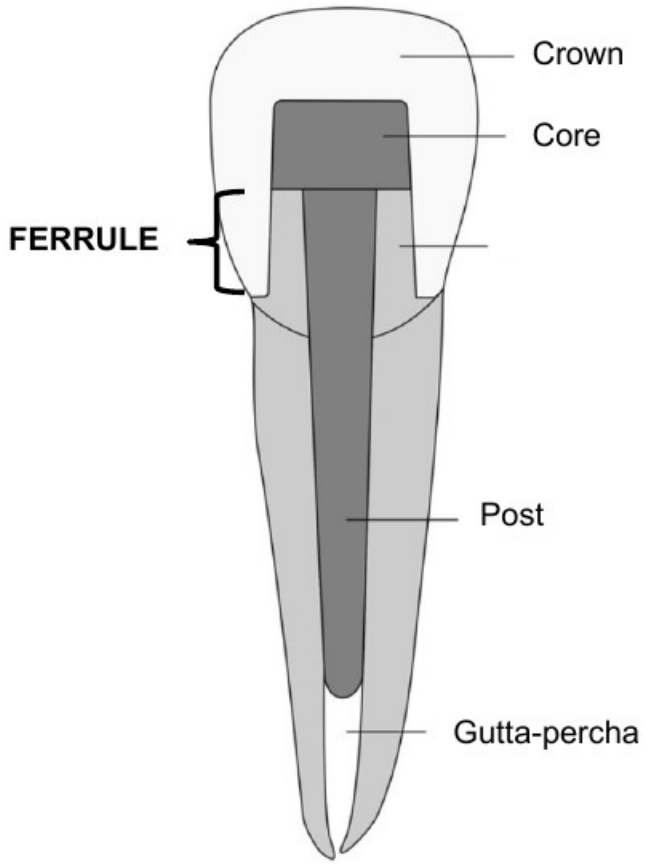




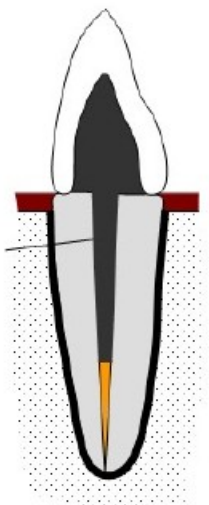
FERRULE

Parallel walls of dentin extending coronally from the crown margin provide ferrule

Ferrule effect: a 360 metal collar of the crown surrounding the parallel walls of the dentine extending coronal to the shoulder of the preparation.



No Ferrule

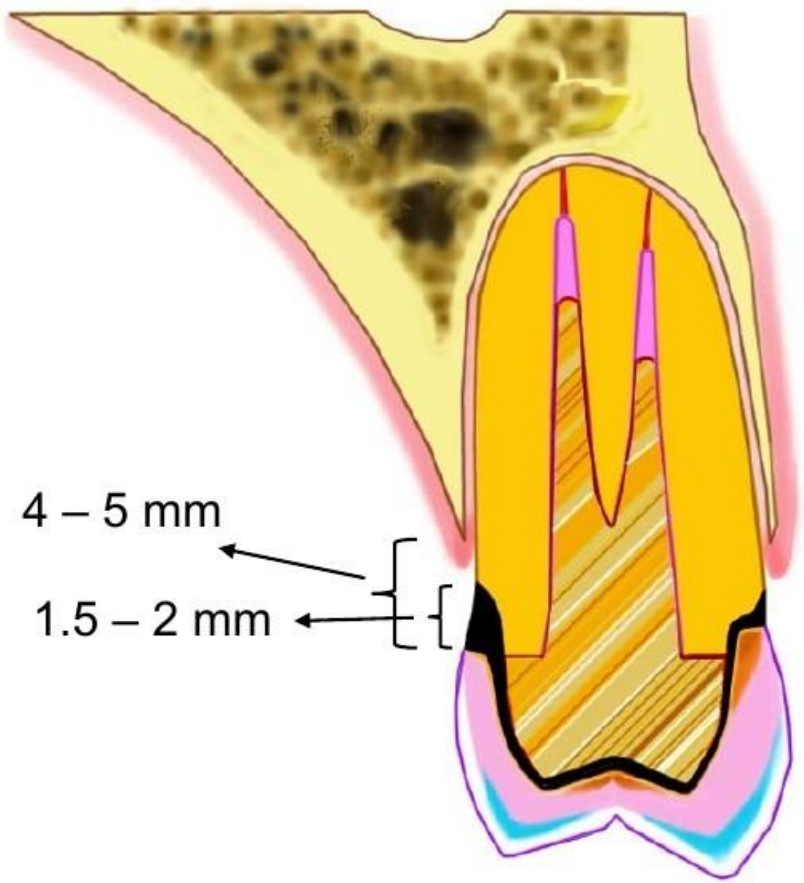


↑ Resistance form

↓ Stress within the tooth = TOOTH PROTECTION

JOE. Juloski et al. 2012

FERRULE



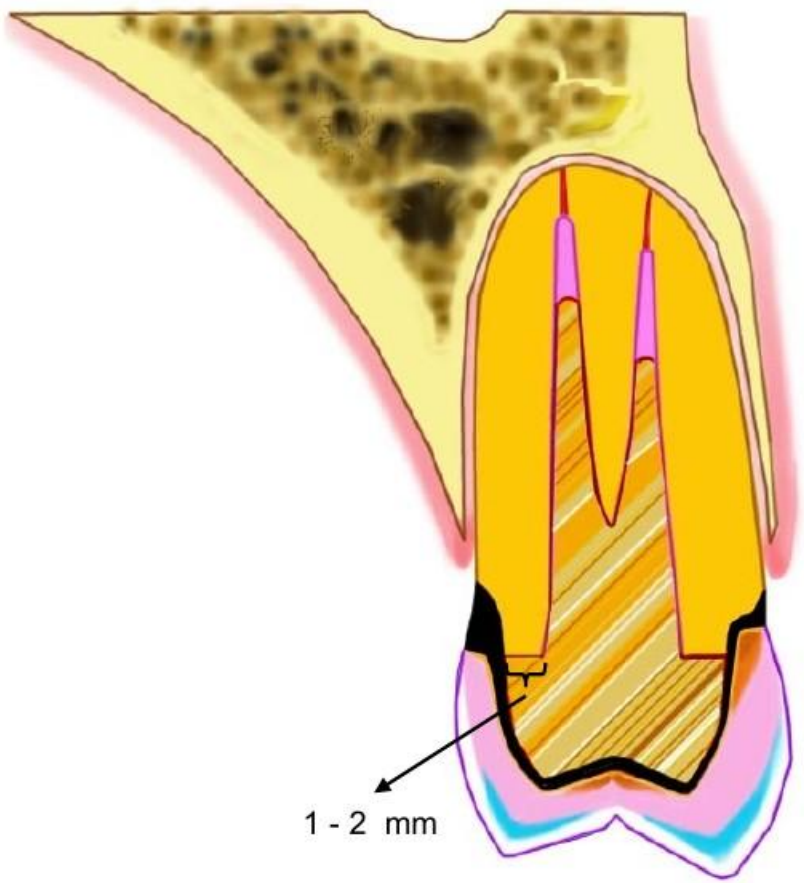
Height

- Minimum amount of ferrule: 1.5 – 2 mm
- Determined by the amount of sound tooth structure above the ginigival margin
- At least 4 – 5 mm of tooth structure coronal to the bone crest (2 – 3 mm of biological width)

The greater the height of remaining tooth structure above the margin of the preparation, the better fracture resistance provided Akkayan B 2014

JOE. Juloski et al. 2012, Jotkowitz et al. 2010

FERRULE



Width

- Minimal thickness of remaining dentine: 1 - 2 mm
- The axial reduction of the crown preparation and the width of the post preparation with determine the ferrule width (dentin thickness)

Jotkowitz et al. 2010

FERRULE

Location

- Circumferential ferrule is the ideal
- This may not be possible due to:
  - Caries
  - Erosion and abrasion (more common on buccal wall)
  - Over-reduction during tooth preparation

An incomplete ferrule is a better option than a complete lack of ferrule

Jotkowitz et al. 2010

FERRULE

Location

- Partial ferrule

Influence of remaining coronal tooth structure location on the fracture resistance of restored endodontically treated anterior teeth

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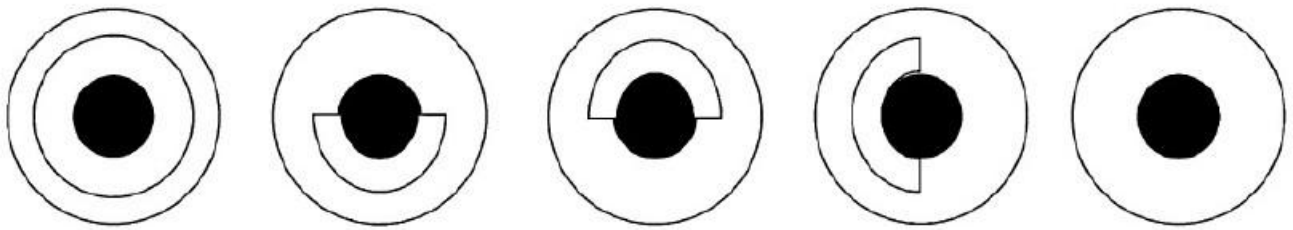


RESULTS:

- The location of the ferrule is important for the fracture resistance
- Maxillary incisors: the palatal ferrule is the most important to provide longevity for the restoration

FERRULE

Providing an adequate ferrule lowers the impact of the post and core system, luting agents, and the final restoration on tooth performance

What should you do when there is no tooth structure to create a ferrule?

- Check the restorability of the tooth

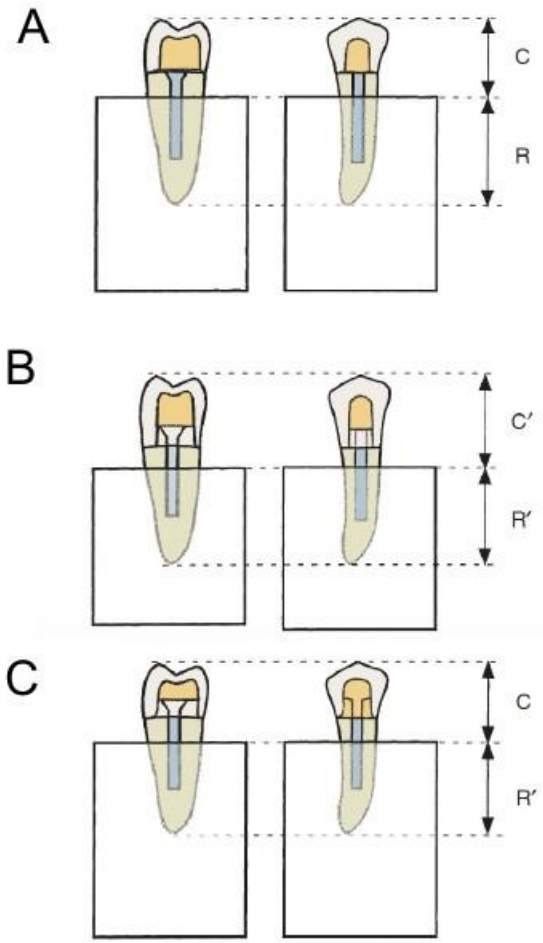
  If yes

Your need to expose tooth structure above the gingival margin

- Crown lengthening – surgical procedure
- Orthodontic extrusion

What should you do when there is no tooth structure to create a ferrule?

A) No Ferrule
B) Crown lengthening – surgical procedure
C) Orthodontic extrusion



Crown lengthening vs Ortho extrusion

- Both reduce root length
- Surgical crown lengthening reduces root length (R′) and increases crown length (C′).
- Time and cost may limit Orthodontic extrusion

Contemporary Fixed Prosthodontics 4th ed

OTHER FACTORS THAT AFFECT THE FERRULE

- ***Type of tooth and the extent of lateral load***

Posterior vs Anterior teeth

- Different sizes and direction of load

Anterior: oblique forces
Posterior: vertical forces along the axis

Anterior teeth	**Posterior teeth**
Deep bite Parafunction Dietary habits	Group function High cusps

MORE FERRULE

Non-desirable forces introduced by the restoration (interferences, inadequate occlusal design) is probably more important for survival of structurally compromised endodontic treated teeth than is the post and core system

Jotkowitz et al. 2010

OTHER FACTORS THAT AFFECT THE FERRULE

- ***Type of post***

Different types available

Pre-fabricated
Cast post and core

Materials
Mechanical properties
Technique
Cementation

- No universal recommendations have been established
- New literature seems to favor bonded fiber reinforced post (pre-fabricated) as opposed to metal post (cast post and core).

Main reason is related to catastrophic failures

- More favorable failure pattern
- Less root fracture
- Tooth fracture occur more occlusally

CAREFUL INTERPRETATION

1.5-2 mm ferrule in sound tooth structure is more important in fracture resistance than the post design or type

Jotkowitz et al. 2010

OTHER FACTORS THAT AFFECT THE FERRULE

- ***Core materials (for pre-fabricated post)***

Amalgam:
Advantage: good for posterior teeth due to high compression strength
Disadvantage: - does not bond to tooth structure
- require retentive features (undercuts) that may weaken the remaining walls

Composite:
Advantage: bond to tooth structure (dentin bonding is less reliable), the modulus of elasticity more similar to dentin
Disadvantage: weak composite/tooth interface (technique sensitive) may compromise the final restoration

Controversy : composite may reinforce residual tooth structure as it is bonded restoration

Bryant et al 1986, Jotkowitz et al. 2010

OTHER FACTORS THAT AFFECT THE FERRULE

- ***Core materials (for pre-fabricated post)***

Amalgam

Composite

GIC: block out undercuts in the vertical walls (away from margins)

An amalgam coronal-radicular dowel and core technique for endodontically treated posterior teeth

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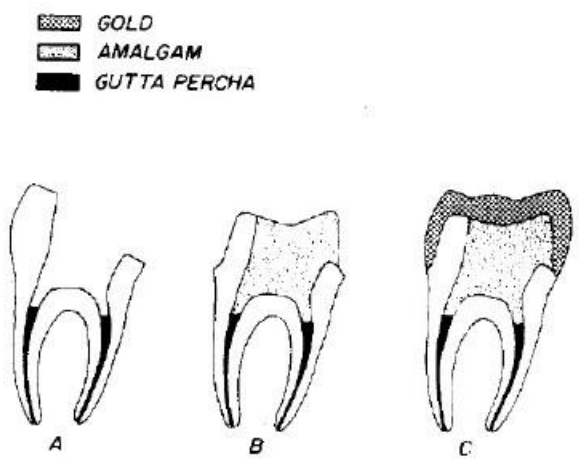

- The natural divergence of the canals and the undercuts in the pulp chamber provide extra retention to the core.
- Natural coronal structure is still necessary for resistance form and ferrule effect

TECHNIQUE

- Remove the GP from the pulp chamber and 2 to 4 mm from the canal
- Leave undercuts and divergence of canals
- Remove unsupported tooth structures
- Place matrix band
- Condense the amalgam into the cavity starting from the root canal
- Restore the tooth anatomy
- Next session, crown preparation

REFERENCES

THE UNIVERSITY OF WESTERN AUSTRALIA | Oral Health Centre of Western Australia

- Barnes, J., Patel, S. Contemporary endodontics – part 1. Br Dent J 211, 463–468
- Torabinejab and Walton. Endodontic Principles and Practice 4th ed.
- Sjbgren et al. Factors Affecting the Long-term Results of Endodontic Treatment. Journal Of Endodontics. 16 (10) 1990
- Rosenstiel et al. Contemporary Fixed Prosthodontics 4th ed
- Heifer et al. Determination of the moisture content of vital and pulpless teeth Oral Surg Oral Med Oral Pathol. 1972 Oct;34(4):661-70
- Papa et al Moisture content of vital vs endodontically treated teeth. Endod Dent Traumatol. 1994 Apr;10(2):91-3.
- Fusayama and Maeda. Effect of pulpectomy on dentin hardnessJ Dent Res. 1969
- Randow K, Glantz PO. On cantilever loading of vital and non-vital teeth. An experimental clinical study. Acta Odontol Scand 1986;44:271–7
- Lewinstein and Grajower Root dentin hardness of endodontically treated teeth JOURNAL OF ENDODONTICS I VOL 7, NO 9, SEPTEMBER 1981
- Huang et al. Effects of Mo. isture Content and Endodontic Treatment on Some Mechanical Properties of Human Dentin. Journal of Endodontics. 18(5), 1992.
- Sedgley et al. Are Endodontically Treated Teeth more Brittle? Journal of Endodontics 18(7),1992
- Gutmann The dentin-root complex: Anatomic and biologic considerations in restoring endodontically treated teeth. J PROSTHET DENT 1992;67:468-67
- Glossary of Prosthodontic Terms 4th ed
- Goodacre et al. The Prosthodontic Management of Endodontically Treated Teeth:A Literature Review.Part I. Success and Failure Data, Treatment Concepts. J Prosthod 1994;3:243-250.
- Tang et al. Identifying and Reducing Risks for Potential Fractures in Endodontically Treated Teeth. JOE — Volume 36, Number 4, April 2010
- Ko et al. Effects of post on dentin stress distribution in pulpless teeth J Prostret Dent 1992
- Juloski et al. Ferrule Effect: A Literature Review. Journal of Endodontics 38 (1)2012 (11-19)
- Akkayan B. An in vitro study evaluating the effect of ferrule length on fracture resistance of endodonti- cally treated teeth restored with fiber-reinforced and zirconia dowel systems. J Prosthet Dent 2004; 92: 155-162.
- Jotkowitz et al. Rethinking ferrule – a new approach to an old dilemma. British Dental Journal 2010; 209: 25–33
- Bryant et al. Modulus of elasticity in bending of composites and amalgams. Journal Of Prosthetic Dentistry 1986
- Ng et al Influence of remaining coronal tooth structure location on the fractureresistance of restored endodontically treated anterior teeth J Prosthet Dent 2006;95:290-6.
- Nayyar et al. An amalgam coronal-radicular dowel and core technique for endodontically treated posterior teeth JOURNAL OF PROSTHETIC DENTISTRY 1980