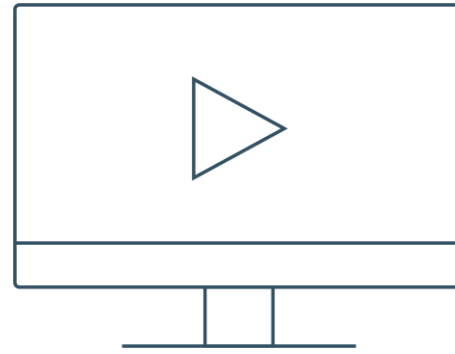


The Great Tooth Killer: Epidemic of Cracked Teeth, the Science of Strong Teeth



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lectures@bioclearmatrix.com

Step by Step Guide for
Injection Molded Class II

The Adjustable Push-Pull Instrument
for Ideal Contacts



EVOLVE MATRIX SYSTEM

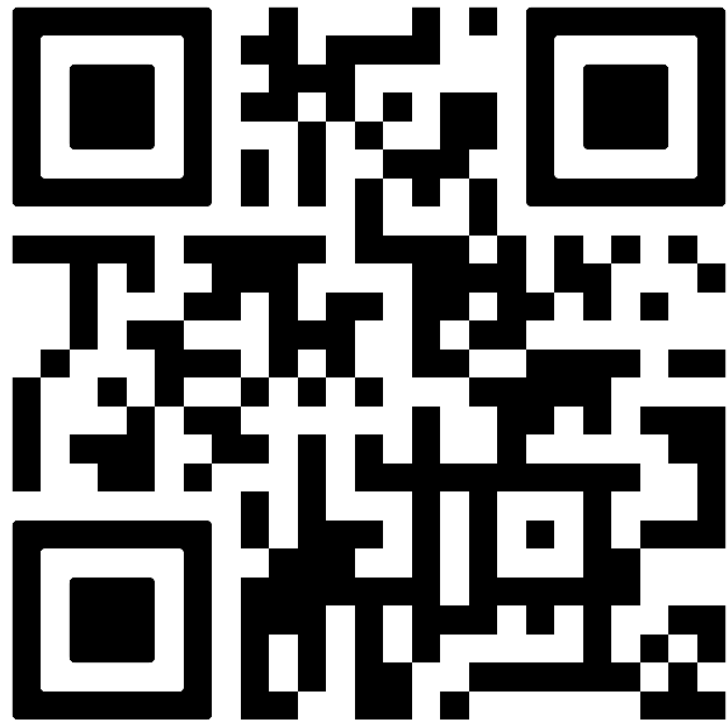
of Class II
Restorations

The Bioclear Direct Contact Strut

Creating Contacts for Diastemas, Peg Laterals, and Bioclear 360° Veneers

- PART 1 + PART 2 PREVIEW -

For a copy of today's presentation,
Learning Center info or the essential
Learning Center Library



Disclosures:
Dr. Clark has financial interest in Bioclear

A scenic photograph of a sunset over a calm body of water. The sky is filled with vibrant orange and yellow clouds, with the sun low on the horizon. A dark silhouette of a forest line runs across the middle ground, and its reflection is clearly visible in the still water below.

THE SCIENCE OF STRONG RESTORED TEETH



DR. DAVID CLARK



DR. ALEX FOK



Dr Alex Fok is a Mechanical Engineer with expertise in solid mechanics, structural analysis and mathematical modeling. He is currently the Academic Director of the Minnesota Dental Research Center for Biomaterials and Biomechanics (MDRCBB). The MDRCBB is an international leader in the development and application of novel characterization techniques for dental biomaterials, with long-standing collaboration with dental materials manufacturers. Dr Fok's research focuses on the development of techniques for material characterization, nondestructive examination, lifetime prediction and shape optimization of dental restorations. A principal aim of his research is to instill more engineering principles and analytical techniques into the design and assessment of dental restorations and treatments so as to improve their longevity and effectiveness.



DC BIOCLEAR LEARNING CENTER

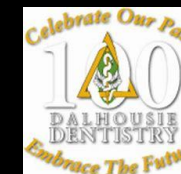
Tacoma USA · Solihull UK
Varberg Sweden · Cairo Egypt
Syracuse Italy · Taubate Brazil
Livermore CA (Bioclear for
pediatrics)



The **Bioclear Learning Center** provides a new pathway for dentists and their office to transition from traditional **GV Black dentistry**, to the extraordinary world of **modern direct dentistry**.



Dental schools/GPR integrating the Bioclear Method



In this case-based lecture
today we explore:

- Coronal (vertical and cuspal)
Fracturing
- Snap-Off Fracturing

A close-up clinical photograph of a tooth with a snap-off fracture. The fracture is a transverse break in the enamel and dentin, exposing the pulp chamber. The pulp chamber is filled with a dark, necrotic material, likely a cast resin core. The surrounding gingiva is pink and appears slightly inflamed. The text "Snap-Off Fracturing" is overlaid in a blue font on a dark grey background.

Snap-Off Fracturing

Today's Summary

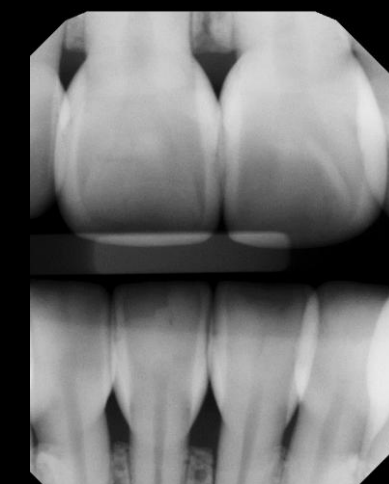
- Why things break...
- Modern cavity preparations
- Injection Overmolding as a 3rd option
- FEA of loading of teeth & composite
- Long term outcomes & case studies of composite overlays for cracked teeth
- When to endo, when to extract.

Modern Approach to Composite Restorations

Posterior
Restoration



Black Triangle





The Epidemic of Cracked and Fracturing Teeth



Dr. David Clark, DMD

Teeth are fracturing faster in dental practices. Cracked and fractured teeth are now the third leading cause of tooth loss in industrialized nations.¹ Fractured teeth with conservative analgesic and antibiotic use, sealing, and being crown, crown fracture off at three levels. Fractured teeth treated with veneers, crowns, or fracture off at three levels. Additionally, endodontics are reporting that cracked teeth are now replacing crown teeth for restorative therapy in a number of patients referred for endodontic treatment.

We assume that the reason of this period and growing problem are not so obvious. Longer life span, stress levels are rising, and chewing and bruxism are also more prevalent. It is the advent of the high-speed handpieces, powered billions of horsepower (1/2 HP), every preparation that have work and powder teeth (Figure 2) and the deep etching preparations in the case of porcelain crowns, and yet aggressive "crown-down" endodontic changes in dentals, new metal teeth.

Dentistry has great capacity for healing, is a poorly understood process. A dramatic change in the form of continuing dental education, based on science, dentistry, branding, and logistics has shifted our attention away from some of the most integral aspects of the healing art of dentistry, oral health, top that. But, we now find our profession faced with a tremendous problem that will require a significant reevaluation and reevaluation of



Figure 2. In an anterior right, and buccal view of a maxillary C19, the preparation, and how the tooth is cracked. The crack is visible in the buccal view, and the other cracked buccal view of an anterior showing immediate therapy.

means to address appropriately. There is no need to assess. Many, to start simply will require diagnosis and part to work.

BRINGING DIAGNOSIS AND PREVENTION OUT OF THE ROOM

Microscopic and operator-driven diagnosis have been the accepted modalities for the diagnosis of cracked teeth. The following list

of signs of the lack of visual confirmation create therapies that education can take to the treatment process. One looking first appearance of cracks through the clear coverage is the staggering array of cracks that come within such structures (Figure 3). Traditional visual exam (visual or biopsy) limits the clinician's ability to assess the pro-

cedure or age of

Table 1. How Can We Eliminate Teeth Fracturing?

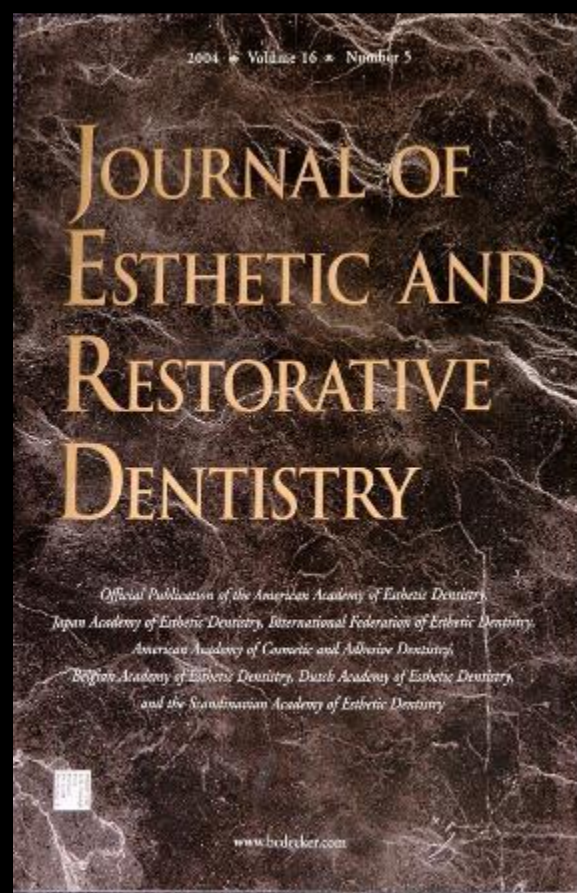
Phase 1:	Phase 2:	Phase 3:	Phase 4:	Phase 5:
Diagnose the crack or fracture in the crown, root, or abutment teeth.	Recognize if or not early preparation or preparation teeth.	Recognize if or not early preparation or preparation teeth.	Recognize if or not early preparation or preparation teeth.	Recognize if or not early preparation or preparation teeth.
Diagnose the crack or fracture in the crown, root, or abutment teeth.	Recognize if or not early preparation or preparation teeth.	Recognize if or not early preparation or preparation teeth.	Recognize if or not early preparation or preparation teeth.	Recognize if or not early preparation or preparation teeth.
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Table 2. Quick Reference Guide for Microscopic Cracks in Posterior Teeth.

1. Most teeth in aging adults display enamel cracks.
2. Cracked teeth, even traumatic cracks, do not necessarily indicate that the tooth is cracked.
3. Only enamel cracks do not penetrate significantly (70-80%).
4. Only enamel cracks that do not penetrate significantly (70-80%).
5. Three types of underlying pathology will produce enamel cracks:
 - Dental cracks, decay, and subnormal enamel (not contributing to microleakage enamel's resistance).
6. Dentinal cracks should be considered as structural cracks.
7. Dentinal cracks do not vary into 2 types: in vertical, generally positioned in the middle of the pulpal floor, are "horizontal" and 2) often generally positioned at the gingival-cervical junction, are "vertical" (Figure 4).
8. Many teeth exhibit both types of dentinal cracks (right maxillary premolar crown preparation). Regional stabilization will be required before any restorative and treatment. All teeth with dentinal cracks should be considered as structurally unsound.

Reevaluation/Prevention Plan for:

1. Microscopic cracks in restorative materials can indicate a lack of correct structural integrity.
2. Evaluation of distribution of a cast-in crown or inlay or a lack of structural integrity.
3. Unusual or unusual spacing between or unusual restoration and tooth structure can indicate a lack of structural integrity.



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 American Academy of Cosmetic and Adhesive Dentistry,
 Belgium Academy of Esthetic Dentistry, Dutch Academy of Esthetic Dentistry,
 and the Scandinavian Academy of Esthetic Dentistry

www.bndraker.com

Prognostic Diagnosis of Early Enamel and Dentinal Cracks Based on Microscopic Evaluation

DAVID J. CLARK, DMD,
 CHELSEY G. SHEETS, DDS,
 JACINTHE M. BAQUETTE, DMD

Microscopic diagnosis of cracked teeth and incomplete coronal fractures have historically been performed with the dental operating microscope at x16 magnification can fundamentally change a clinician's ability to diagnose such conditions.

There have been observations of cracks under extreme magnification for nearly a decade. Patients come to the dentist with no symptoms or discomfort in fractured teeth. Conversely, many cracks are not structural and can lead to misdiagnosis and treatment. Methodically microscopic examination, an understanding of crack progression, and appreciation of the types of cracks will guide a doctor to making appropriate decisions.

Teeth can have structural cracks in various stages. To date, diagnosis and treatment are very often at an end stage of crack development.

CLINICAL SIGNIFICANCE

This article gives new guidelines for recognition, visualization, classification, and treatment of cracked teeth based on the realistic use of x16 magnification. The significance of enamel cracks as they relate to dentinal cracks is detailed.

(J Esthet Restor Dent 15:XXX-XXX, 2003)

Microscopic and symptom-driven diagnoses have been the accepted modalities for cracked teeth. The inherent limitations of the lack of visual confirmation mask it therapies that often come too late in the treatment process. One lacking first impression of vision through a clinical microscope is the staggering array of cracks that exist within tooth structures. Traditional visualization is limited

or ocular (visual) limits the clinician's ability to assess the presence or severity of the majority of these cracks (Figure 1).

At extreme magnification levels (x14 and greater), the translucent nature of enamel yields a wealth of information. Subtle color changes within the enamel may indicate early decay, microleakage, and a lack of structural integrity of dentin and

enamel. Being able to see previously invisible cracks can lead to earlier diagnosis to more appropriate early treatment of compromised teeth before devastating fractures, pulpal involvement, and periodontal breakdown occur. The value of early diagnosis of the structural breakdown of teeth will become even more significant with our aging population coupled with increased tooth retention in this population.

Dr. Clark is President, Academy of Microscopic Esthetic Dentistry, University of Southern California, Los Angeles, CA, clinical professor, Restorative Dentistry, USC School of Dentistry, Los Angeles, CA, USA.
 Dr. Sheets is Professor, American Academy of Esthetic Dentistry, Los Angeles, CA, USA.
 Dr. Baquette is Professor, American Academy of Esthetic Dentistry, Los Angeles, CA, USA.

Epidemic of Cracked Teeth



Glossary

- Bending
Mode of loading that creates curvature, resulting in tension on one side and compression on the other
- Compression
Squeezing of an element
- Hooke's law
This is obeyed when the strain of a material is proportional to the stress applied
- Shear
Force or displacement that results in an angular change in shape of an element
- Spring
Most fundamental structural element in solid mechanics
- Strain
Displacement per unit length
- Strength
Maximum stress required to cause fracture or debonding
- Stress
Force per unit area
- Stress concentrator
A structural feature that results in raised stresses within a small region
- Structural analysis or design triangle
Material, geometry and load
- Tension
Stretching of an element
- Toughness
Energy required to create unit surface area
- Shape Optimization
- Modulus
- Brittle Materials vs. Ductile and Tough Materials
- Surface Resilience
- Cyclic Fatigue

Case Study “Joe”: Contralateral bicuspids fracture nine years apart

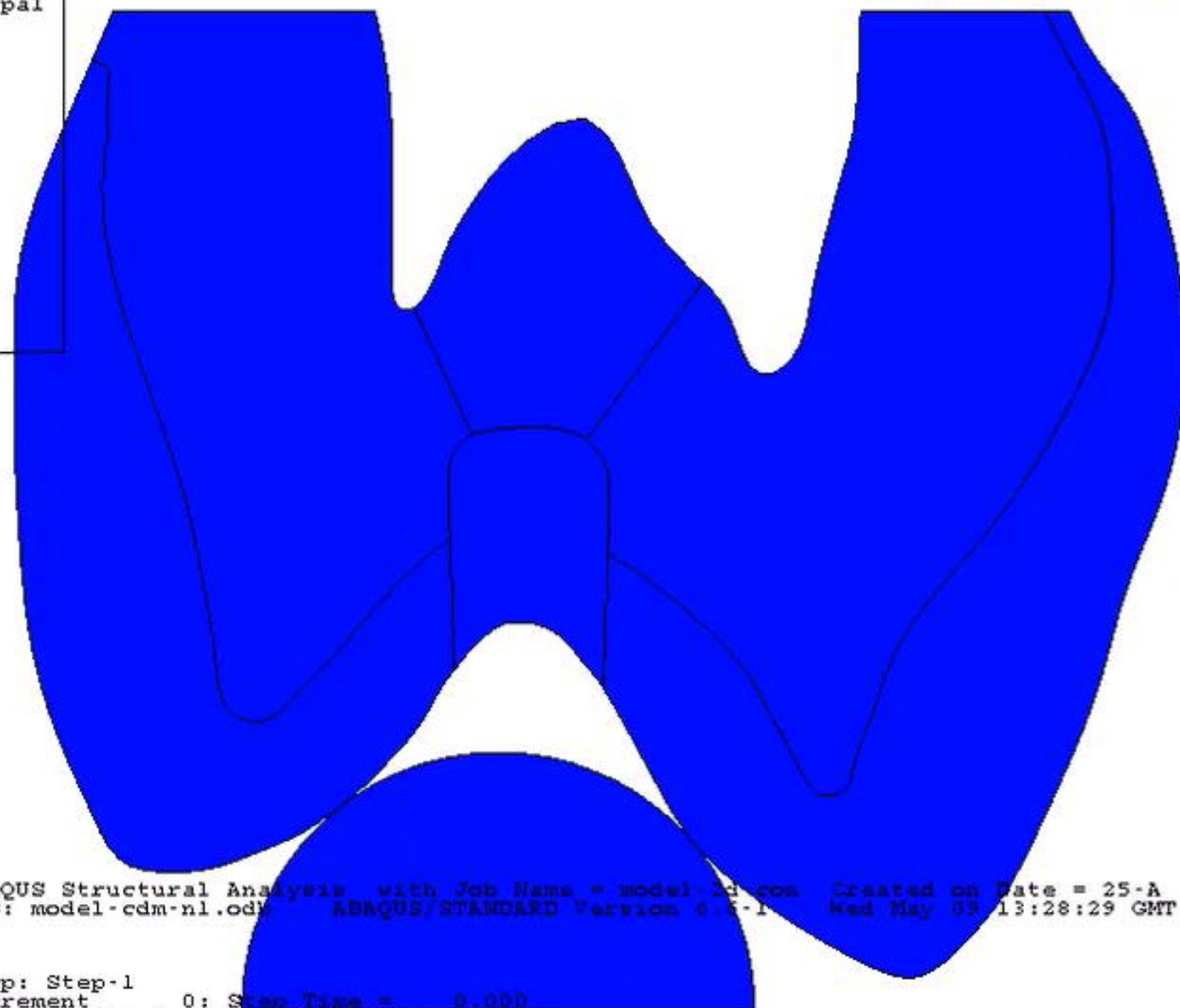
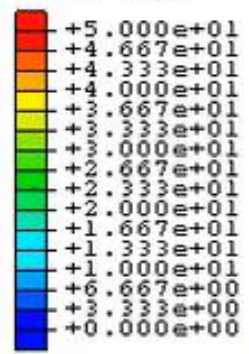
2012: Catastrophic fracture tooth #12. Endo
tooth w/ traditional Class II Resin Restoration



2021: Catastrophic fracture tooth #5. Virgin
Tooth



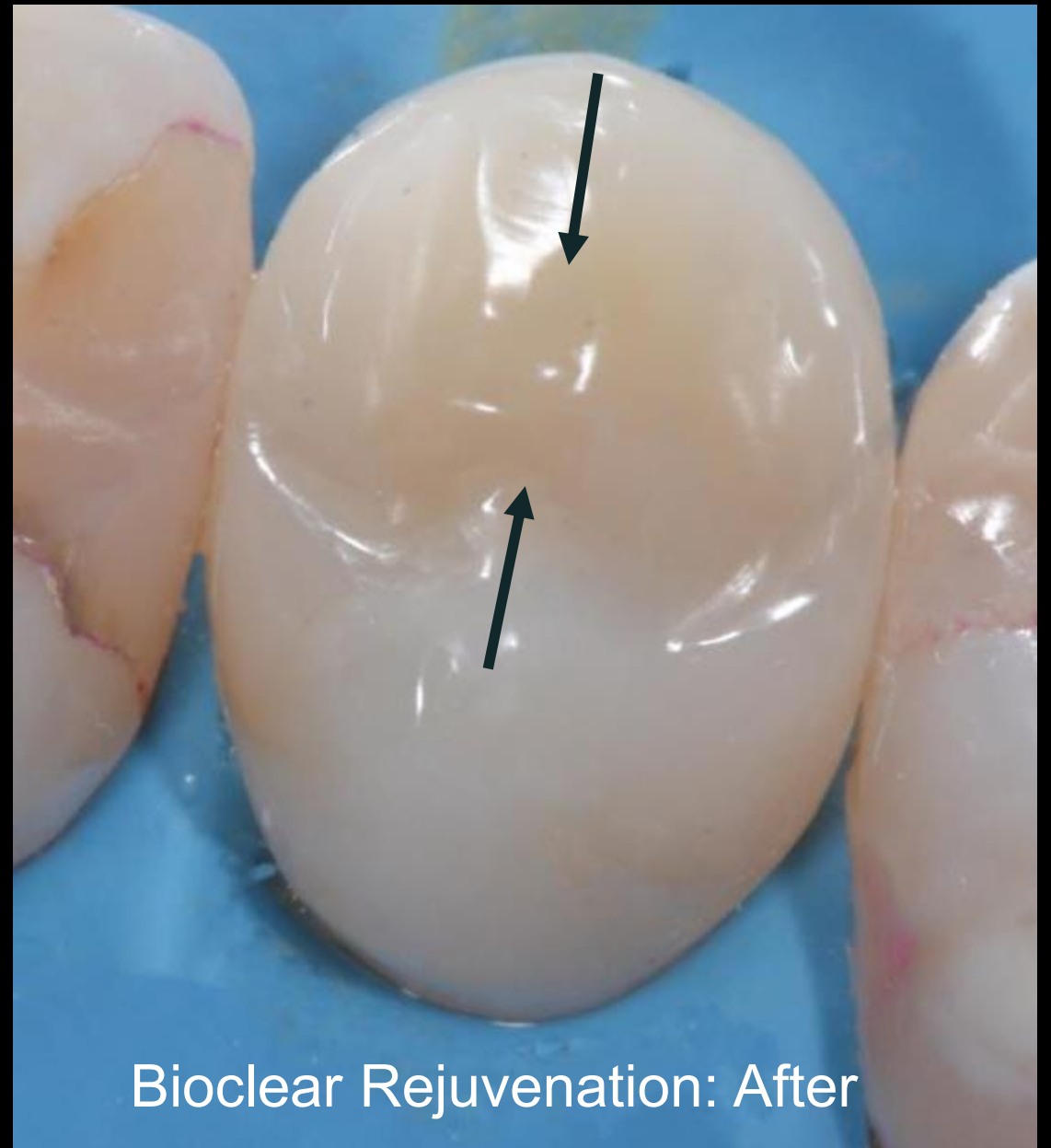
S, Max. Principal
(Avg: 75%)



2
3

ABAQUS Structural Analysis with Job Name = model-cdm-nl.odb Created on Date = 25-A
ABAQUS/STANDARD Version 6.5-1 Wed May 03 13:28:29 GMT Daylight

Step: Step-1
Increment 0: Step Time = 0.000
Primary Var: S, Max. Principal
Deformed Var: U Deformation Scale Factor: +1.000e+01



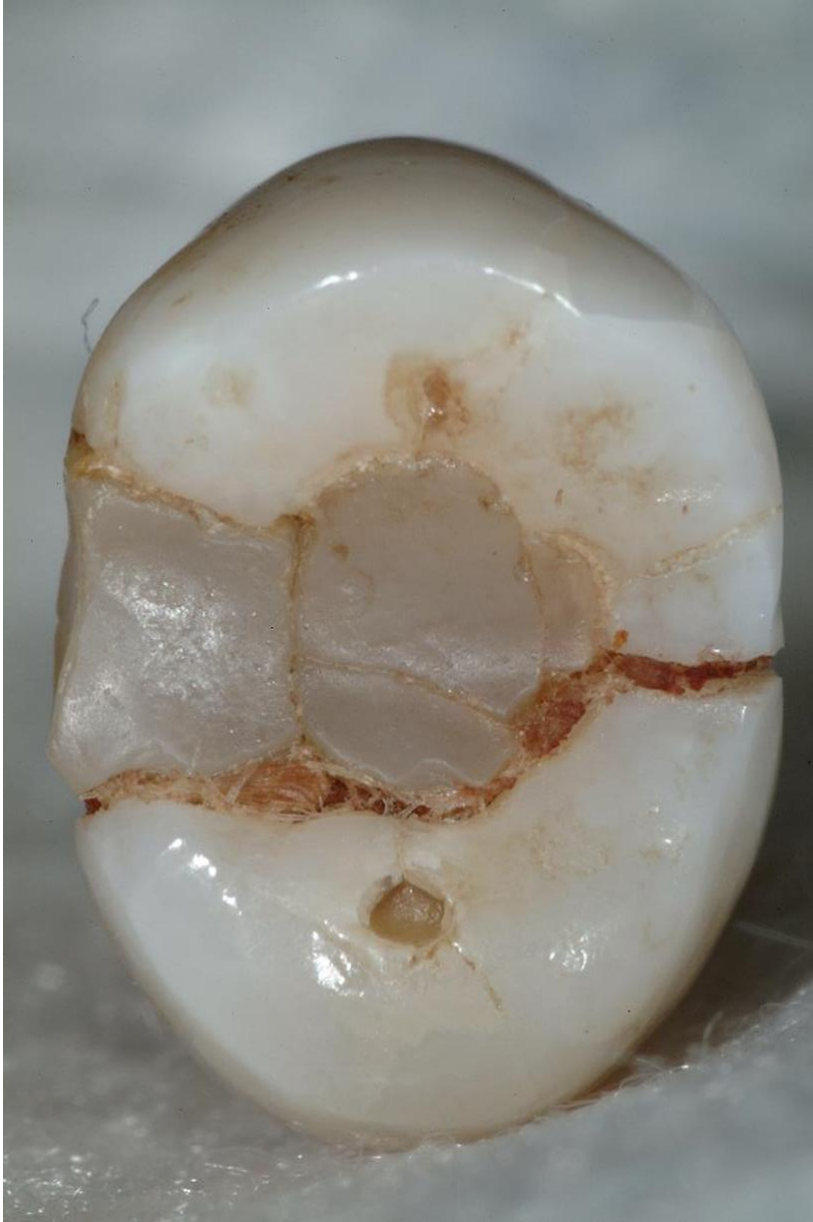
Courtesy Dr. Charlie Regalado

Case Study 1 “Joe”: Contrateral bicuspids fracture nine years apart

2012: Catastrophic
fracture tooth #12.
Endo tooth w/
traditional Class II
Resin Restoration



Case Study Joe bilateral bicuspid fractures



2005: Catastrophic fracture tooth #12. Endo tooth w/ traditional Class II Resin Restoration



Case Study Joe bilateral bicuspid fractures

2021: Catastrophic fracture of #5. Virgin Tooth



Case Study Joe bilateral bicuspid fractures

2021: Catastrophic fracture #12. Virgin Tooth



Case Study “Joe”: Discussion

2012: Catastrophic fracture tooth #12. Endo tooth w/ traditional Class II Resin Restoration



2021: Catastrophic fracture tooth #4. Virgin Tooth



Case Study “Sue”: Traditional Parallel Walled Cavity Preparation (PWCP) 10 years post operative

2021: Asymptomatic tooth at New Patient Examination

When the tooth fractures: Crack initiates at the central groove of composite or at interfacial bond.



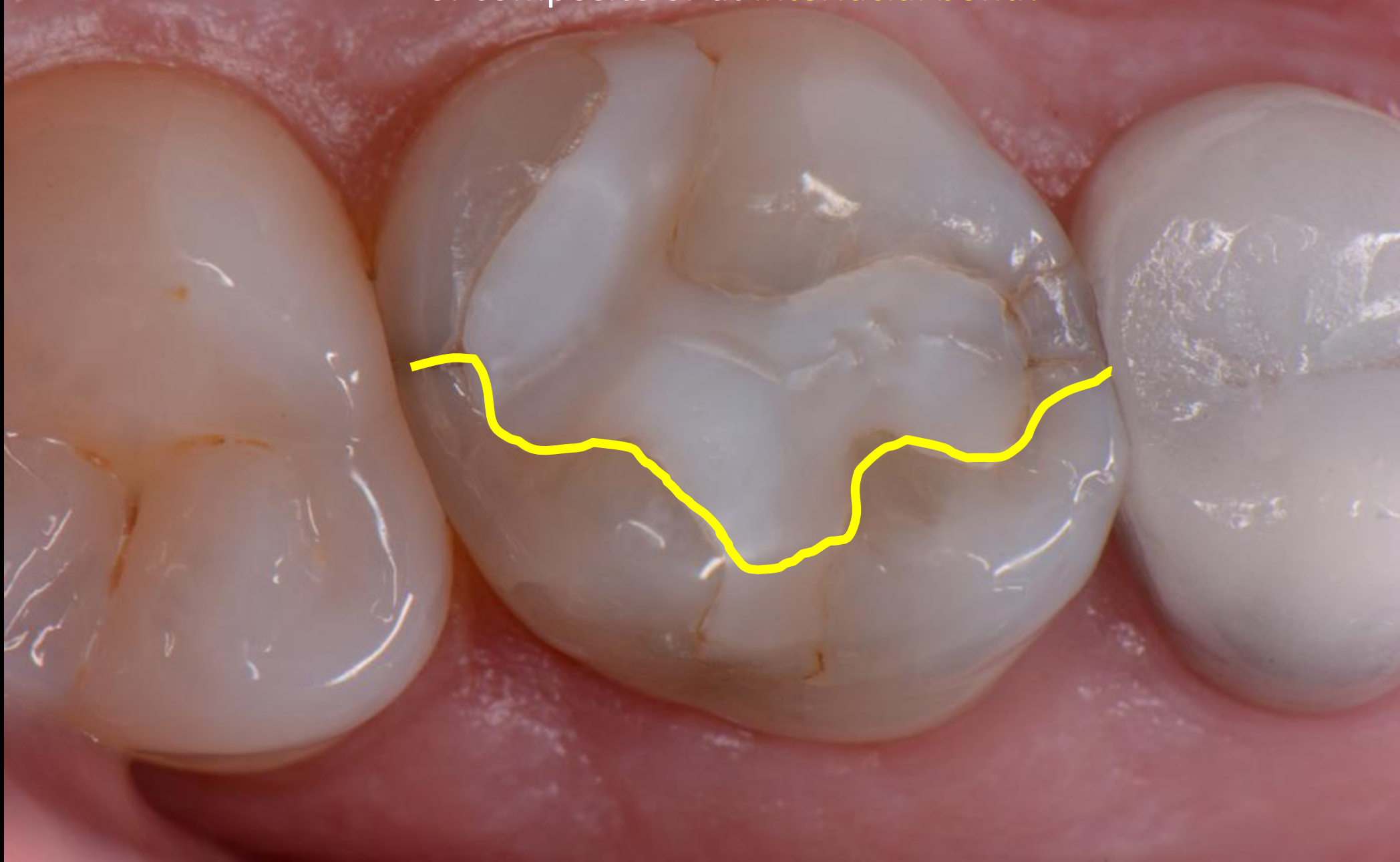
When the tooth fractures: Crack initiates through the central groove of composite or at interfacial bond?



When tooth fractures: Crack initiates through the **central groove of composite** or at interfacial bond?



When the tooth fractures: Crack initiates through the central groove of composite or at **interfacial bond**?



When the tooth fractures: Crack initiates through the central groove of composite or at **interfacial bond**?





Studies Supporting the Bioclear Method

Complete

- Comparing Conventional to Saucer-Shaped Cavity Designs

Dr. Alex Fok, BEng, PhD, MSc

Dr. Hooi Pin Chew, BDS, PhD, FDSRCS

MN Dental Research Center for Biomaterials and Biomechanics

- Comparison of Class II Adaptation and Placement Times

Dr. Richard Price, BDS, DDS, MS, FDS RCS, FRCD(C), PhD

Dept. of Clinical Dental Sciences & Biomedical Engineering Dalhousie University

- Effect of Preheating/Fatiguing/Thermocycling on Mechanical Properties

Taiseer A. Sulaiman, DDS, PhD

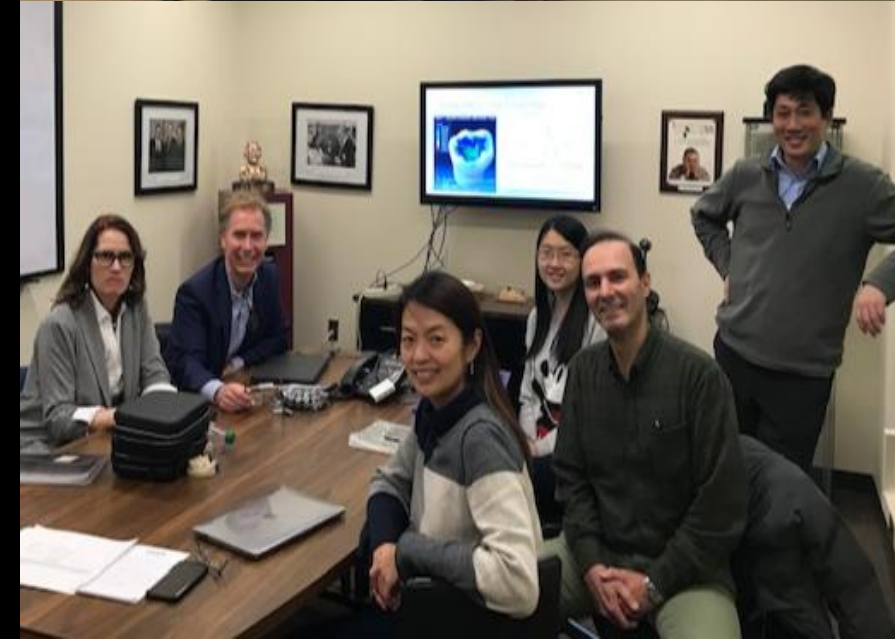
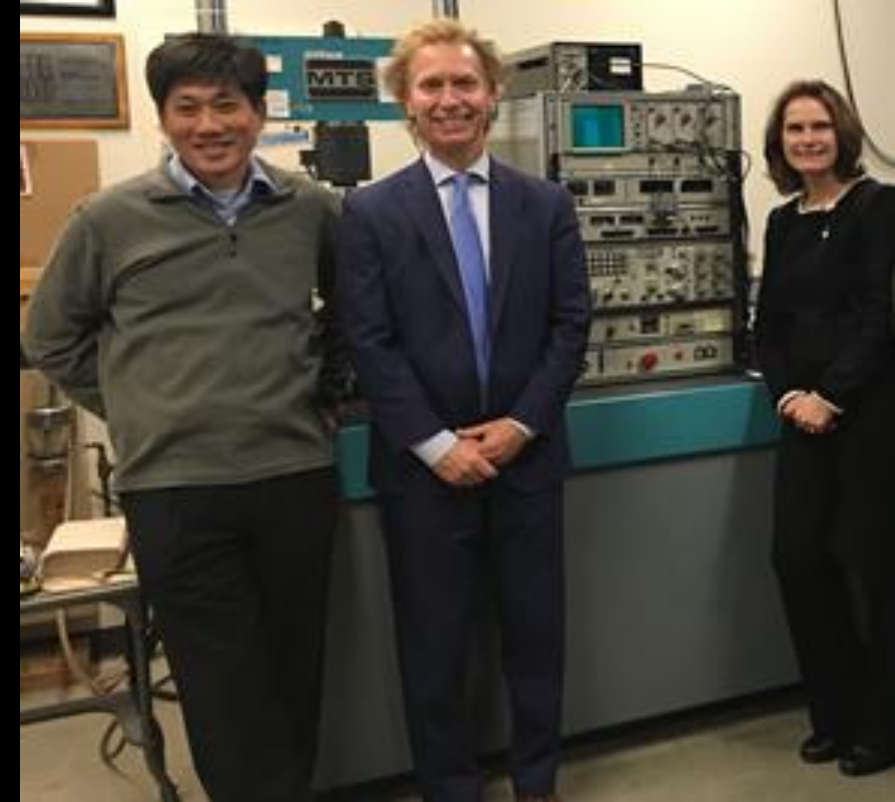
Assistant professor, Division Director of Operative Dentistry and Biomaterials, UNC School of Dentistry

- 3M Extraction and Pulp Temperature Testing

Brad Bagley, PhD, DABT Advanced Toxicology Specialist

- 3M Material Property Testing Including Injection Molding

Timothy D. Dunbar, Ph.D. Advanced Product Development Specialist



In Process

- Biofilm Adhesion Study

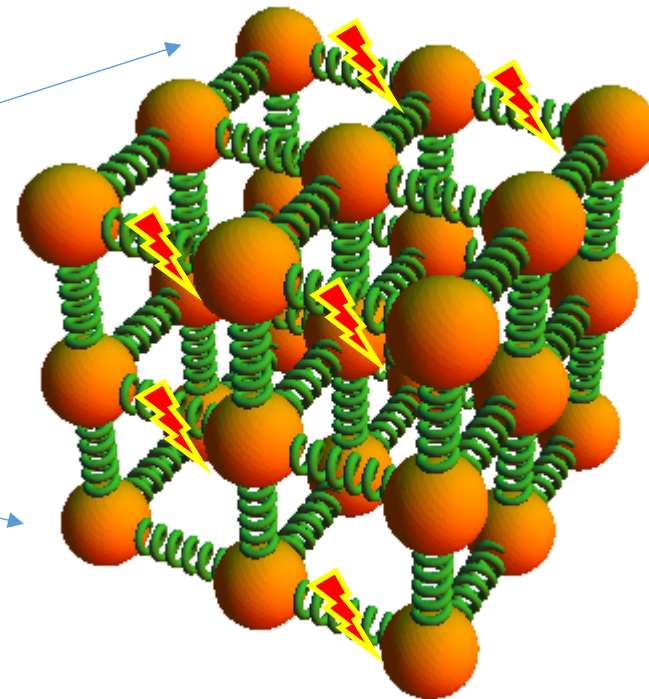
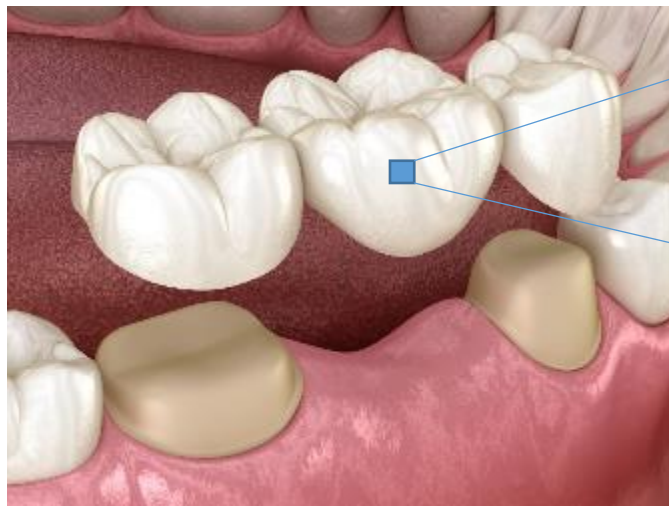
Sabrina F. Sochacki, DDS, MS, PhD

Indiana University School of Dentistry

Basics of Solid Mechanics

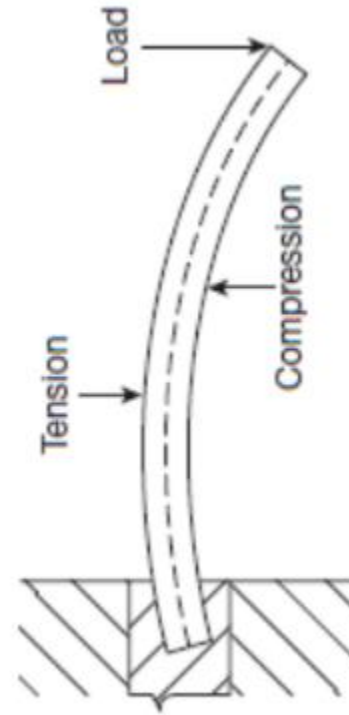
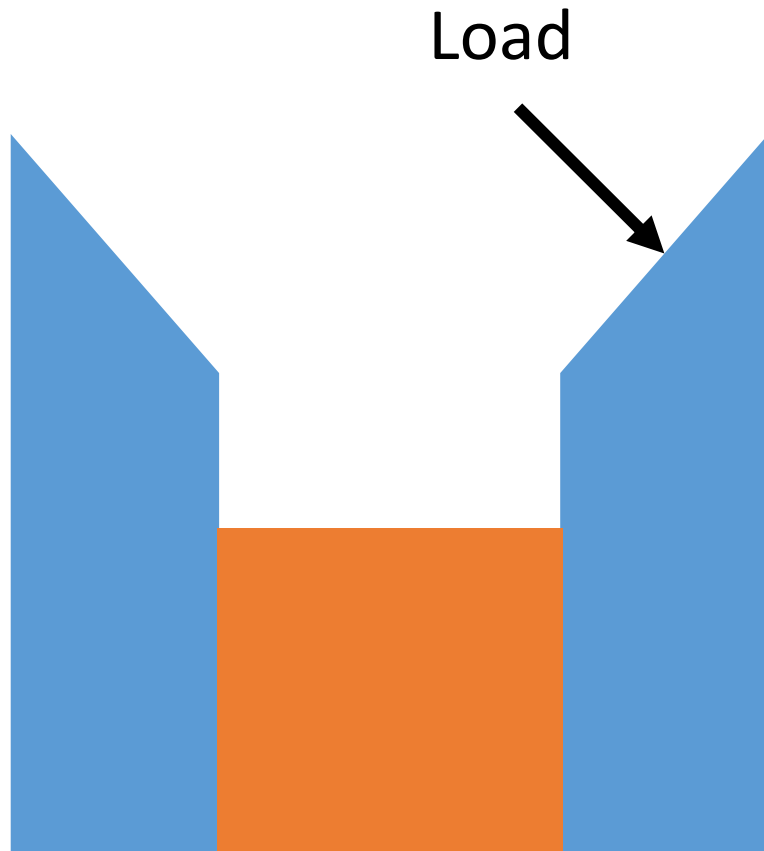


All solid structures can be considered as an assembly of many interconnected springs.



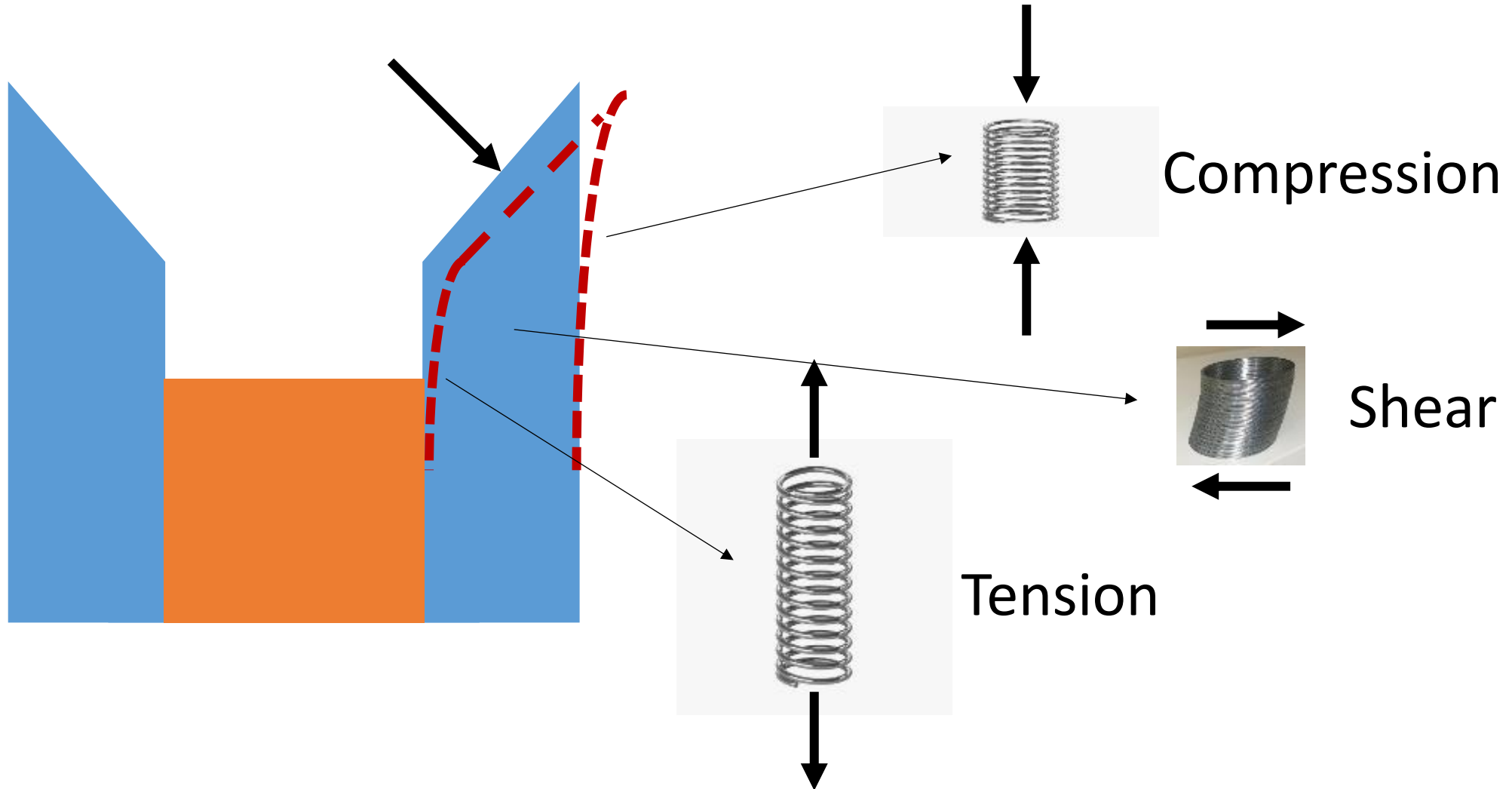


Prepared tooth under load – structural deformation

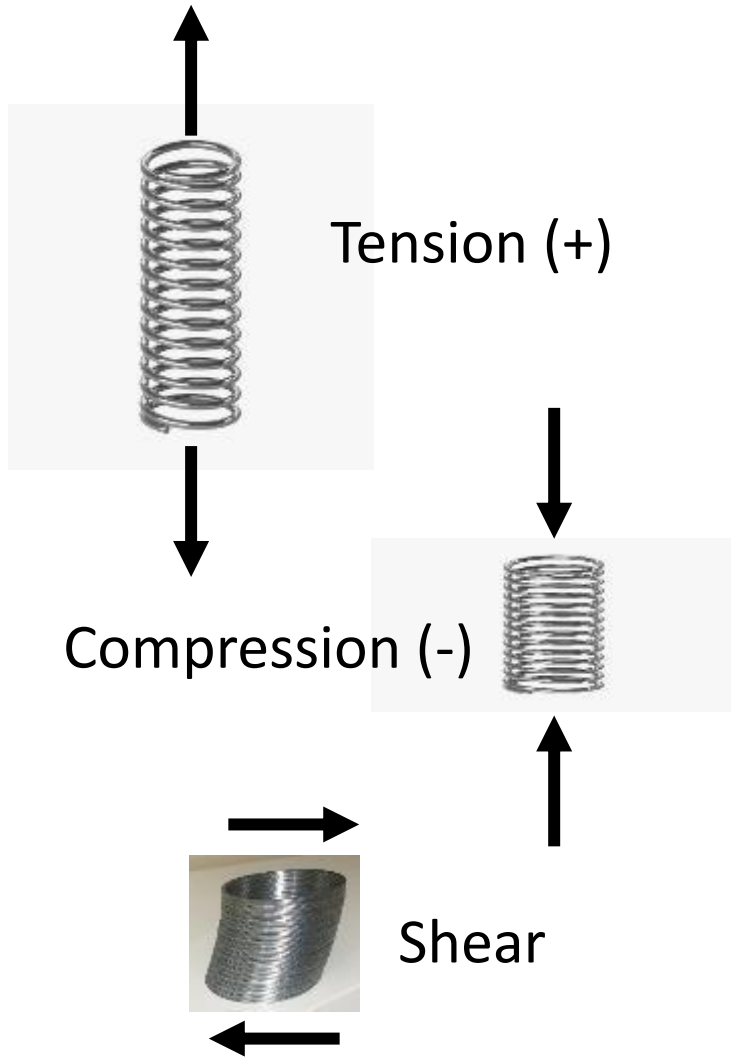


Cavity wall is under cantilever bending

Prepared tooth under load – elemental deformation



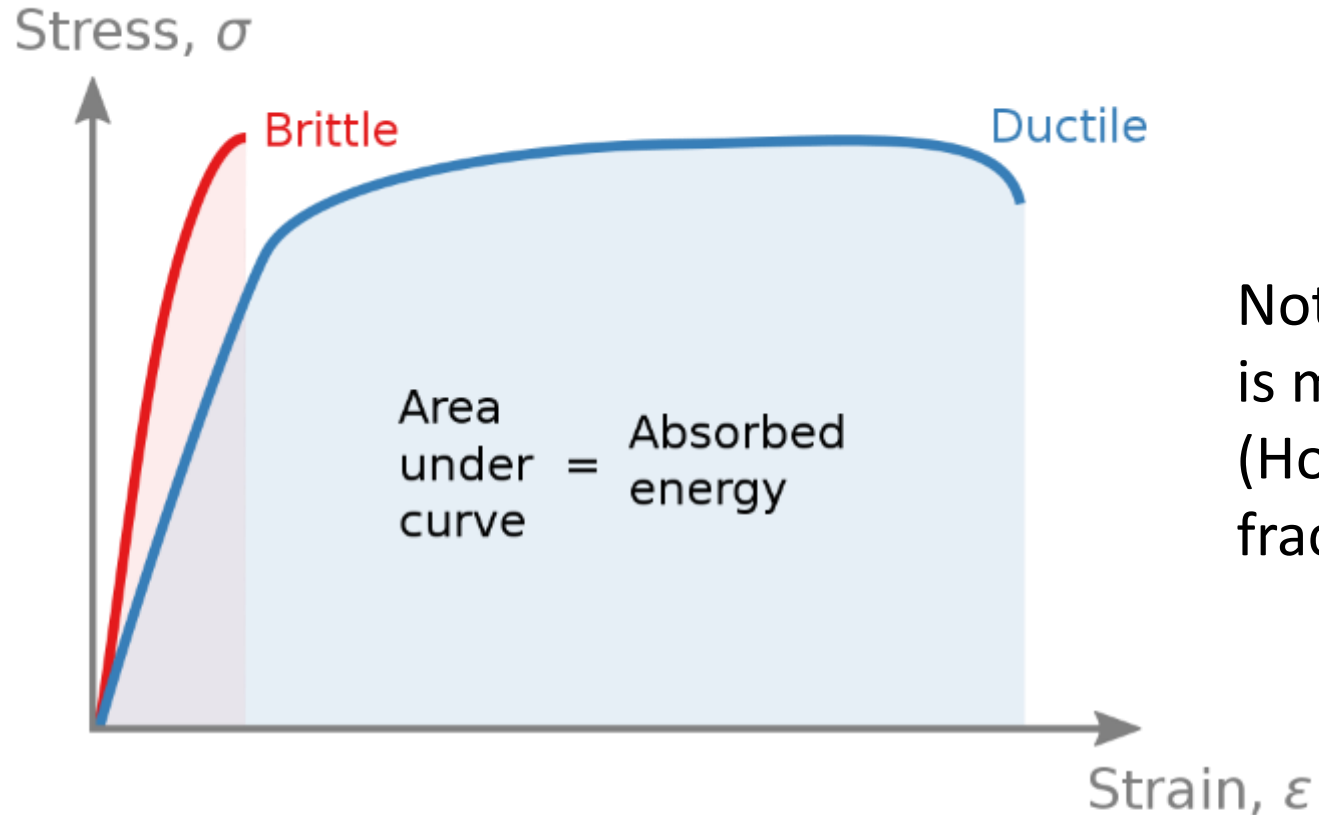
Stresses and Strains



Stress is force (F) per unit area (A) = $\frac{F}{A}$

Strain is displacement (δ) per unit length (L) = $\frac{\delta}{L}$

Stress-strain curves



Note that, for brittle materials, stress is more or less proportional to strain (Hooke's law) right up to the point of fracture.



Brittle materials are stronger in compression/shear than in tension

The stones in an arch bridge are under compression.

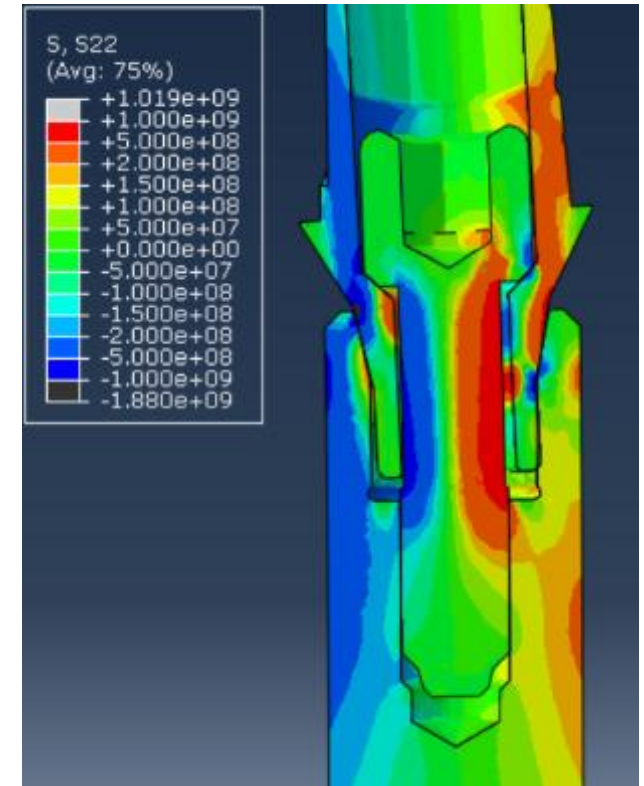
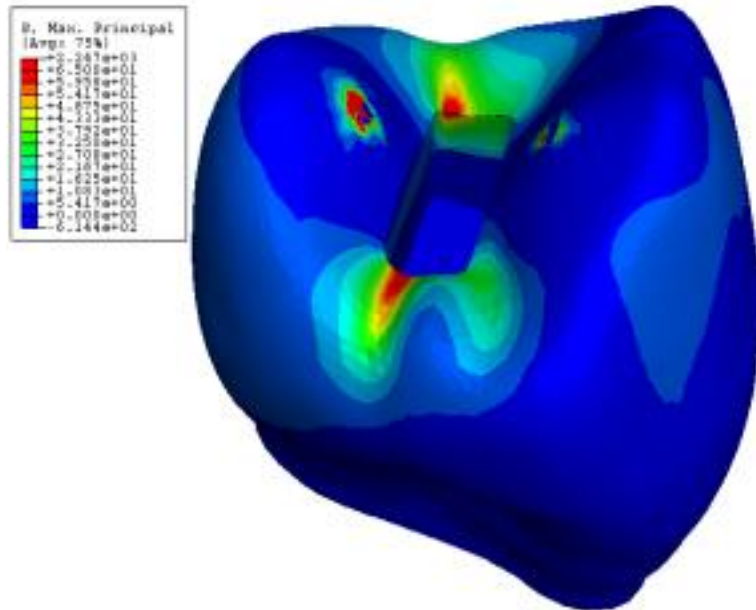


It is easier to lift a carpet (tension) than to pull it along the floor (shear).

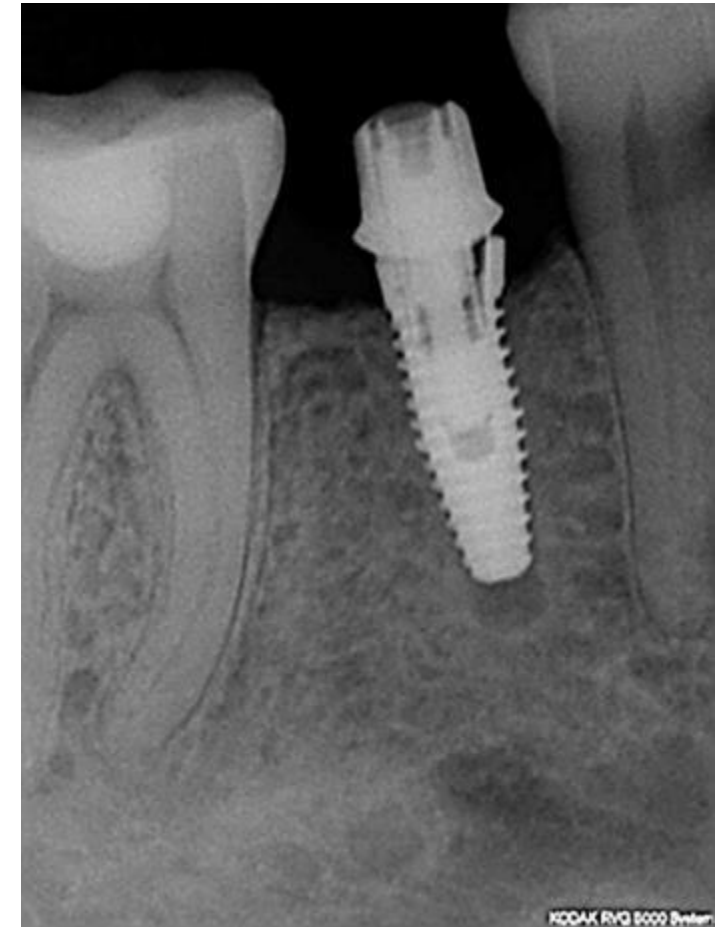
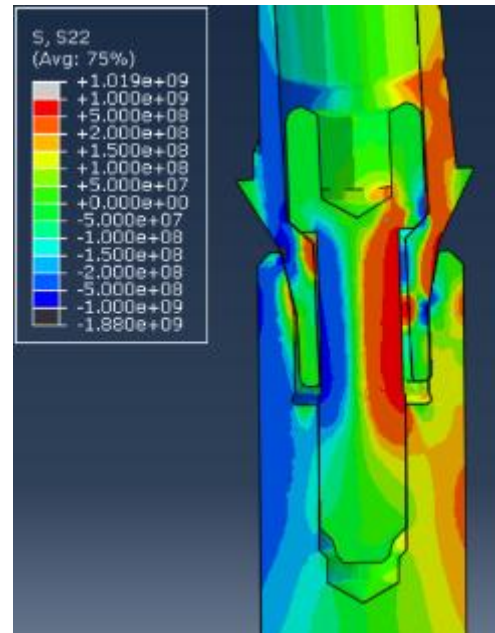
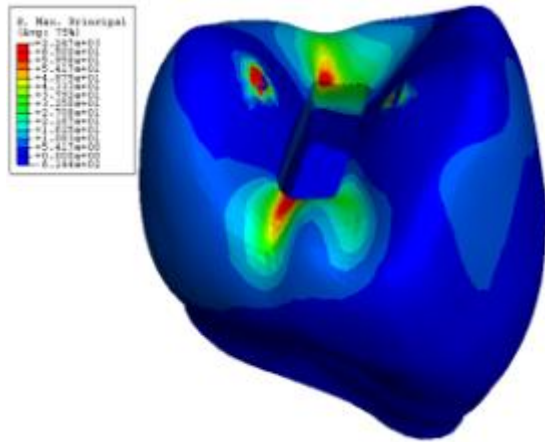
Stress/strain concentration

This occurs at

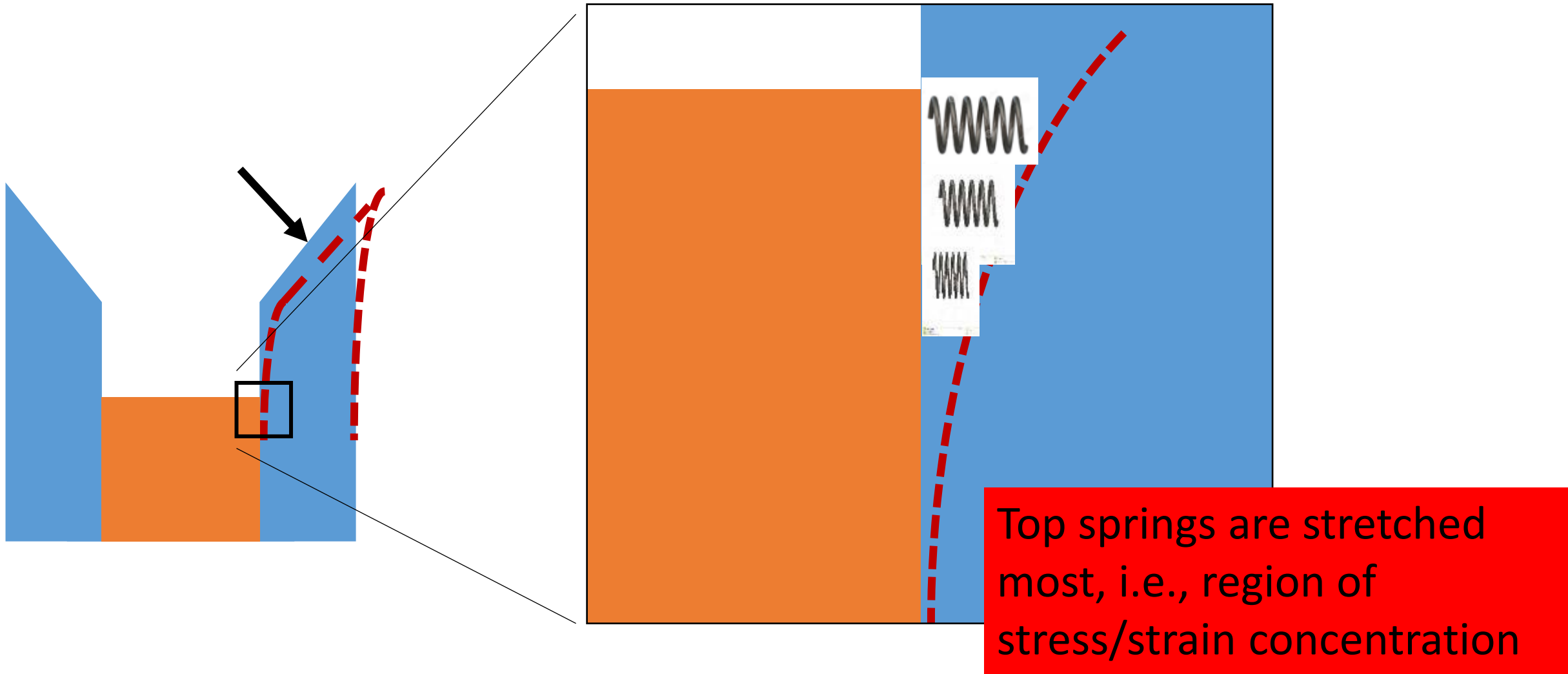
- Abrupt changes in geometry
- Mismatches in mechanical properties
- Concentrated loads



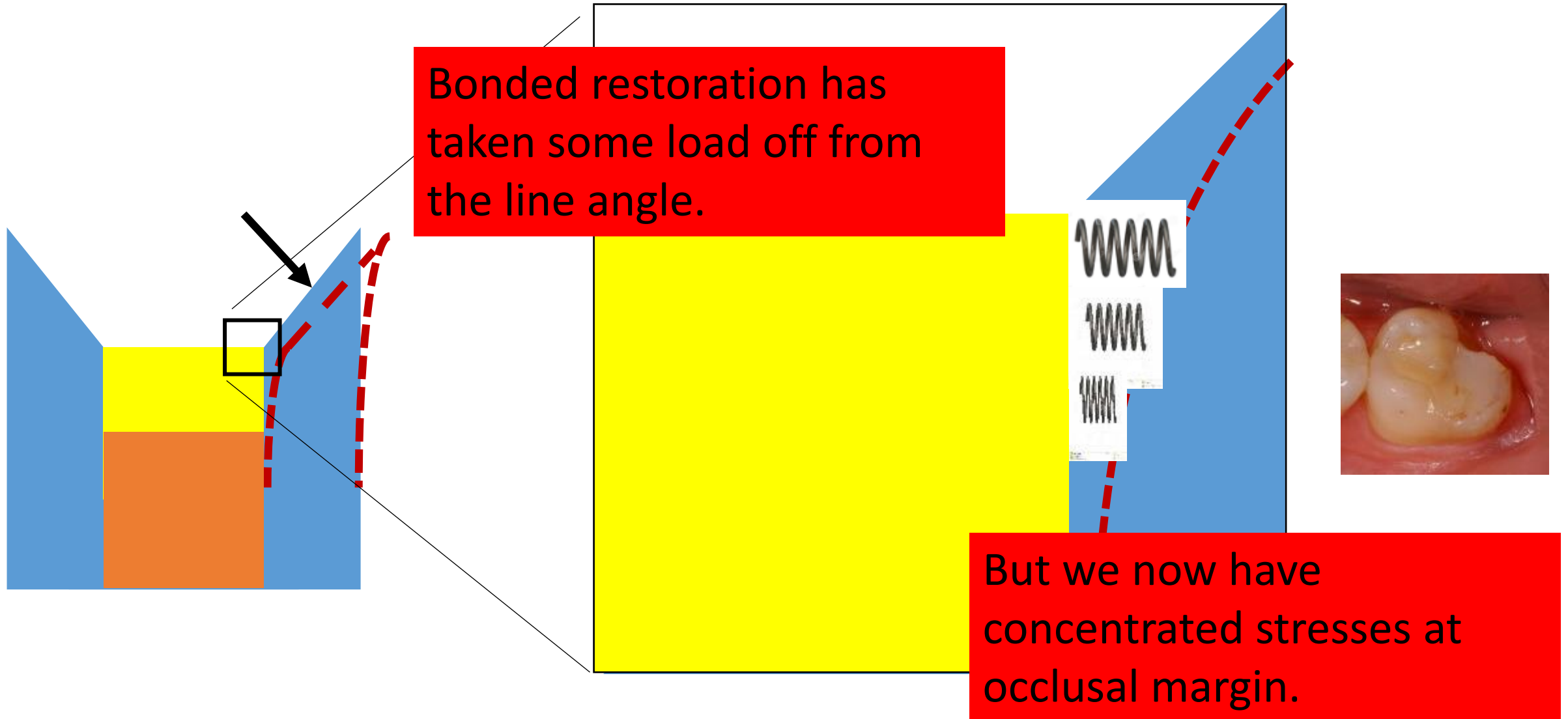
Regions of stress concentration are often origins of failure



Stress/strain concentration – line angle

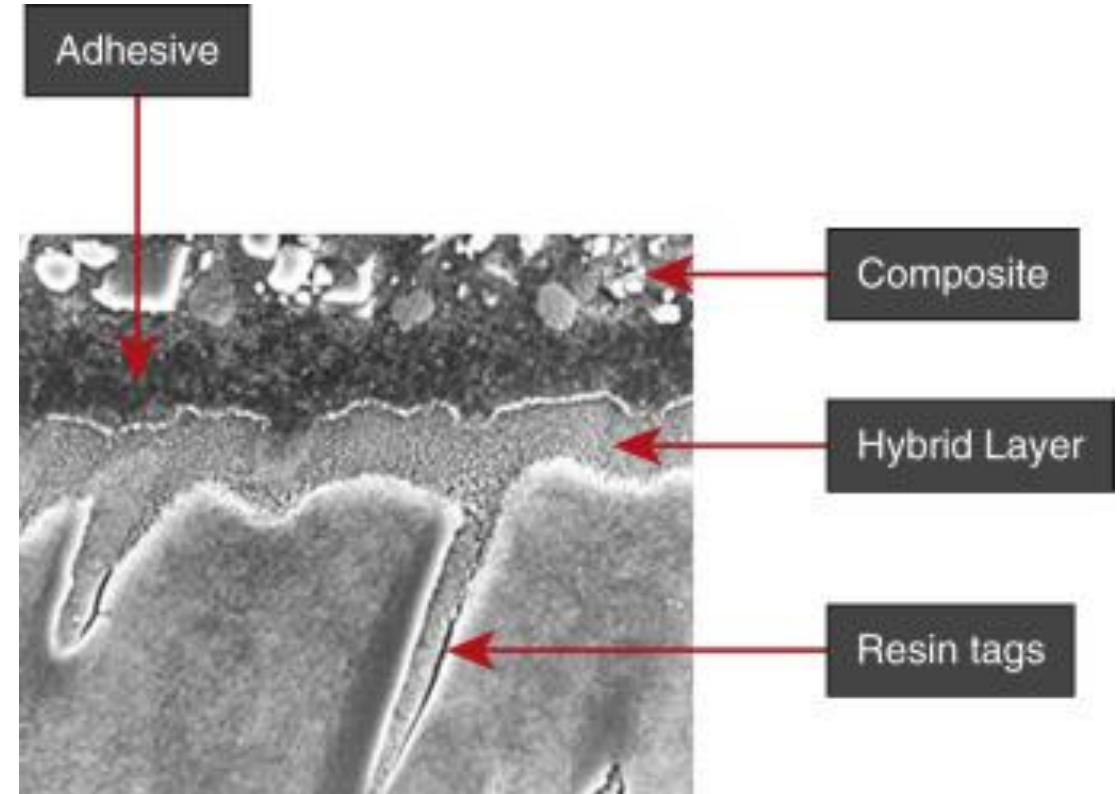
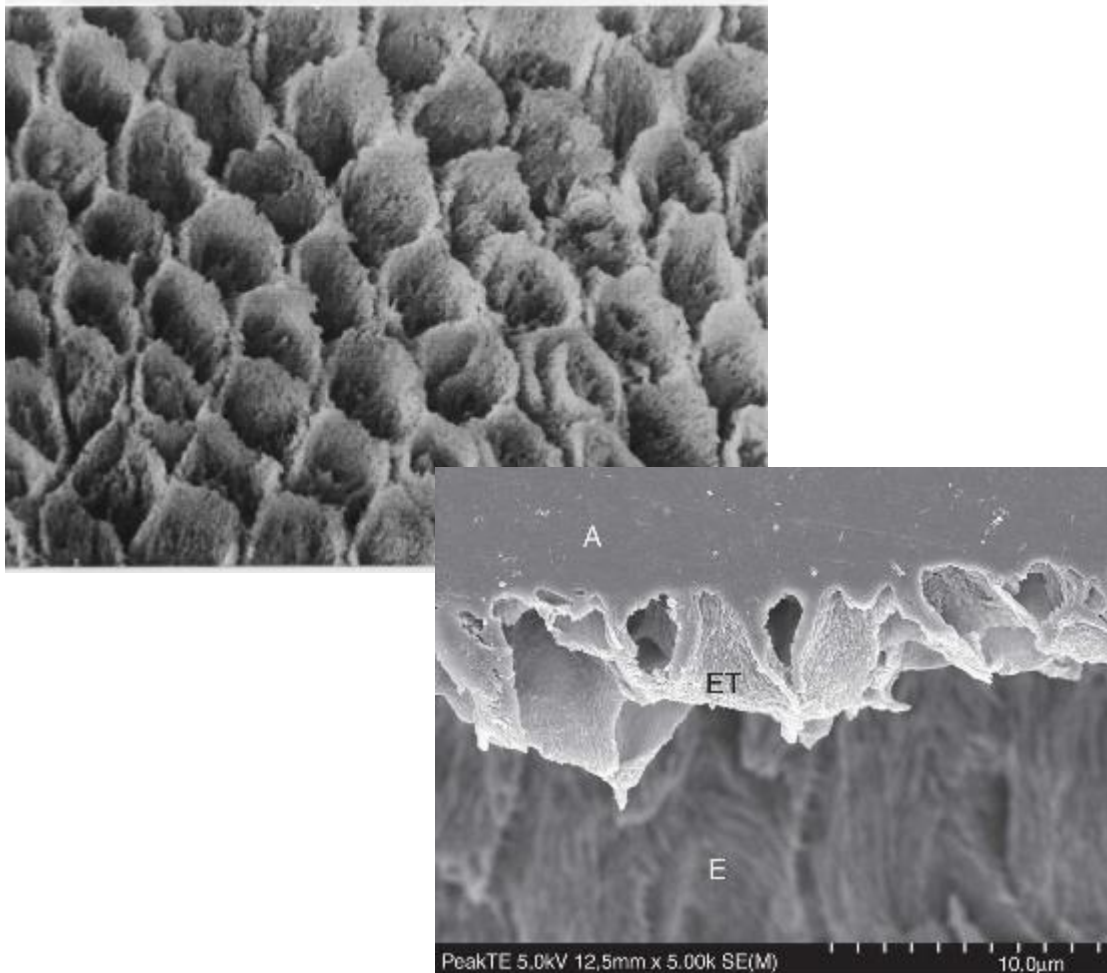


Stress/strain concentration – occlusal margin



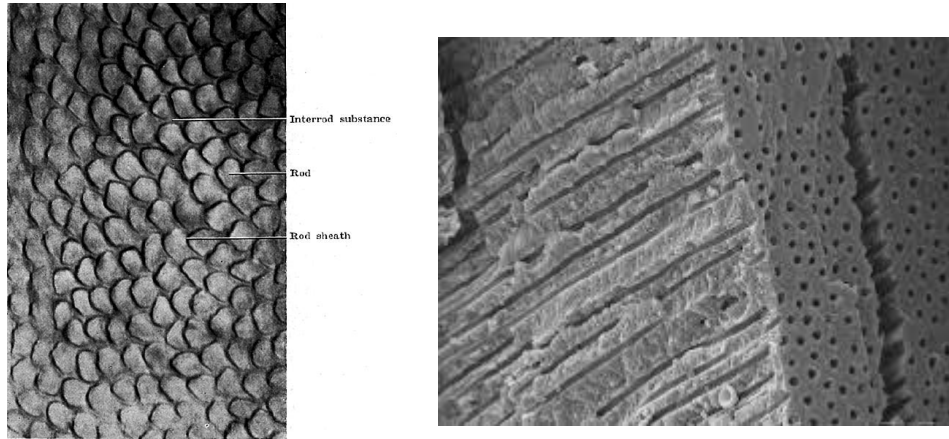
Enamel vs. Dentin Bonding

Bonding to enamel is mostly micromechanical.

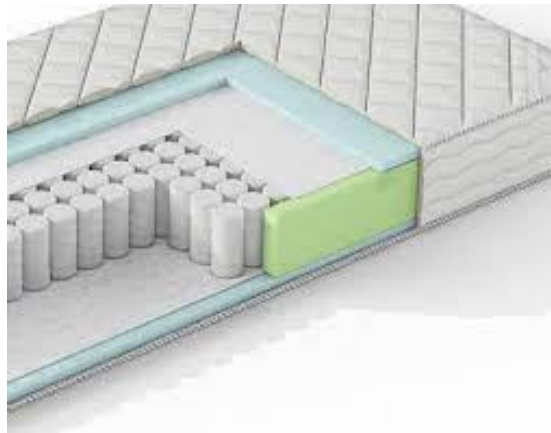


Bonding to dentin is more complicated, involving a hybrid layer and exposed collagen that are prone to enzymatic attack.

Anisotropy : tooth tissues

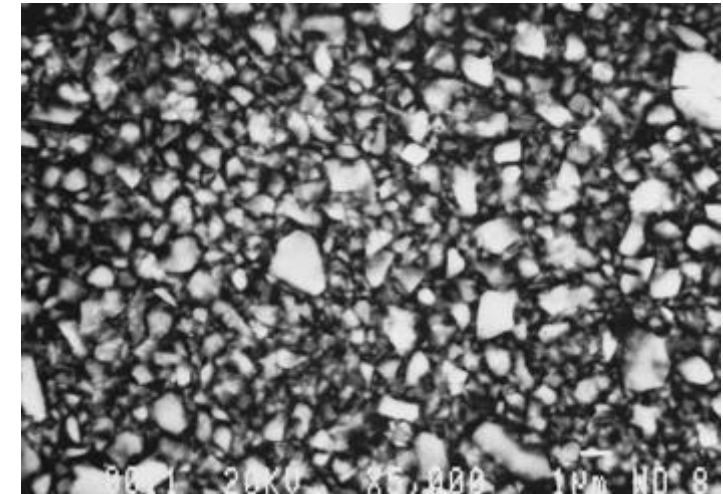


From Orban (1949) Oral Histology and Embriology, St. Louis: C.V. Mosby.



No bending stresses

Isotropy: resin composite



VS.



Enamel vs. Resin Composite



Enamel rods?

Resin composite



Impact of materials on design of structures



The discovery of metals has allowed us to build bigger and stronger structures ...



Impact of materials on design of structures



... and literally turns many structures on their heads.



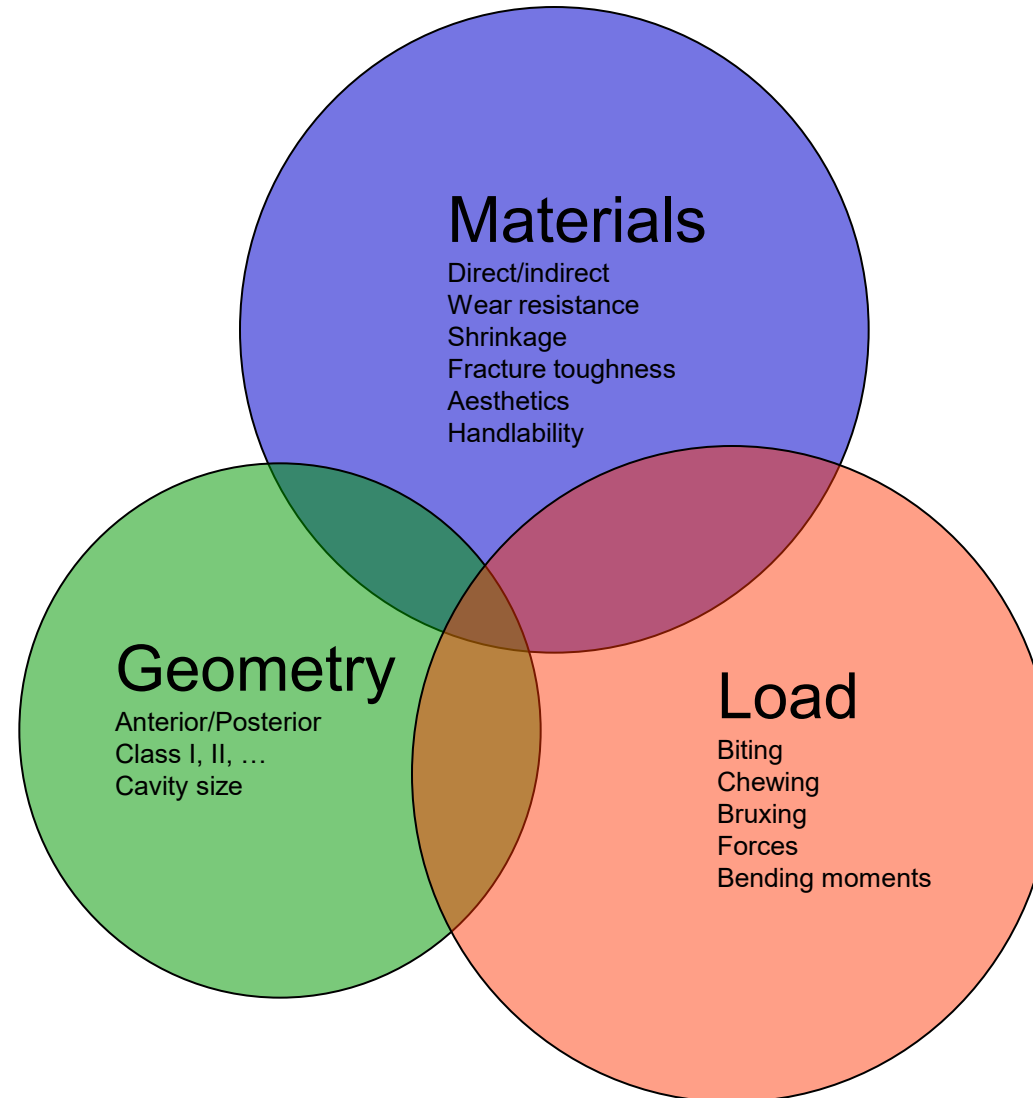
Impact of materials on design of structures



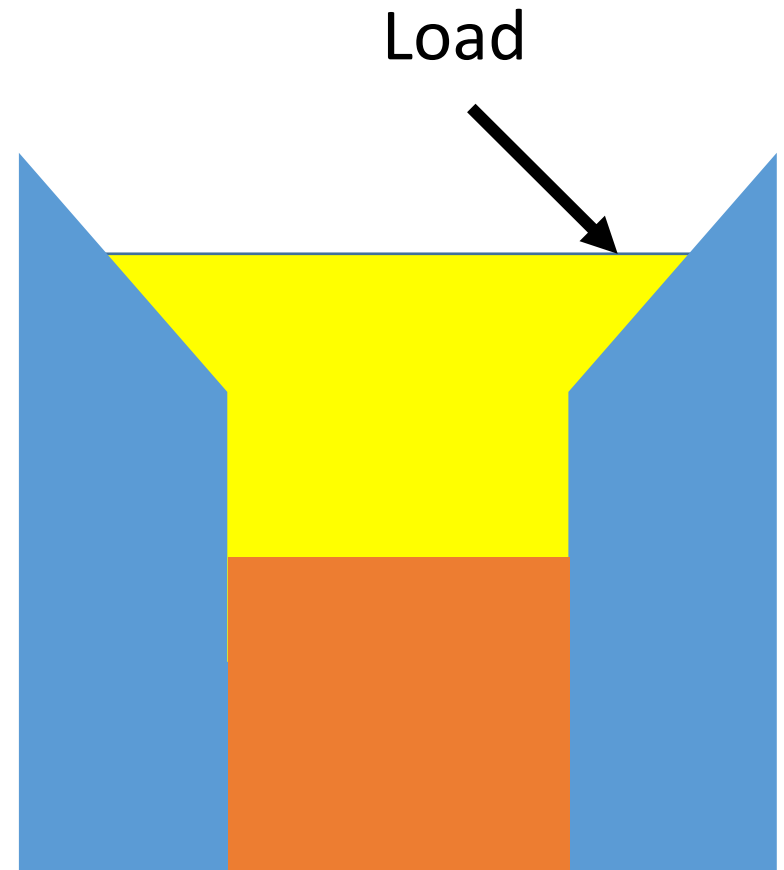
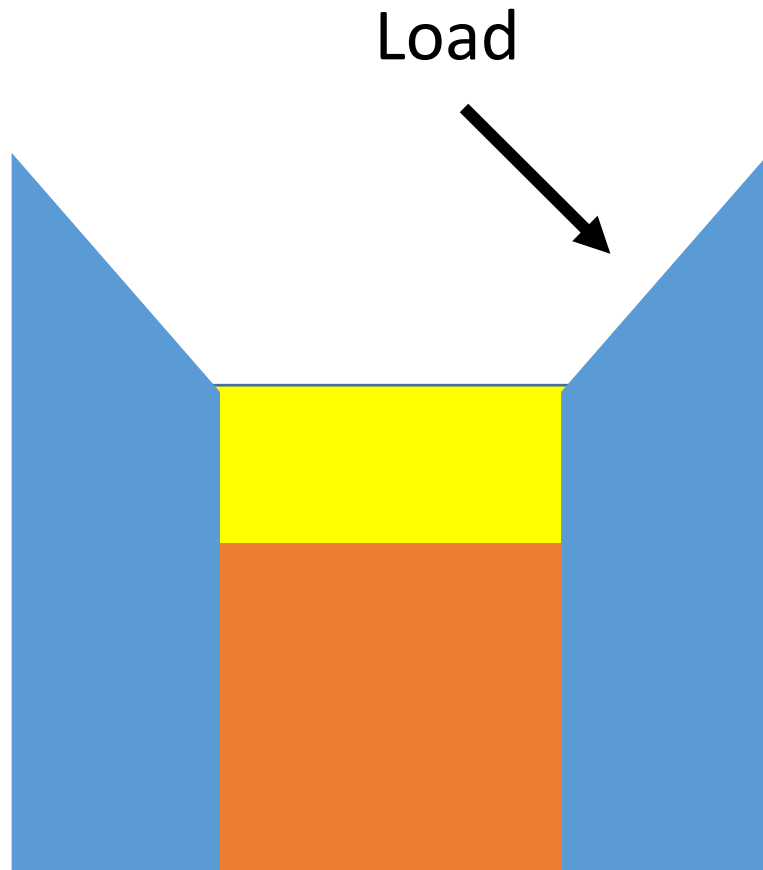
In contrast, to improve esthetics, restorative dentistry is moving away from metals ...

Design Δ - Tooth Restoration

The three components of structural design/analysis, i.e. material, geometry and loading, interact with and affect one another.



Butt joint vs. bevel joint



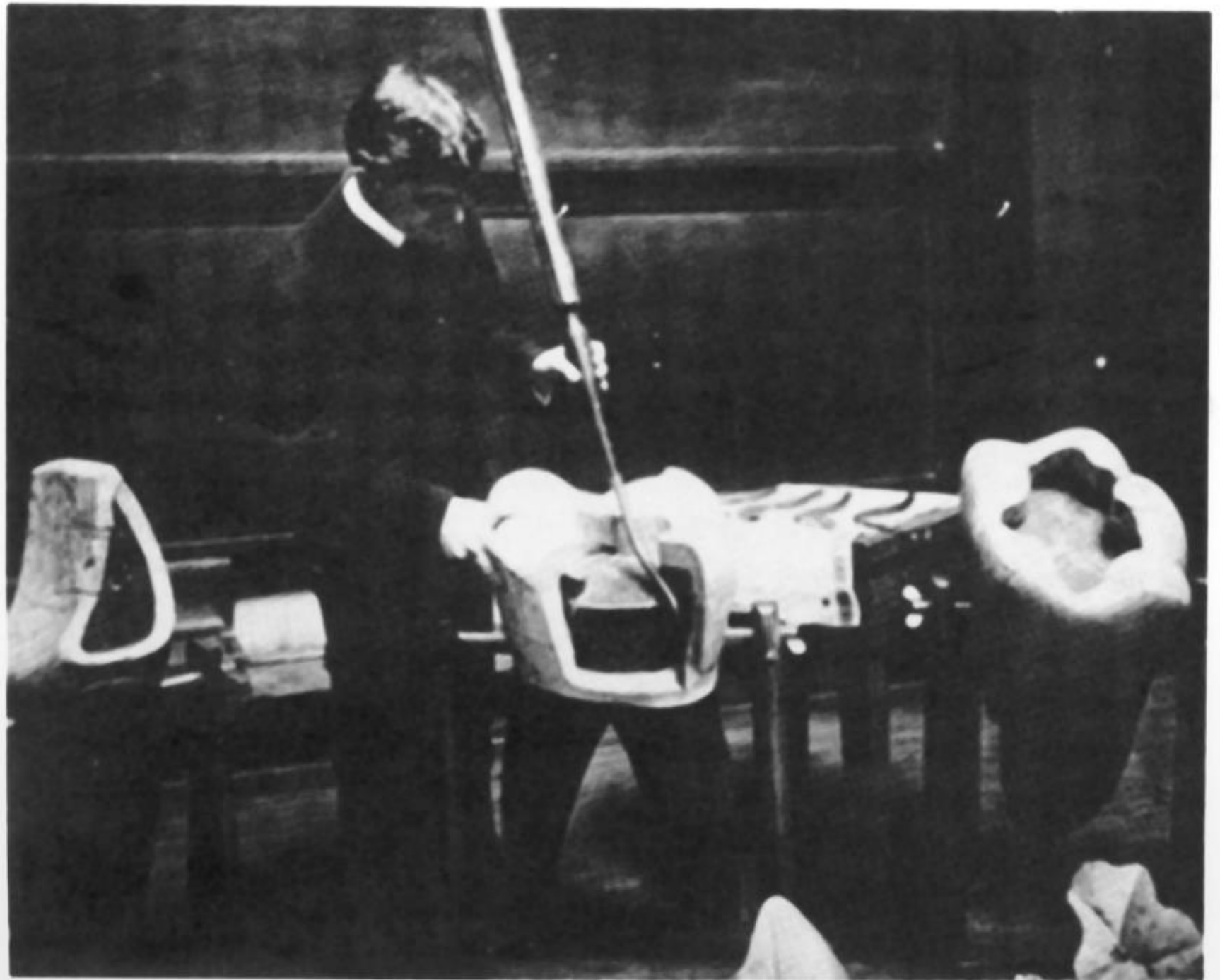
**WHERE ARE WE WITH
CAVITY SHAPES?**

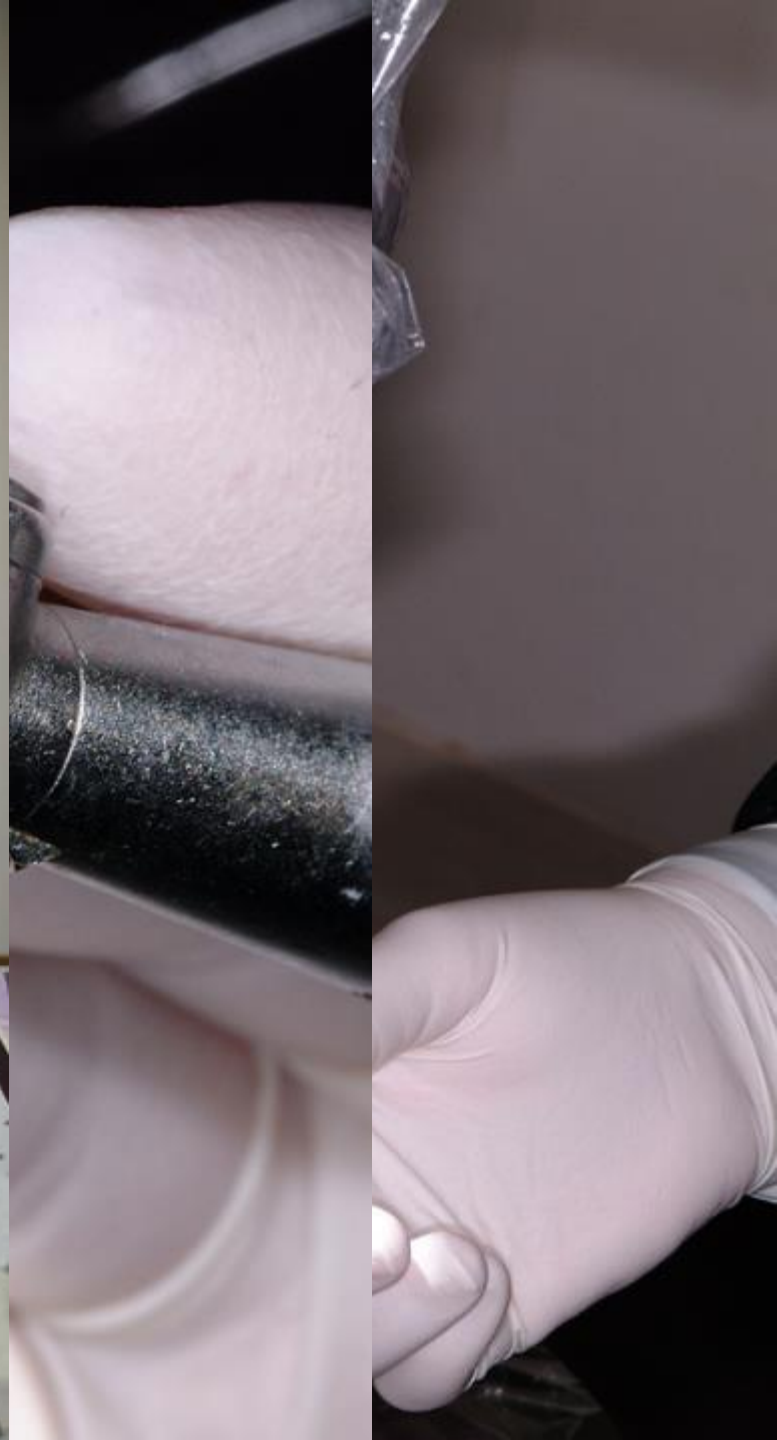
1890

**G. V. BLACK,
M.D., D.D.S.,
Sc.D., LL.D.,
1836-1915**



**MORTICE AND
TENON JOINTS
NECESSARY FOR
MECHANICAL
RETENTION OF
AMALGAM**





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CONSERVATIVE APPROACH TO DEEP CARRIES LESIONS

NATHANIEL LAWSON, DMD, PhD, and
AUGUSTO ROBLES, DMD, MS

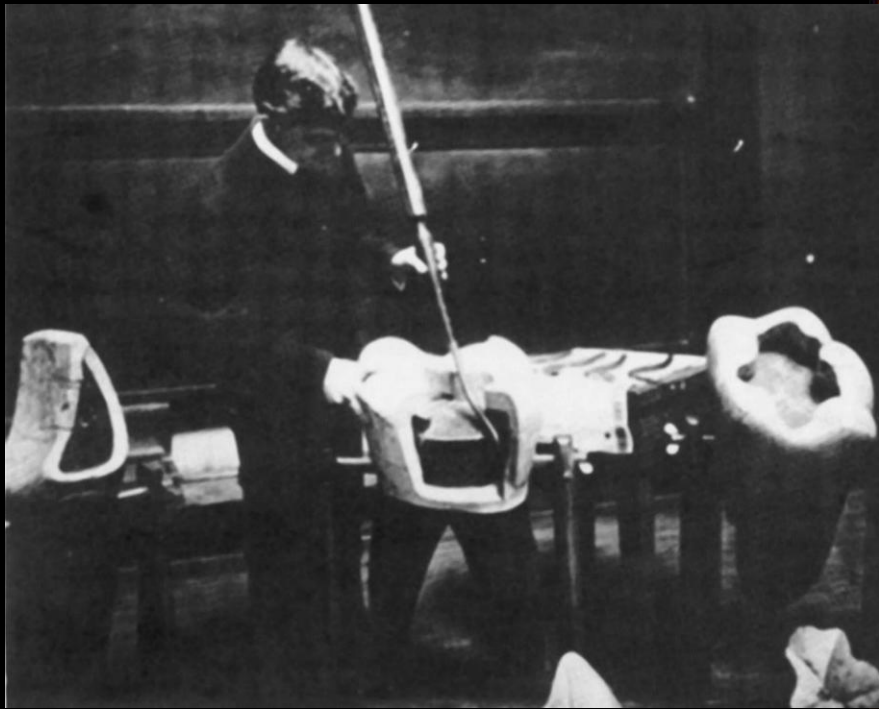
RISK FACTORS IN
ORAL CANCER
SCREENING
SARAH GLASS, DDS

HOW MANAGED
CARE WILL IMPACT
DENTAL PRACTICE
JOEL H. BERG, DDS, MS

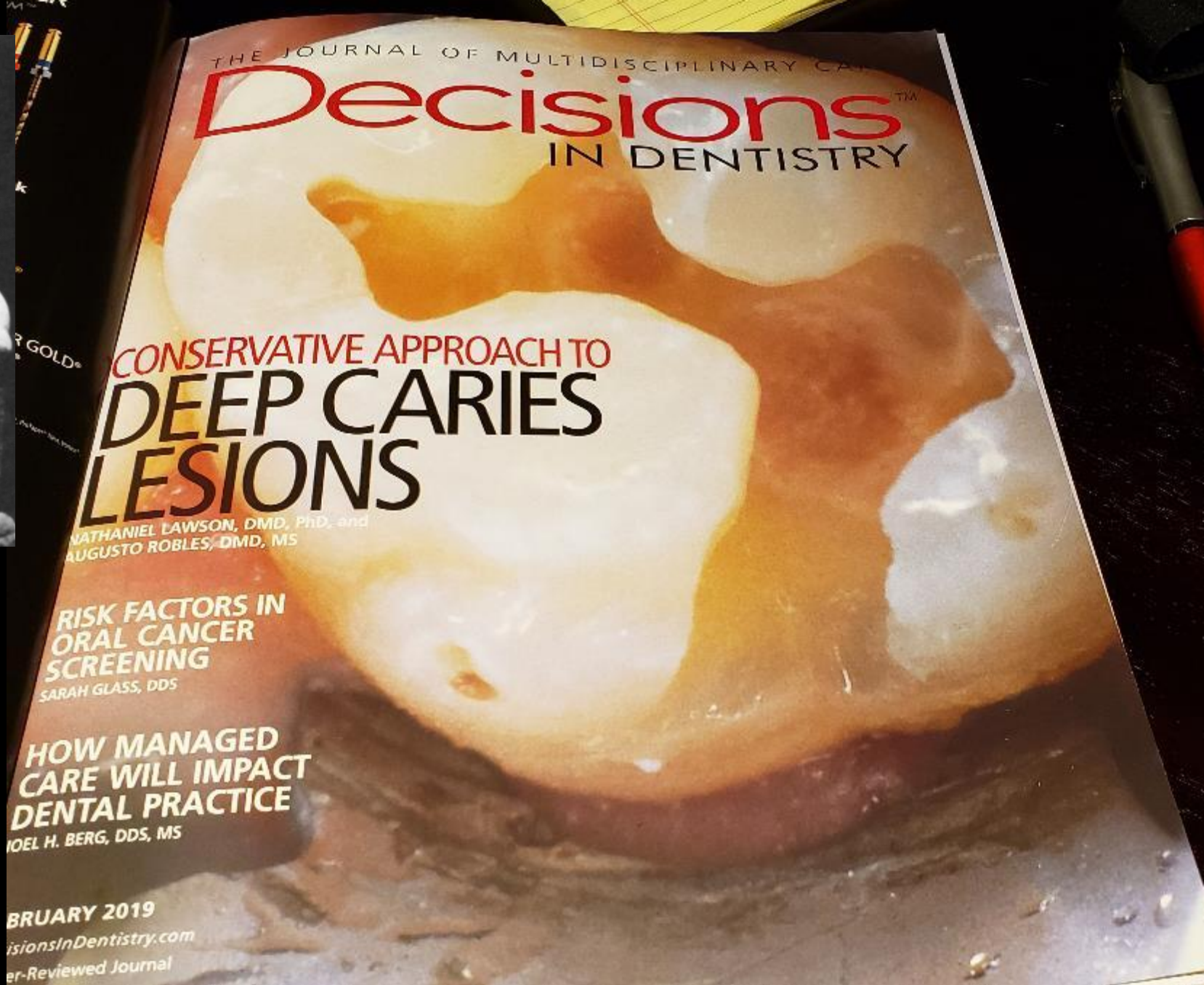
FEBRUARY 2019

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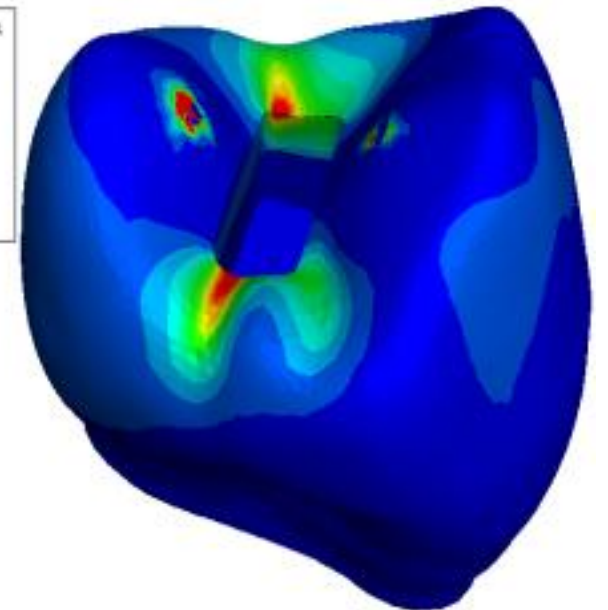
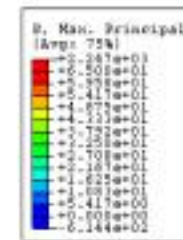
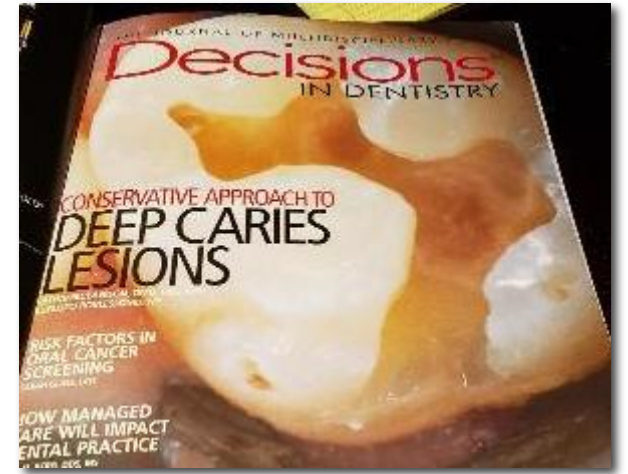


Is this the
year 2025
or 1890?



Stress/Strain Concentration

- Abrupt changes in geometry
- Mismatches in mechanical properties
- Concentrated loads

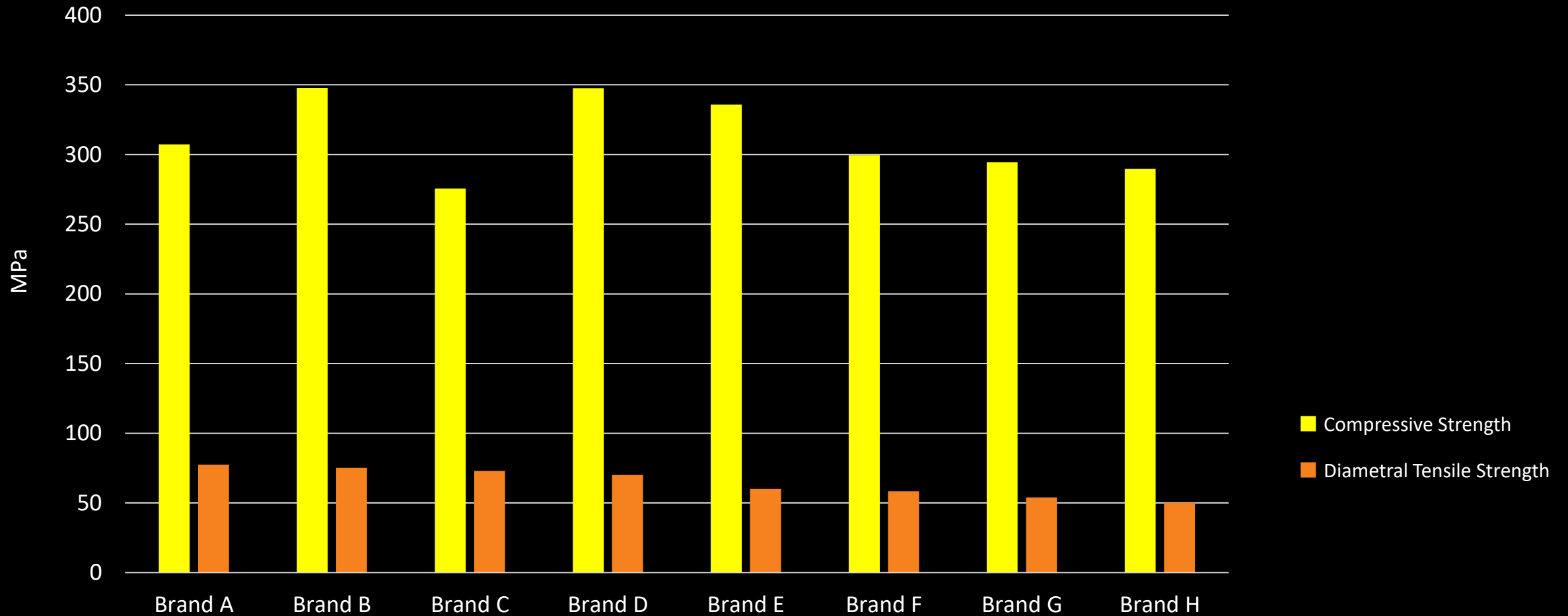


Epidemic of Cracked Teeth...Why?

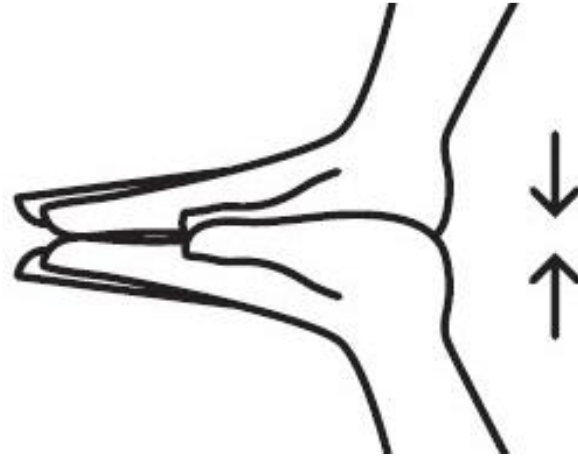
**Brittle Materials with
Tension joints**

Composite Resin Material Properties

Compressive vs Diametral Tensile Strength



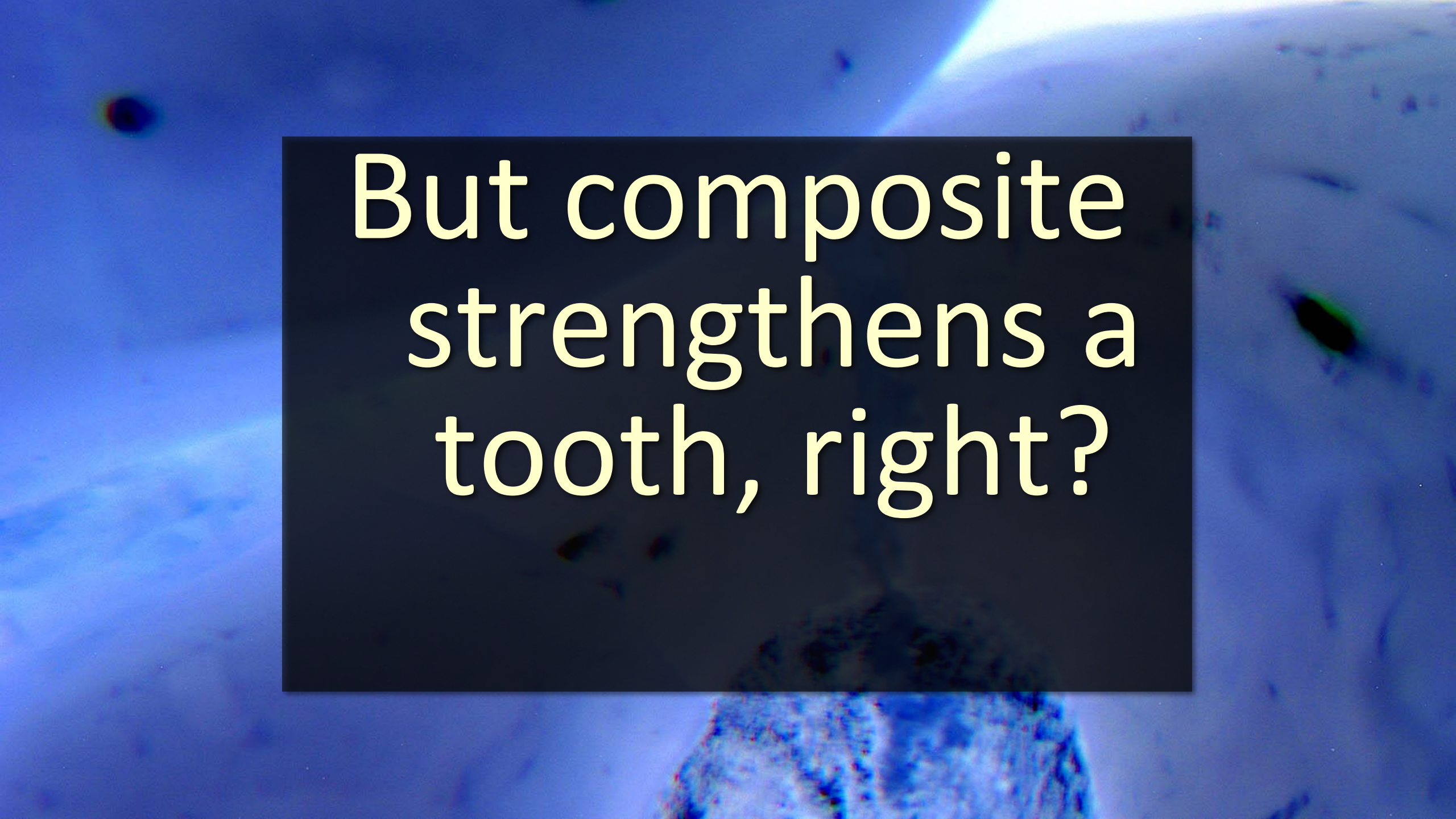
Compression vs. Tension is “Engineering 101”



compression



tension

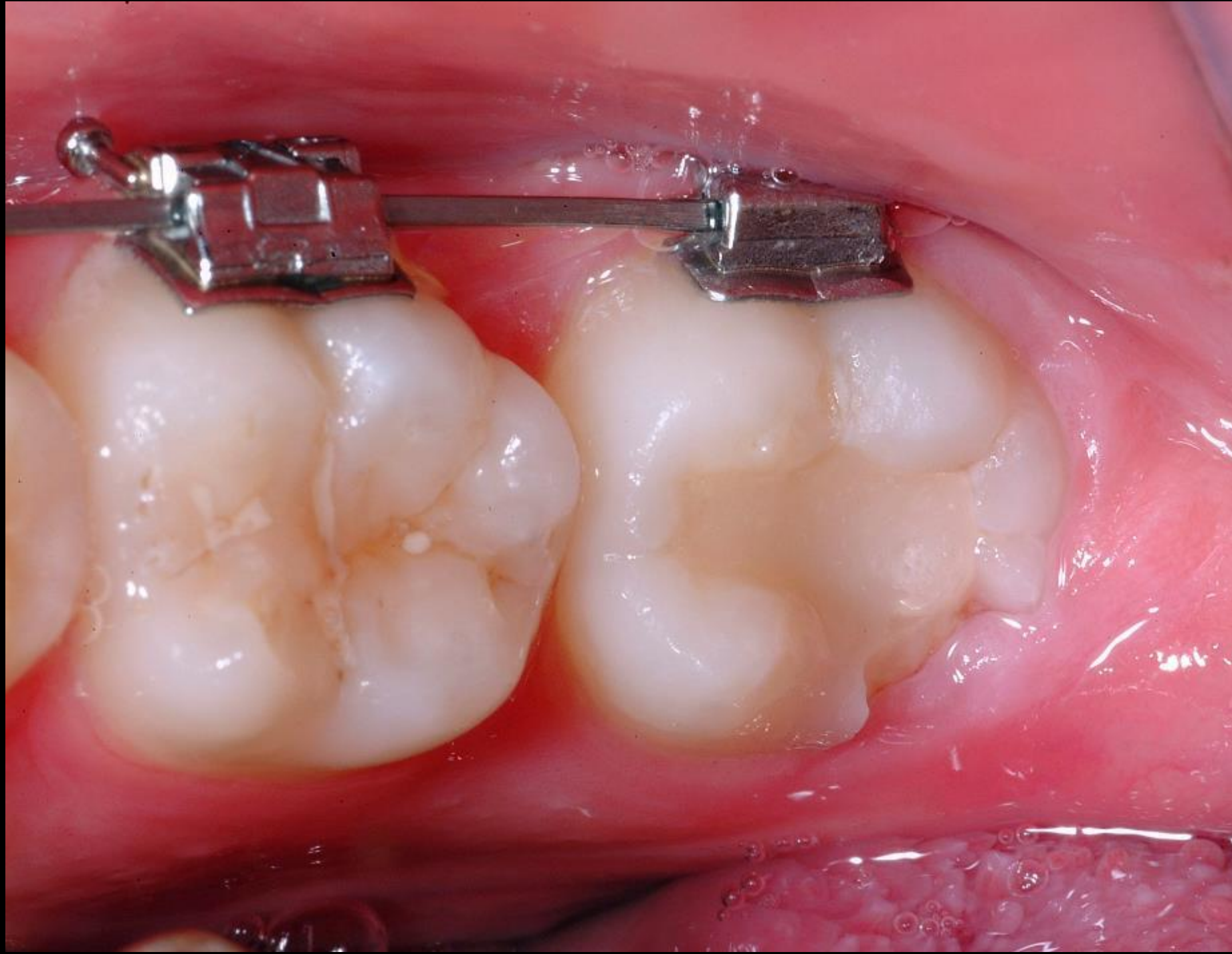
A close-up photograph of a tooth with a composite filling. The tooth is the central focus, showing a dark, textured filling material. The background is a blurred, light-colored surface, likely the rest of the tooth or the surrounding tissue. A black rectangular text box is overlaid on the right side of the image, containing white text.

But composite
strengthens a
tooth, right?

Does composite strengthen the tooth?

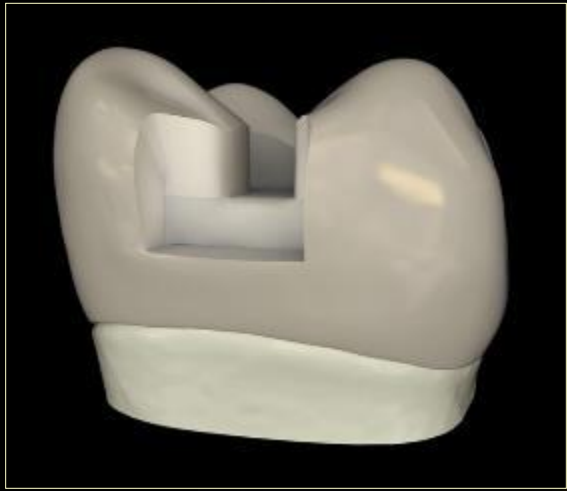
No more than does amalgam

Wahl MJ, Schmitt MM,
Overton DA, Gordon MK.
Prevalence of cusp
fractures in teeth restored
with amalgam and with
resin-based composite.
JADA 135:1127-1132
(2004)





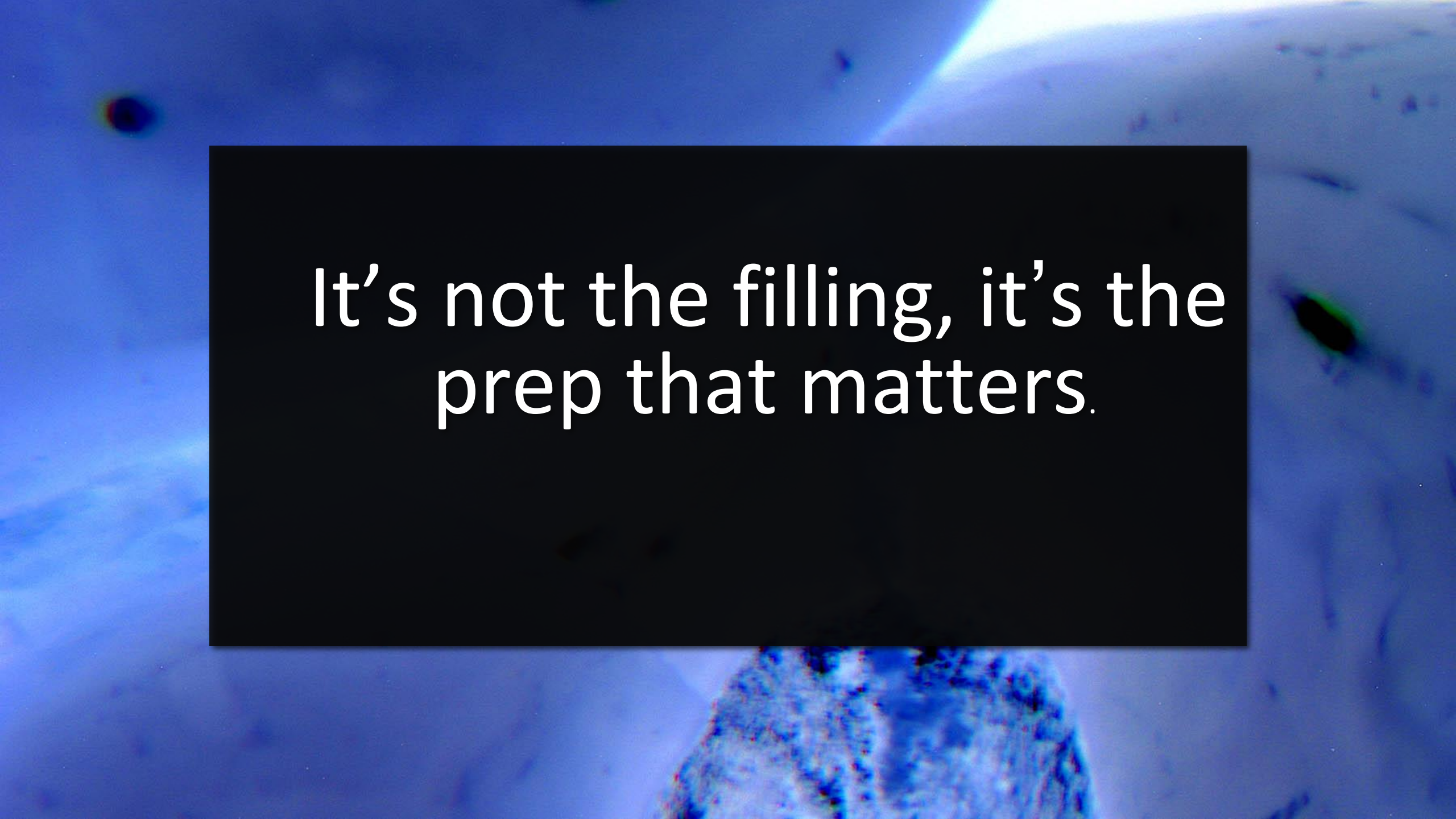




Boxes are bad.

Bevels make them less bad.

The Clark Class II replaces
beveling with radius walls.



It's not the filling, it's the
prep that matters.

The New Science of Strong Materials

or Why You Don't Fall through the Floor

J. E. Gordon



MAGNIFICATION

The Epidemic of Cracked and Fracturing Teeth



Tooth and jawbone fractures are on the rise. A study by the National Institute of Dental and Craniofacial Research (NIDCR) found that the number of cracked teeth has increased significantly since 1990. The study, published in the *Journal of Endodontics*, found that the number of cracked teeth has increased significantly since 1990. The study, published in the *Journal of Endodontics*, found that the number of cracked teeth has increased significantly since 1990.

REVERSE CAUSING AND PREVENTION
The study found that the number of cracked teeth has increased significantly since 1990. The study, published in the *Journal of Endodontics*, found that the number of cracked teeth has increased significantly since 1990.

Phase 1	Phase 2	Phase 3	Phase 4
Initial and early stages of tooth fracture	Progression of tooth fracture	Advanced stages of tooth fracture	Severe stages of tooth fracture

- 1) Initial and early stages of tooth fracture
- 2) Progression of tooth fracture
- 3) Advanced stages of tooth fracture
- 4) Severe stages of tooth fracture

Associated Medications/Drugs
The study found that the number of cracked teeth has increased significantly since 1990. The study, published in the *Journal of Endodontics*, found that the number of cracked teeth has increased significantly since 1990.



Figure 1. An advanced stage of tooth fracture. The tooth is cracked and the pulp is exposed.

RESTORATIVE

Fracture Resistant Endodontic and Restorative Preparations



Figure 1. Preparation of the tooth for a fracture resistant endodontic and restorative preparation.

INTRODUCTION
The number of cracked teeth has increased significantly since 1990. The study, published in the *Journal of Endodontics*, found that the number of cracked teeth has increased significantly since 1990.

The study found that the number of cracked teeth has increased significantly since 1990. The study, published in the *Journal of Endodontics*, found that the number of cracked teeth has increased significantly since 1990.

THE SCIENCE OF STRONG MATERIALS
The study found that the number of cracked teeth has increased significantly since 1990. The study, published in the *Journal of Endodontics*, found that the number of cracked teeth has increased significantly since 1990.

Restoratively, It's Not the Size of the Hole, but the Shape of the Hole

The formula for determining stress concentration due to a cavity preparation is $(1+2\sqrt{\frac{L}{R}})$ where L is length of the cut and R is the radius of the cut. In simple terms, the longer the cut, the worse the cut. A long narrow cut, interestingly, is worse than a wide, round-bottomed cut. One reason that intracoronal composites do not protect the tooth from long-term from

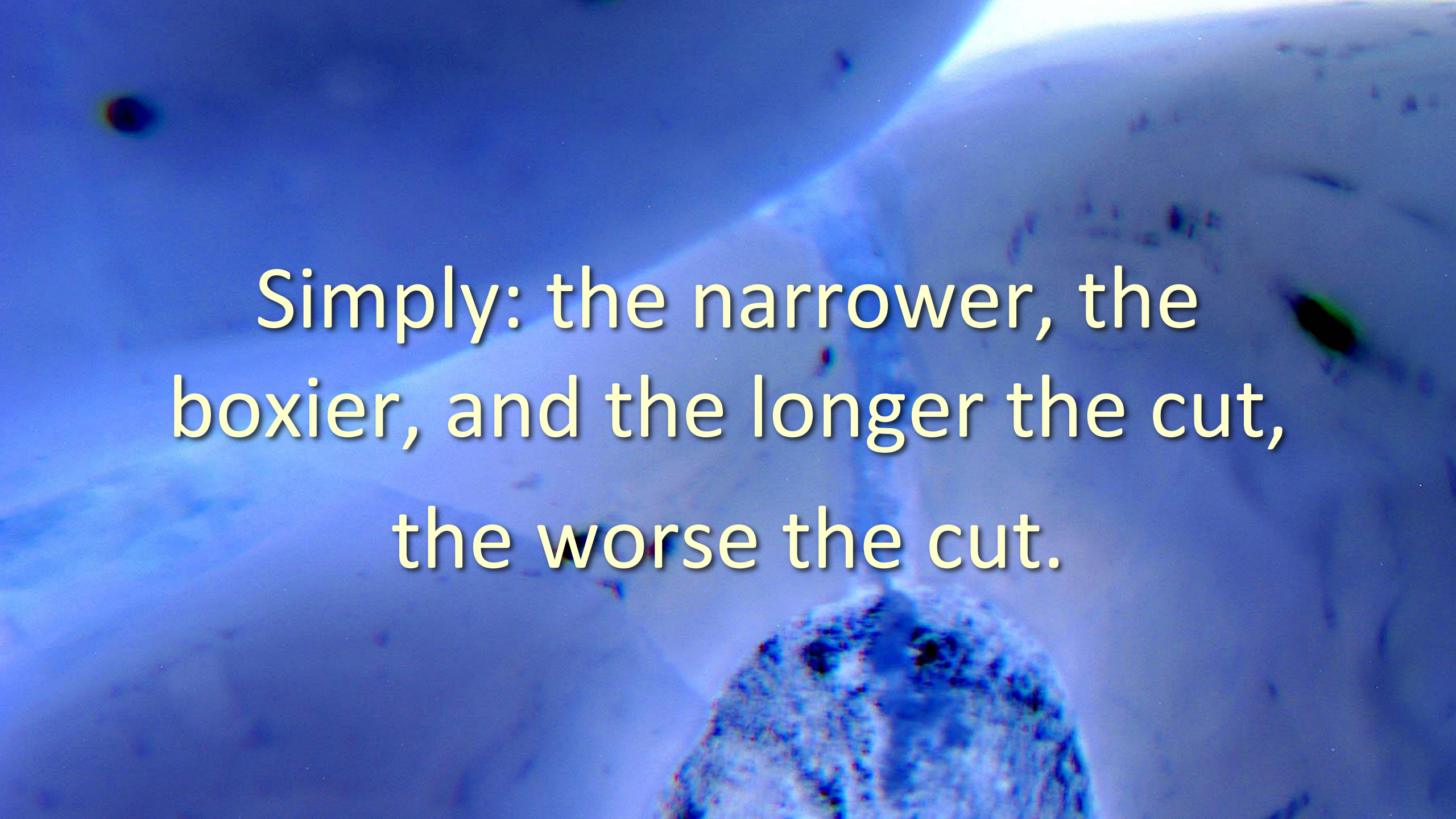


The formula for stress concentration in a cavity is

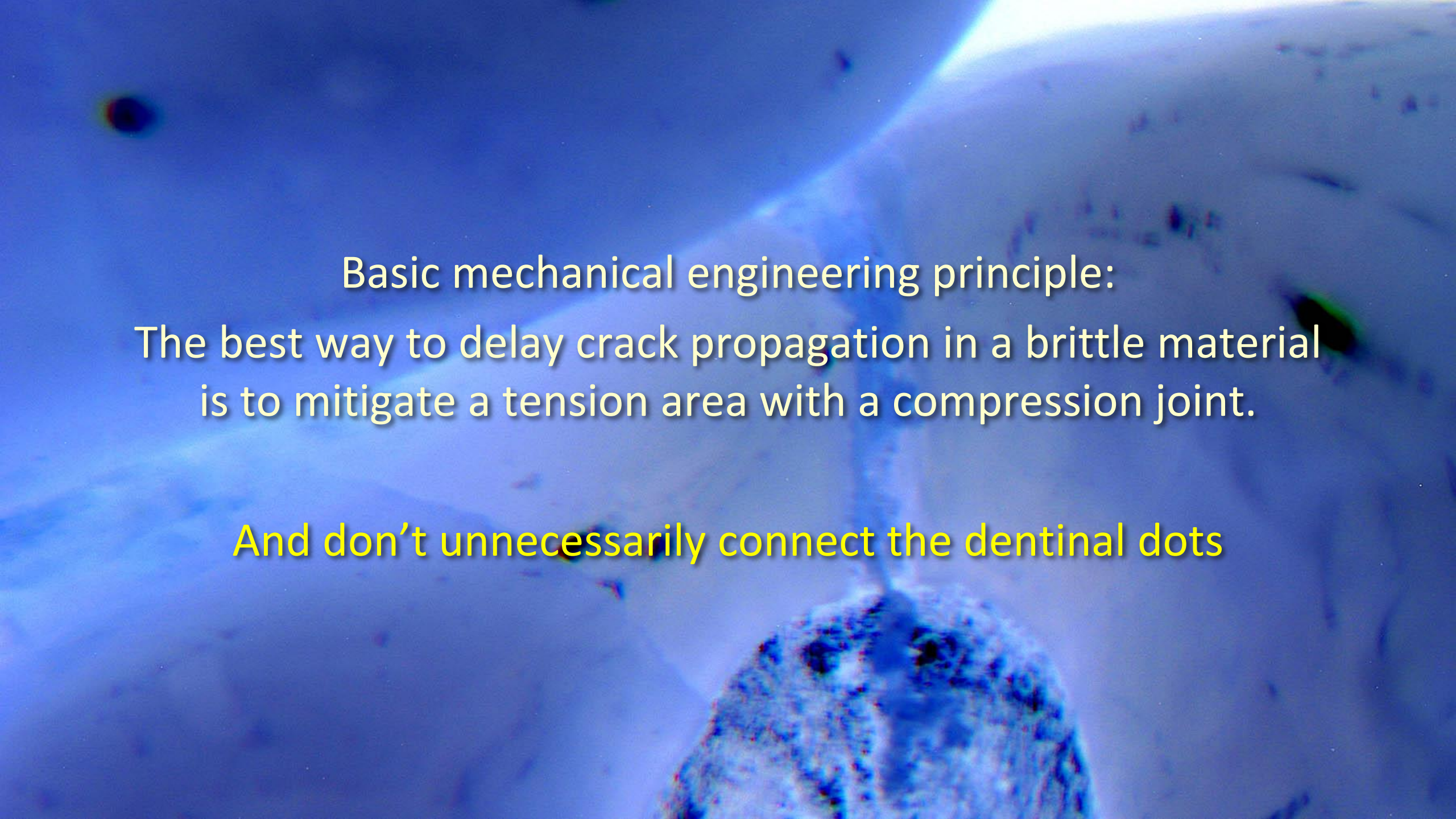
$$1 + 2 \sqrt{L/R}$$

L is the depth of the cut.

R is the radius of the cut.



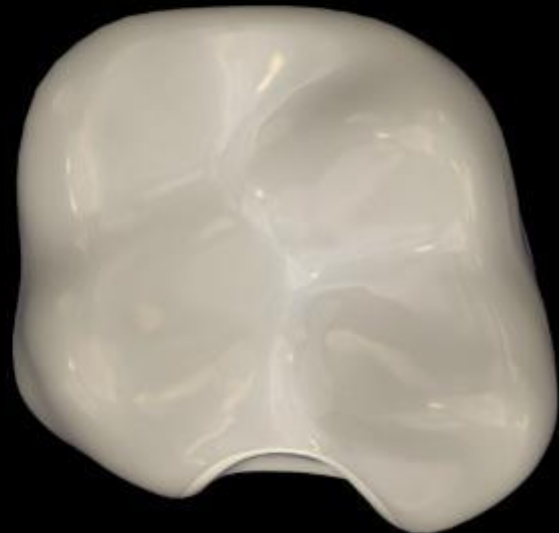
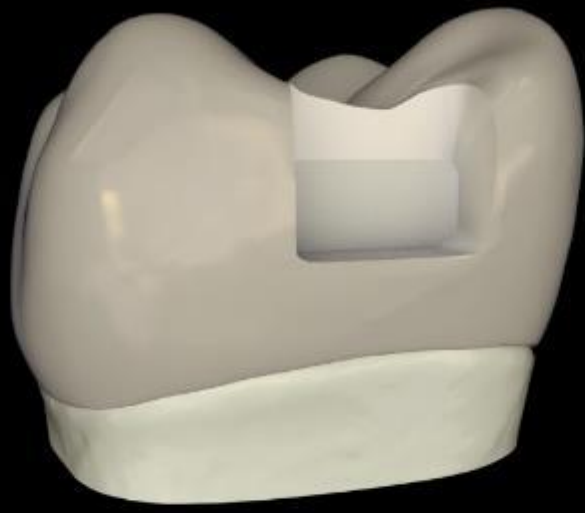
Simply: the narrower, the
boxier, and the longer the cut,
the worse the cut.

A microscopic image of a material surface, likely a metal or ceramic, showing a crack. The crack is a dark, irregular line running diagonally across the frame. The surface has a granular texture with various small features and imperfections. The lighting is bright, creating a strong contrast between the dark crack and the lighter surrounding material.

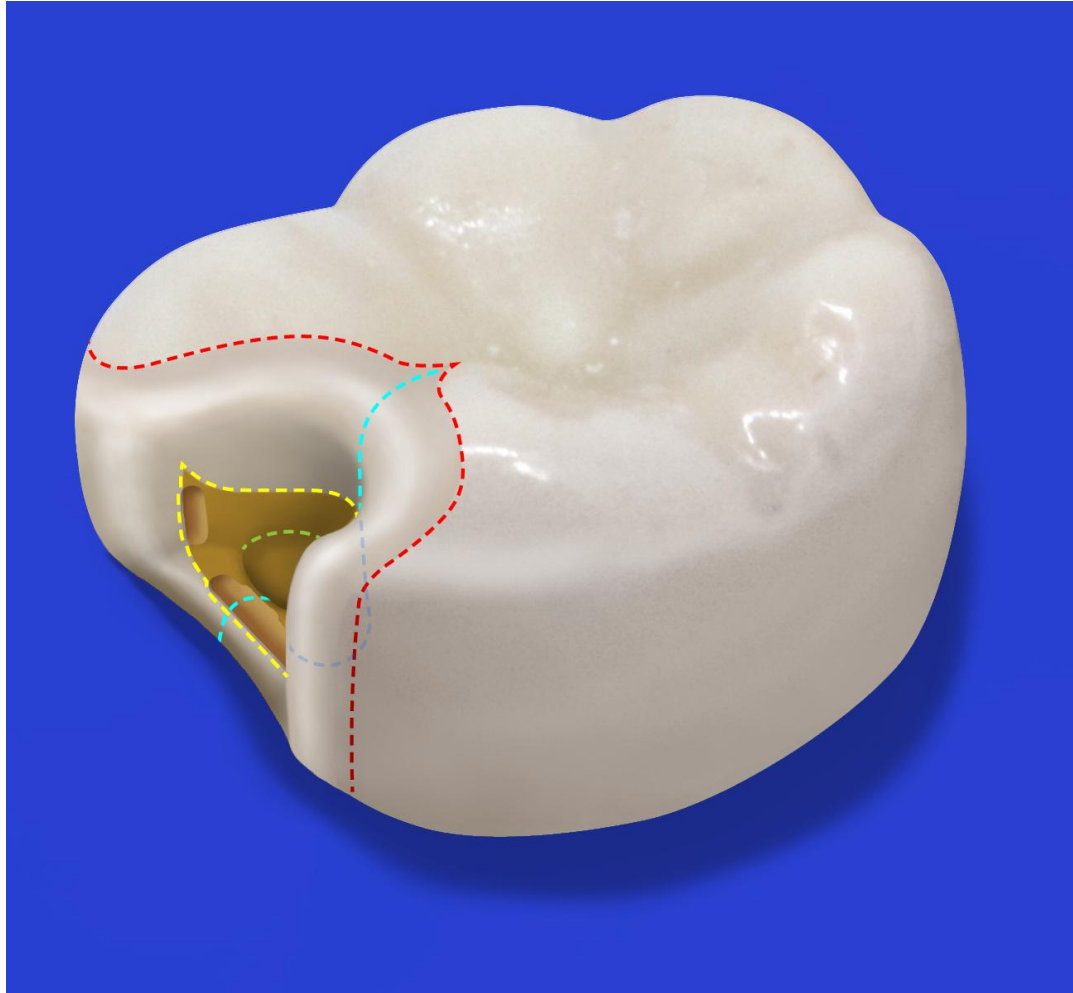
Basic mechanical engineering principle:
The best way to delay crack propagation in a brittle material
is to mitigate a tension area with a compression joint.

And don't unnecessarily connect the dentinal dots

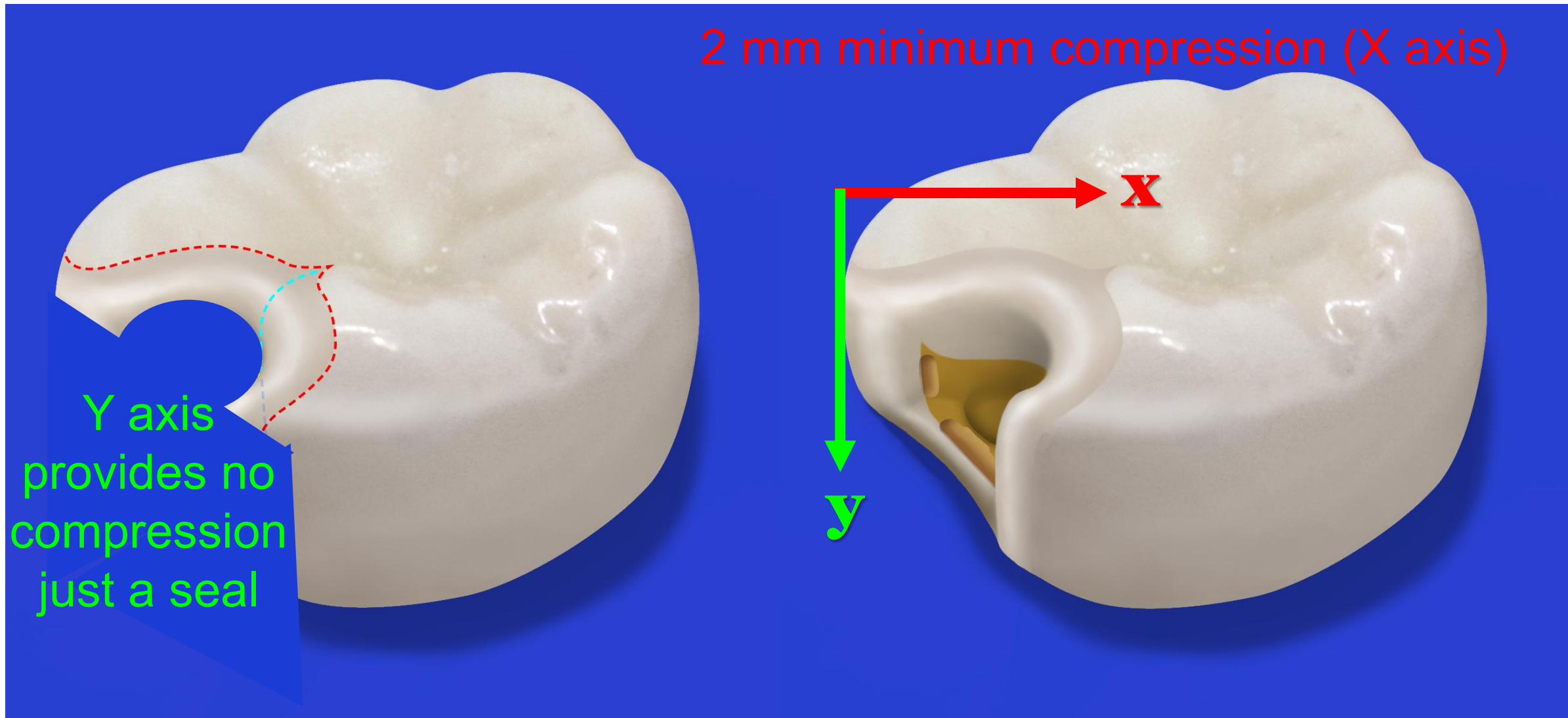
The Prep?



Final views of completed Bioclear Class II Preparation.



To eliminate mechanical retention, we need 2 mm of enamel in compression at the primary strike point of occlusion



Clark Class II Prep Design



Unique Aspects of the Clark Class II Prep Design



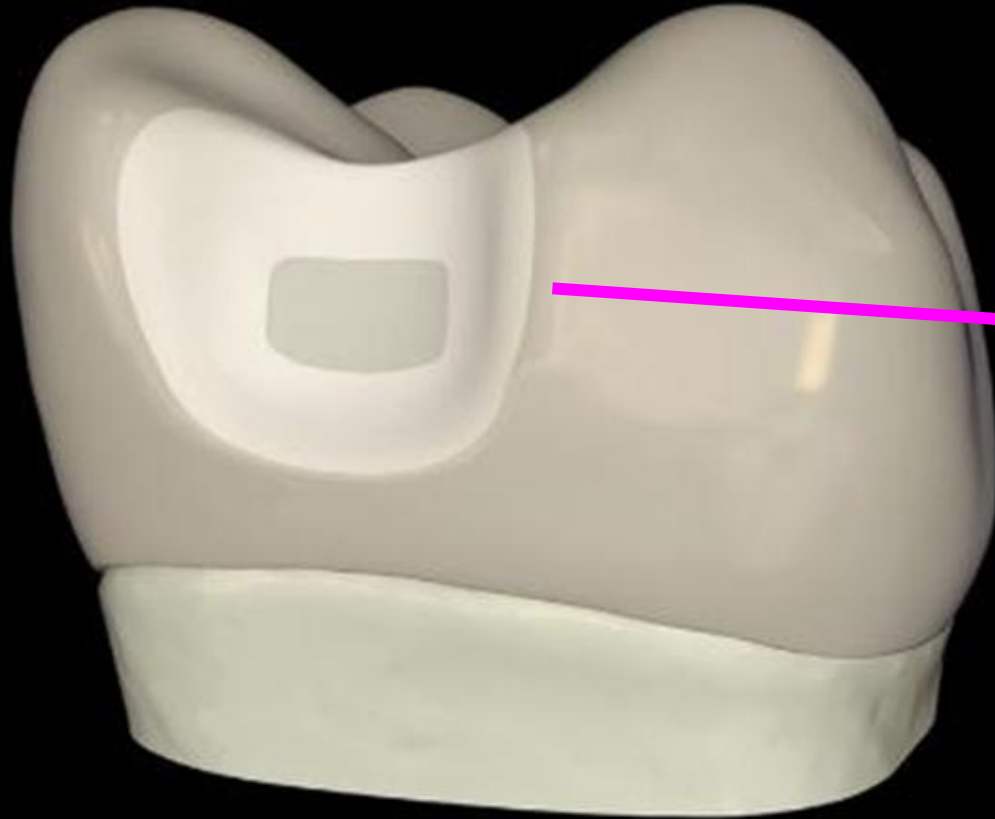
- Removal of biofilm

Unique Aspects of the Clark Class II Prep Design



- Removal of biofilm
- Rounded internal line angles

Unique Aspects of the Clark Class II Prep Design



- Removal of biofilm
- Rounded internal line angles
- Rounded external line angles via the ***Radius Bevel***

Unique Aspects of the Bioclear Prep Design



- Removal of biofilm
- Rounded line angles
- Injection mold rather than place incrementally

Unique Aspects of the Clark Class Prep Design



- Removal of biofilm
- Rounded line angles
- Rounded external line angles via the *Radius Bevel*
- Infinity Edge margins
 - Maximized enamel rod Engagement *with Large Areas of Additive Dentistry*



before

The Bioclear method





Infinity edge
of the T.R.I.

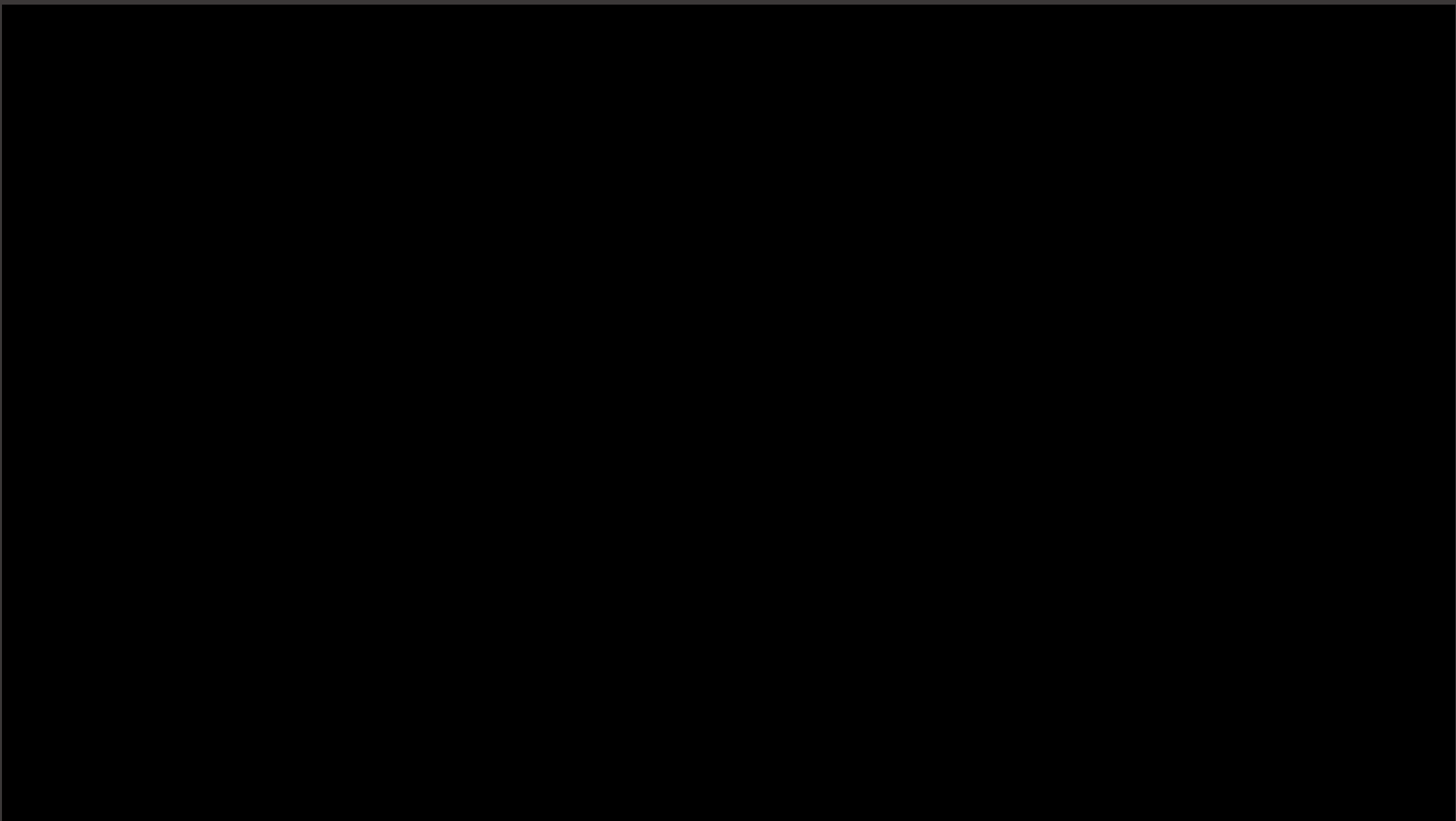
The Bioclear Injection Molding Approach



Failing composite;
traditional preparation



Re-restored using the
Bioclear approach



The Two-Point Spot Weld (5mm max depth)

Studies Supporting the Bioclear Method

Complete

- Comparing Conventional to Saucer-Shaped Cavity Designs

Dr. Alex Fok, BEng, PhD, MSc

Dr. Hooi Pin Chew, BDS, PhD, FDSRCS

MN Dental Research Center for Biomaterials and Biomechanics

- Comparison of Class II Adaptation and Placement Times

Dr. Richard Price, BDS, DDS, MS, FDS RCS, FRCD(C), PhD

Dept. of Clinical Dental Sciences & Biomedical Engineering Dalhousie University

- Effect of Preheating/Fatiguing/Thermocycling on Mechanical Properties

Taiseer A. Sulaiman, DDS, PhD

Assistant professor, Division Director of Operative Dentistry and Biomaterials, UNC School of Dentistry

- 3M Extraction and Pulp Temperature Testing

Brad Bagley, PhD, DABT Advanced Toxicology Specialist

- 3M Material Property Testing Including Injection Molding

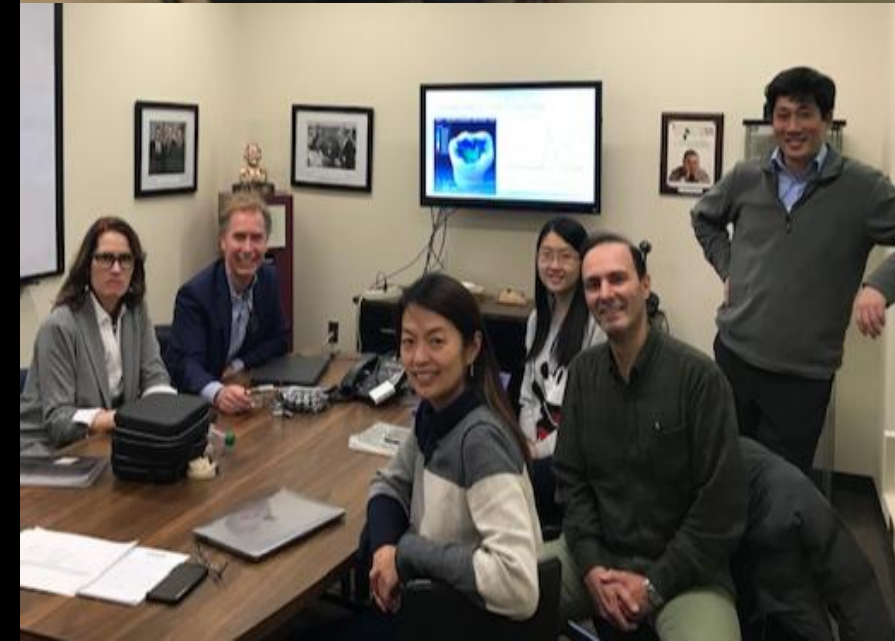
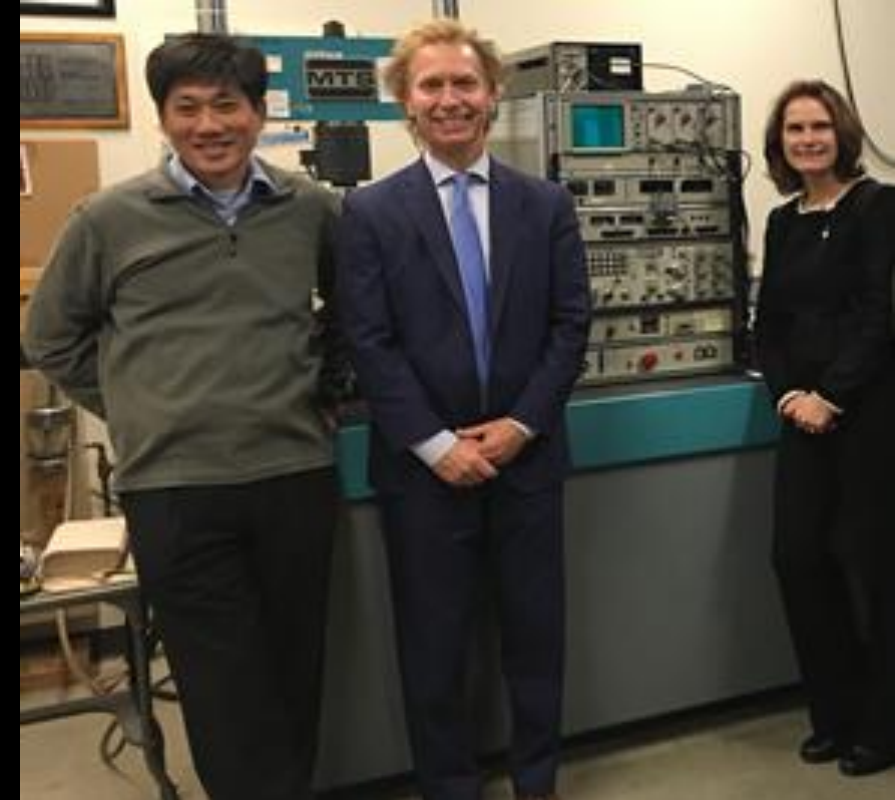
Timothy D. Dunbar, Ph.D. Advanced Product Development Specialist

In Process

- Biofilm Adhesion Study

Sabrina F. Sochacki, DDS, MS, PhD

Indiana University School of Dentistry



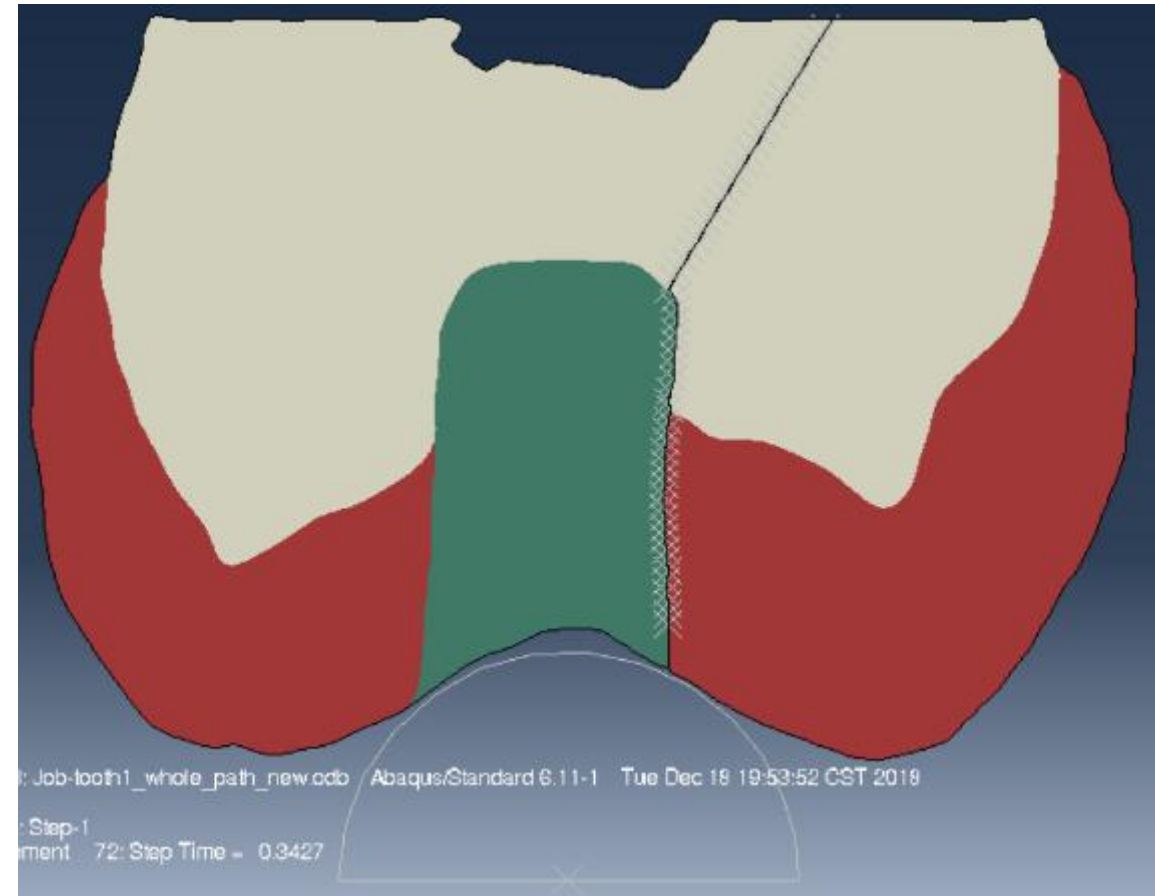
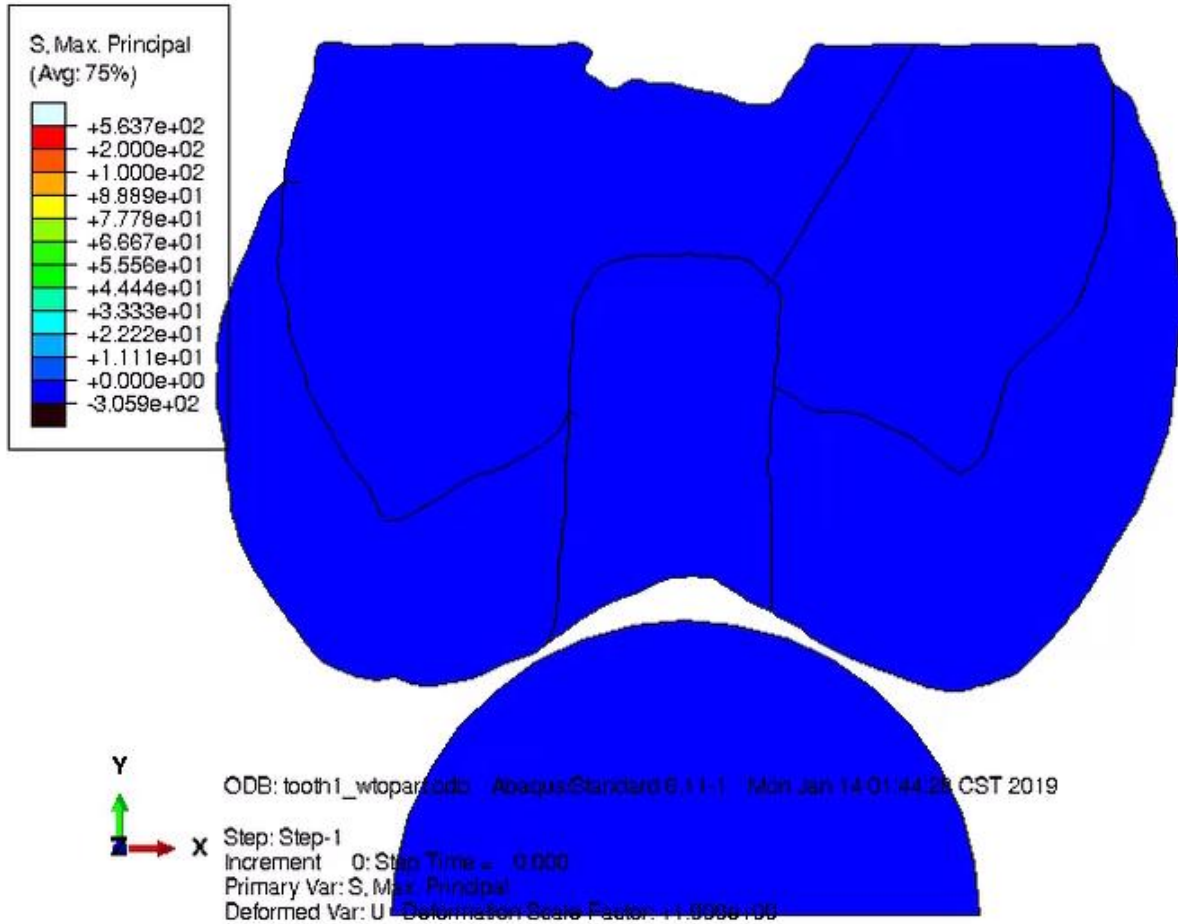
Fracture Simulation of Class-I Restorations



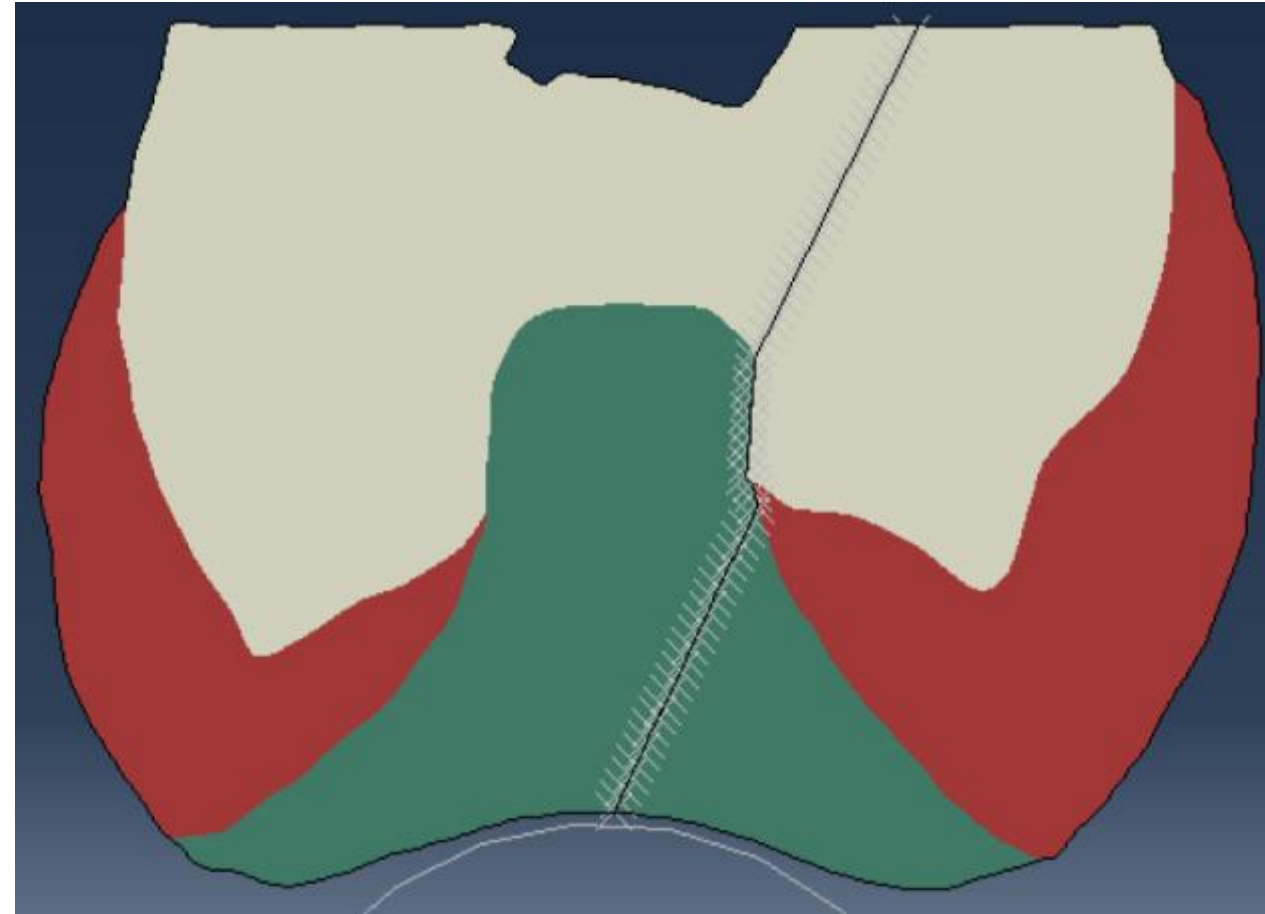
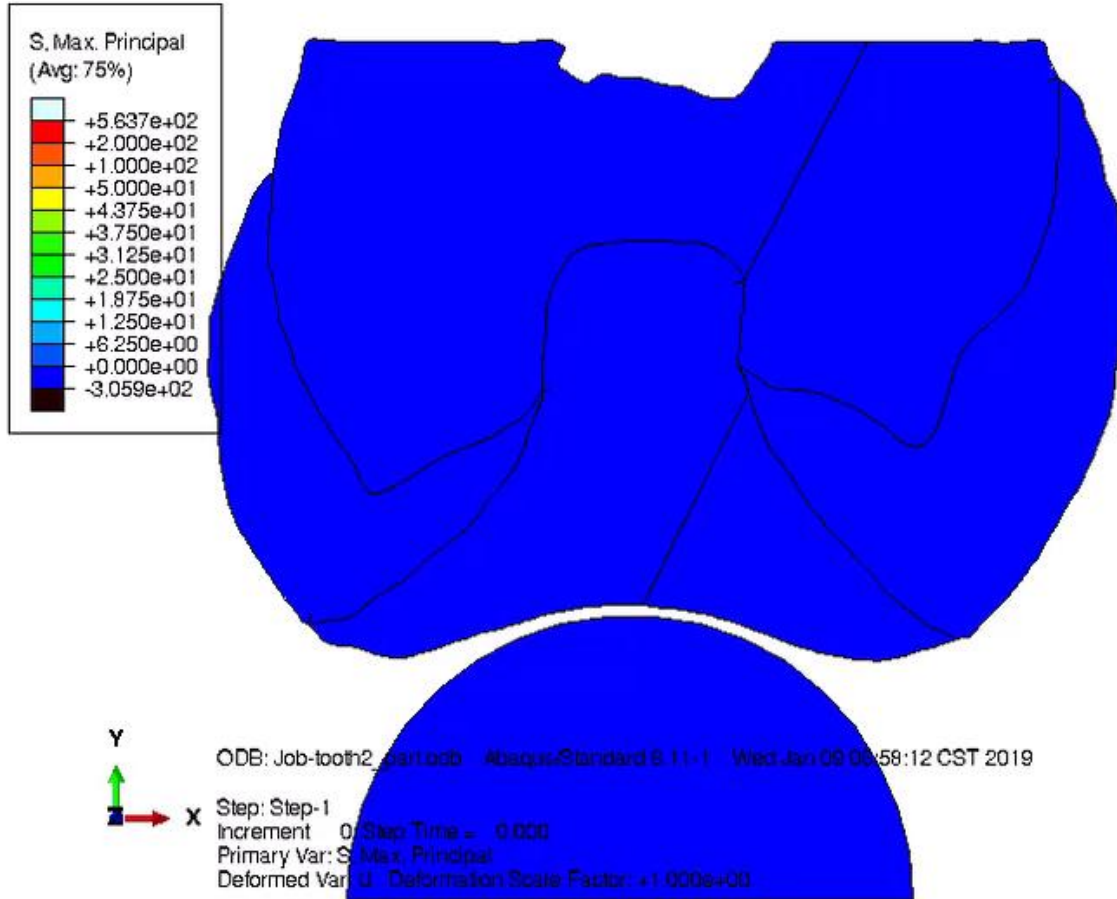
Prepared by: Ning Ye
Date: 1/11/2019

Reference no. MDRRCBB-NY-JAN11-2019

Traditional Class I Prep



Calla Lily Class I Prep



$$A_1 N_1^B = A_2 N_2^B \frac{N_1}{N_2} = \left(\frac{A_2}{A_1} \right)^{1/B}$$

...if Restoration 1 has a fast fracture strength that is **10% higher than Restoration 2**, then its fatigue life is roughly 3 times as long.

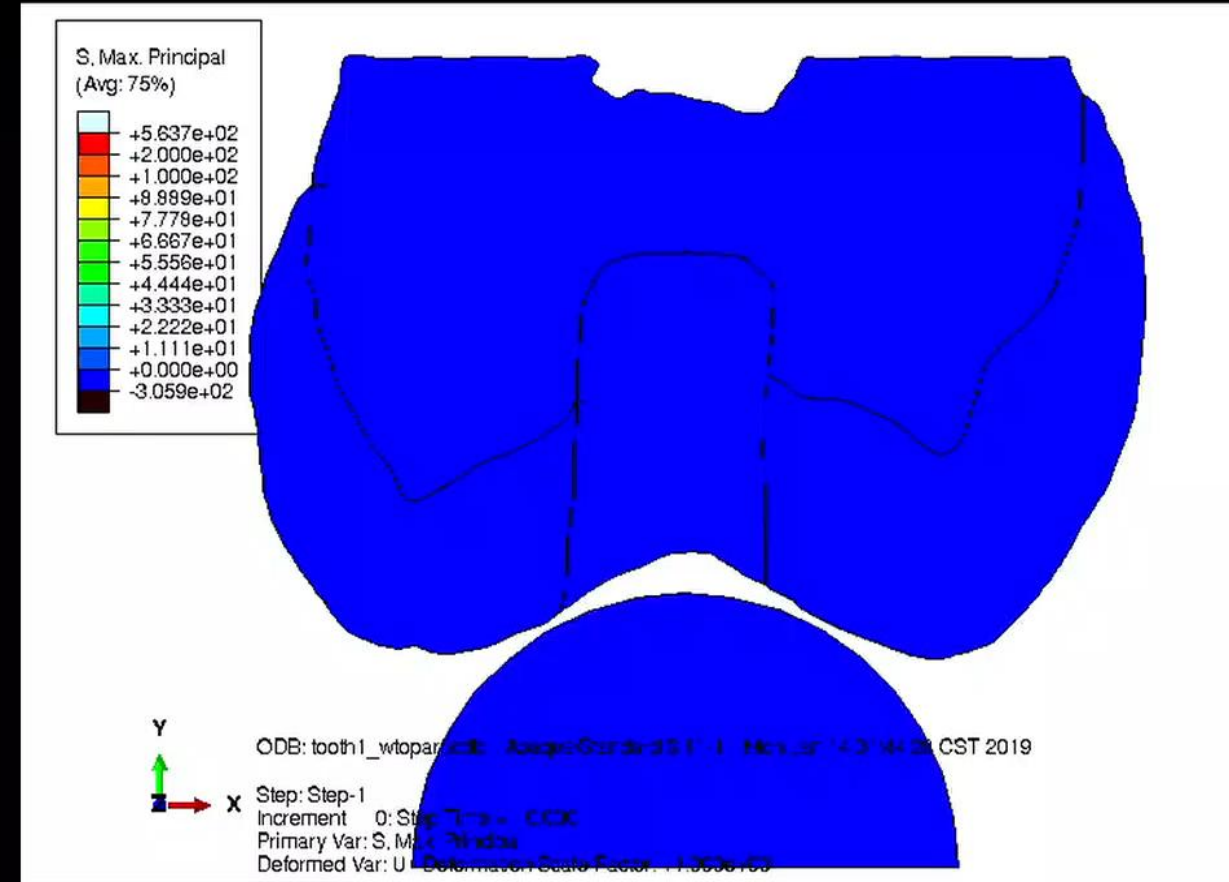
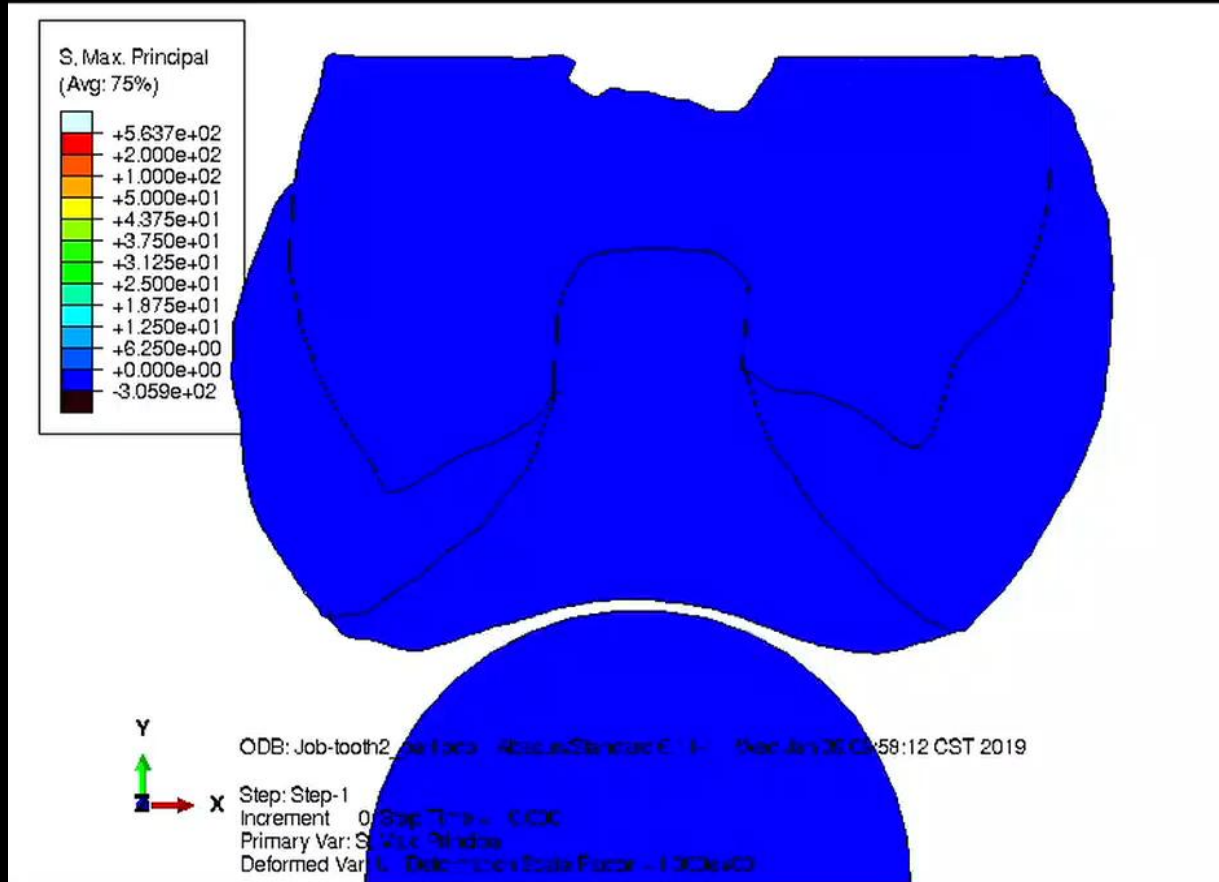
If the difference in fast fracture strength is 20%, then Restoration 1 will last roughly 8 times as long, etc.

Alex Fok

Minnesota Dental Research Center
for Biomaterials and Biomechanics

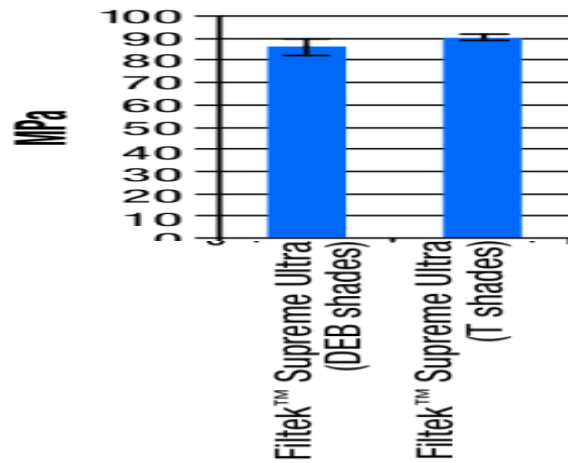
Calla Lily: moderate occlusal caries or re-treatment of Traditional prep

Traditional Class I filled with composite resin

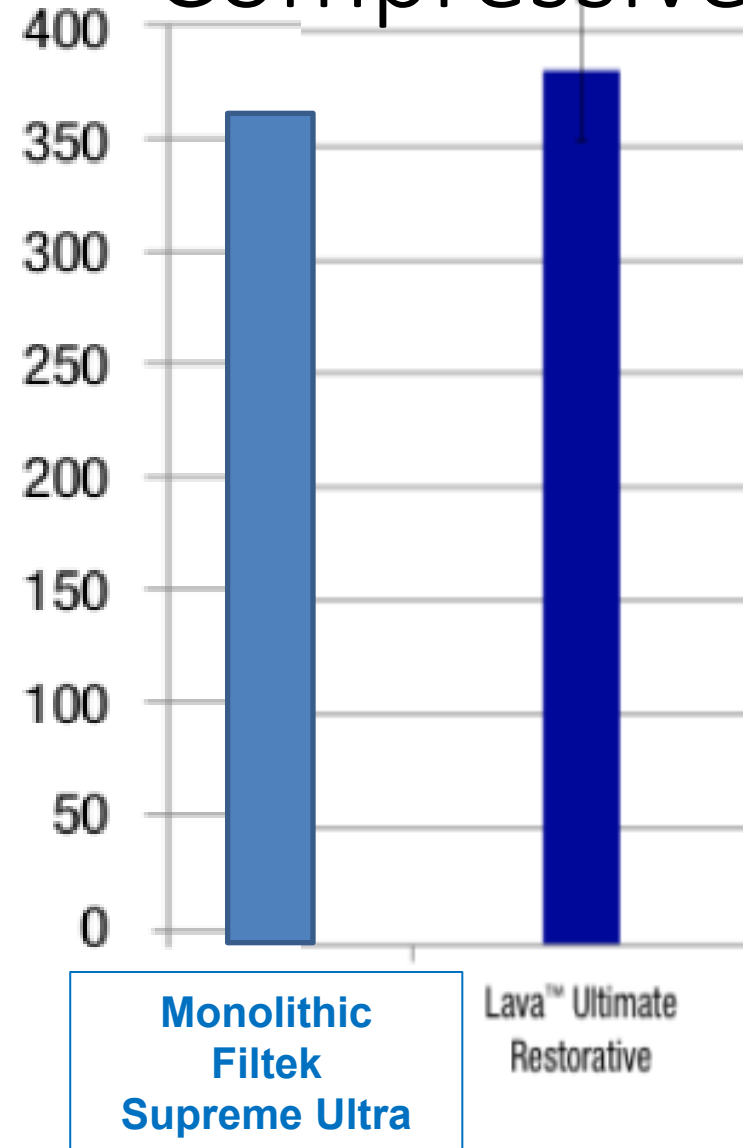


The compressive strength of composite is about 4x the diametral tensile strength.

Tensile



Compressive



Bioclear Learning Center Guidelines:

- In compression, resin over enamel has no minimum thickness requirement
- In compression, resin over dentin needs at least 2mm thickness
- For Incisal Edges and cusp tips we need 2 mm (occluso gingivally and buccal-lingual)
- All monolithic-no seams or grooves

Calla Lily Prep

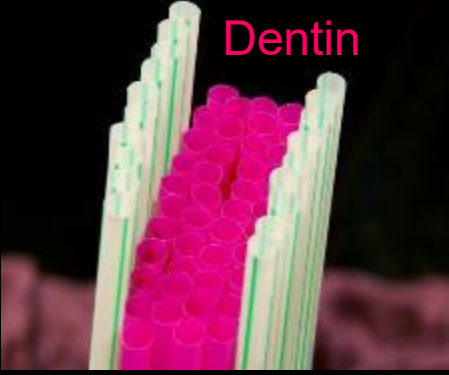
Calla Lily Prep





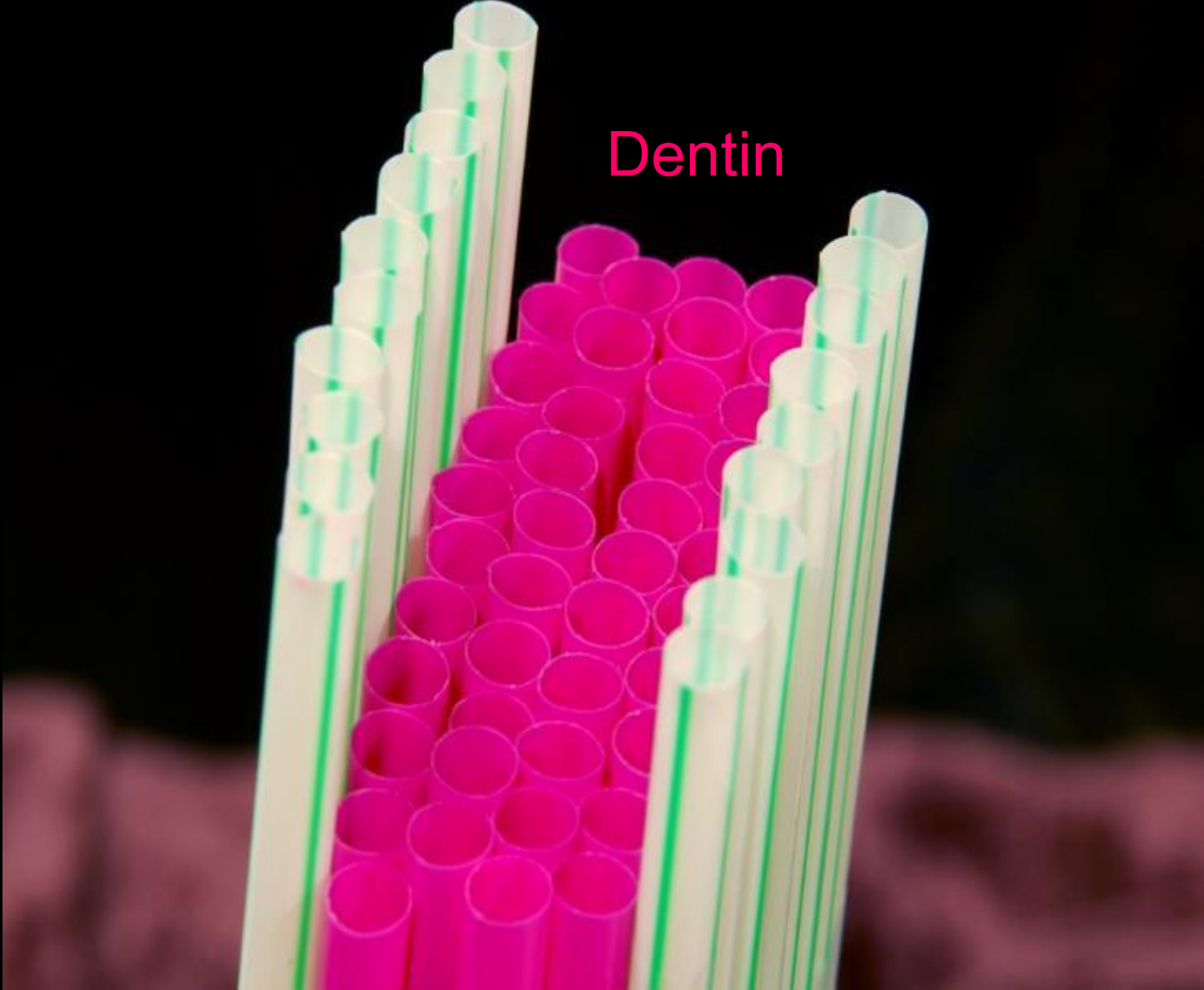
Enamel

Dentin



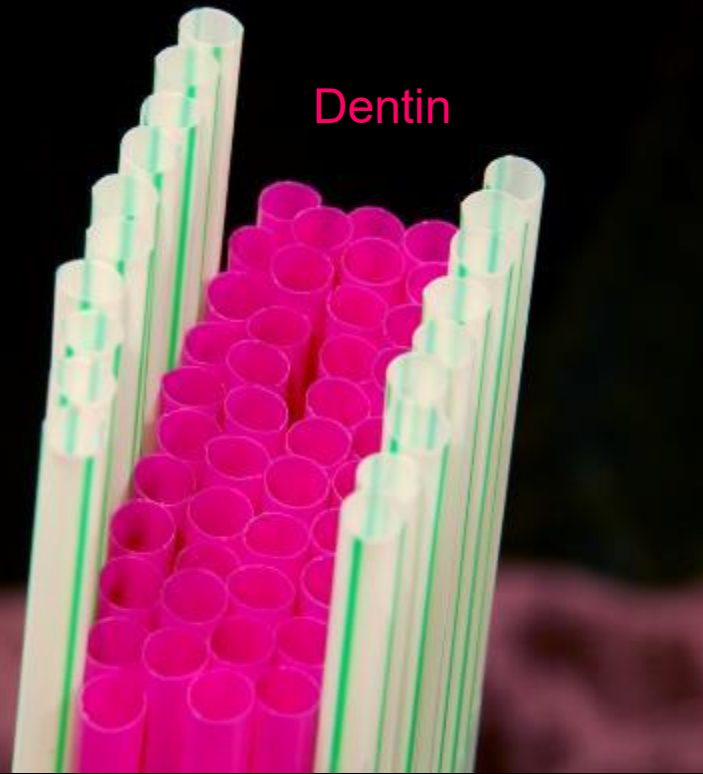
Enamel

Dentin

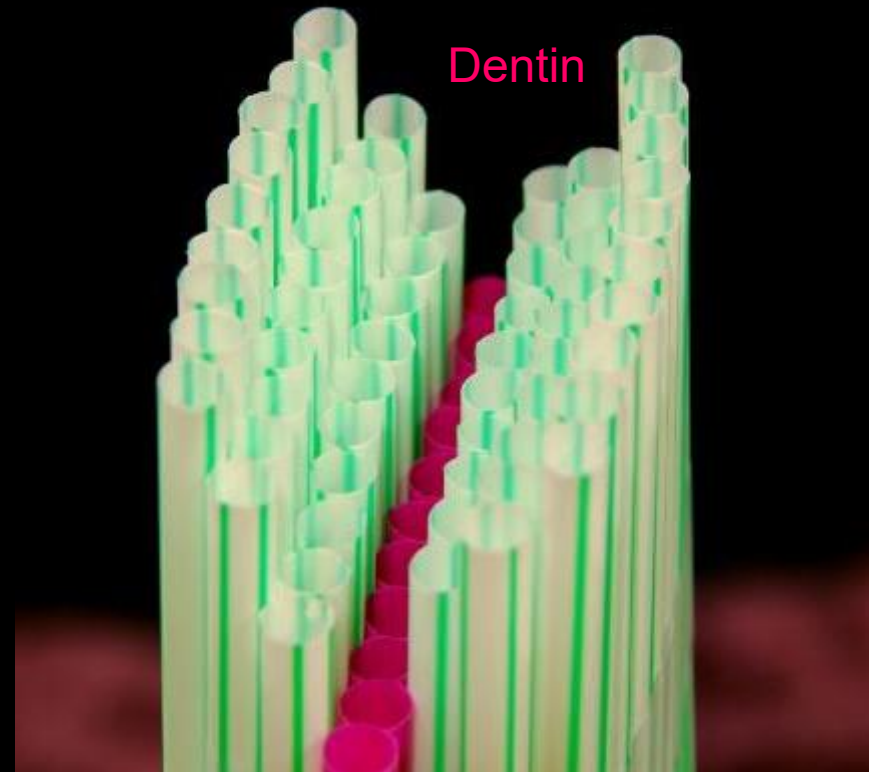


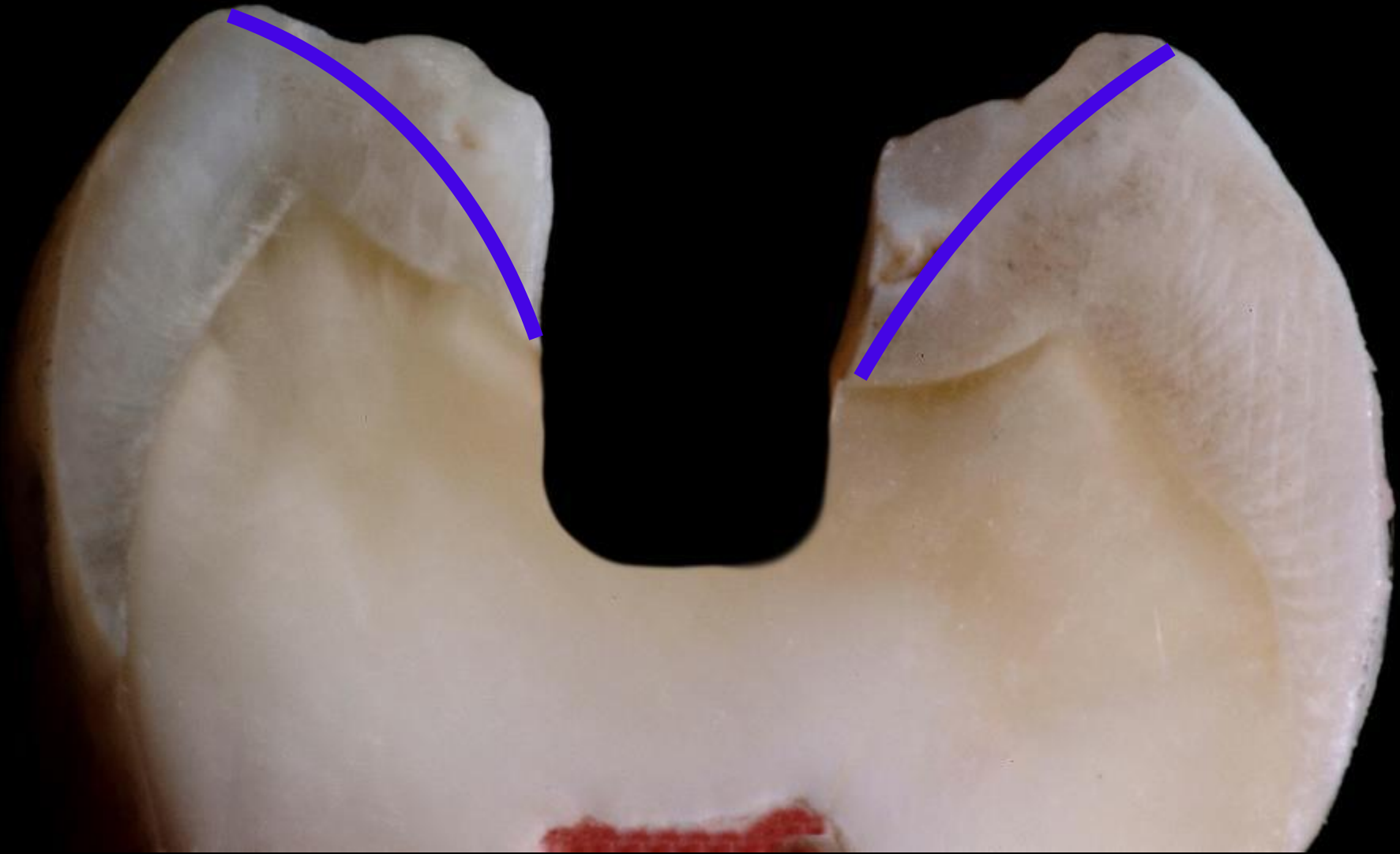
Do you trust enamel bonding or **dentin bonding**?

Enamel

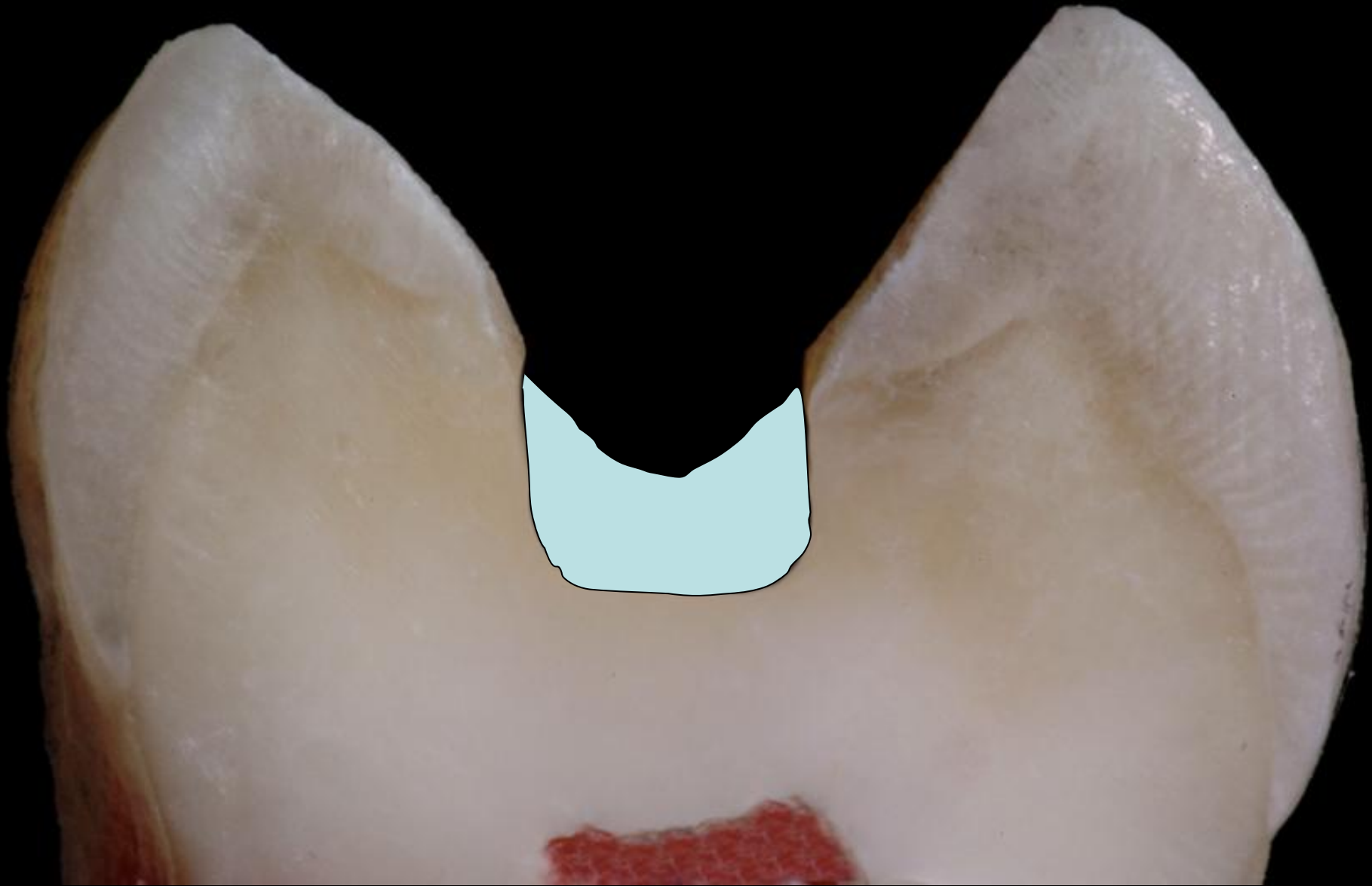


Enamel





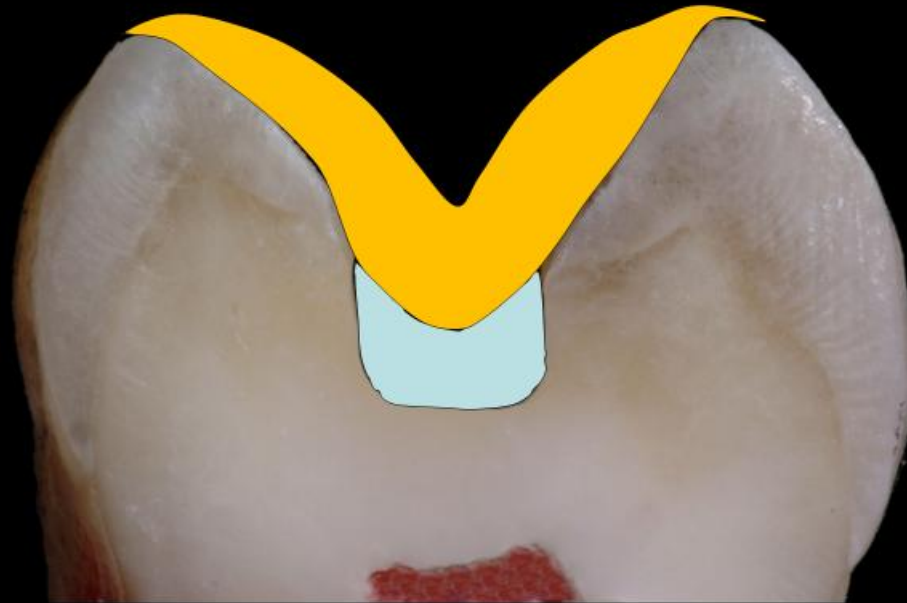








At what point will this tooth go from compression into tension, and vice versa?



Shape Optimization:
As operators we can ***flatten cusps*** or ***fill in the fossae*** (or both).



Enamel vs. resin composite

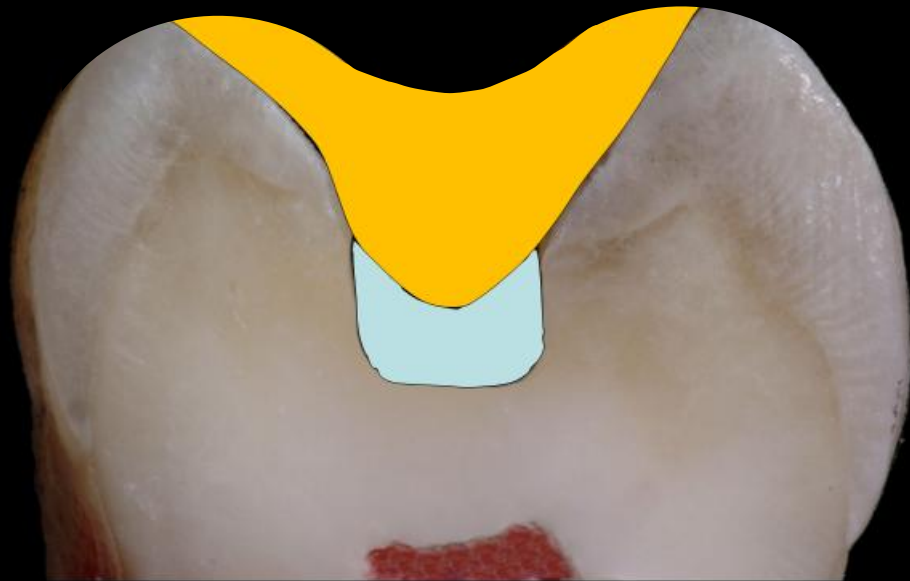


Enamel rods?

Resin composite



Shape Optimization:
Operators we can *flatten cusps* or *fill in the fossae* (or both).



OUCH!!!!!!



Man Copies Nature's Mistake:

Vertical Layering and Deep Continuous Grooves in a Brittle Material (Composite or Ceramic)





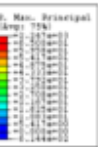




5 year post-op fracture of monolithic zirconia

Stress/Strain Concentration

- Abrupt changes in geometry
- Mismatches in mechanical properties
- Concentrated loads



Symptomatic Cracked Lower Molars: Bioclear Consult (2nd Opinion)

Julia's Seattle dentist has treatment planned her for at least one root canal and crown lower left 1st molar (#31 or 4-6)

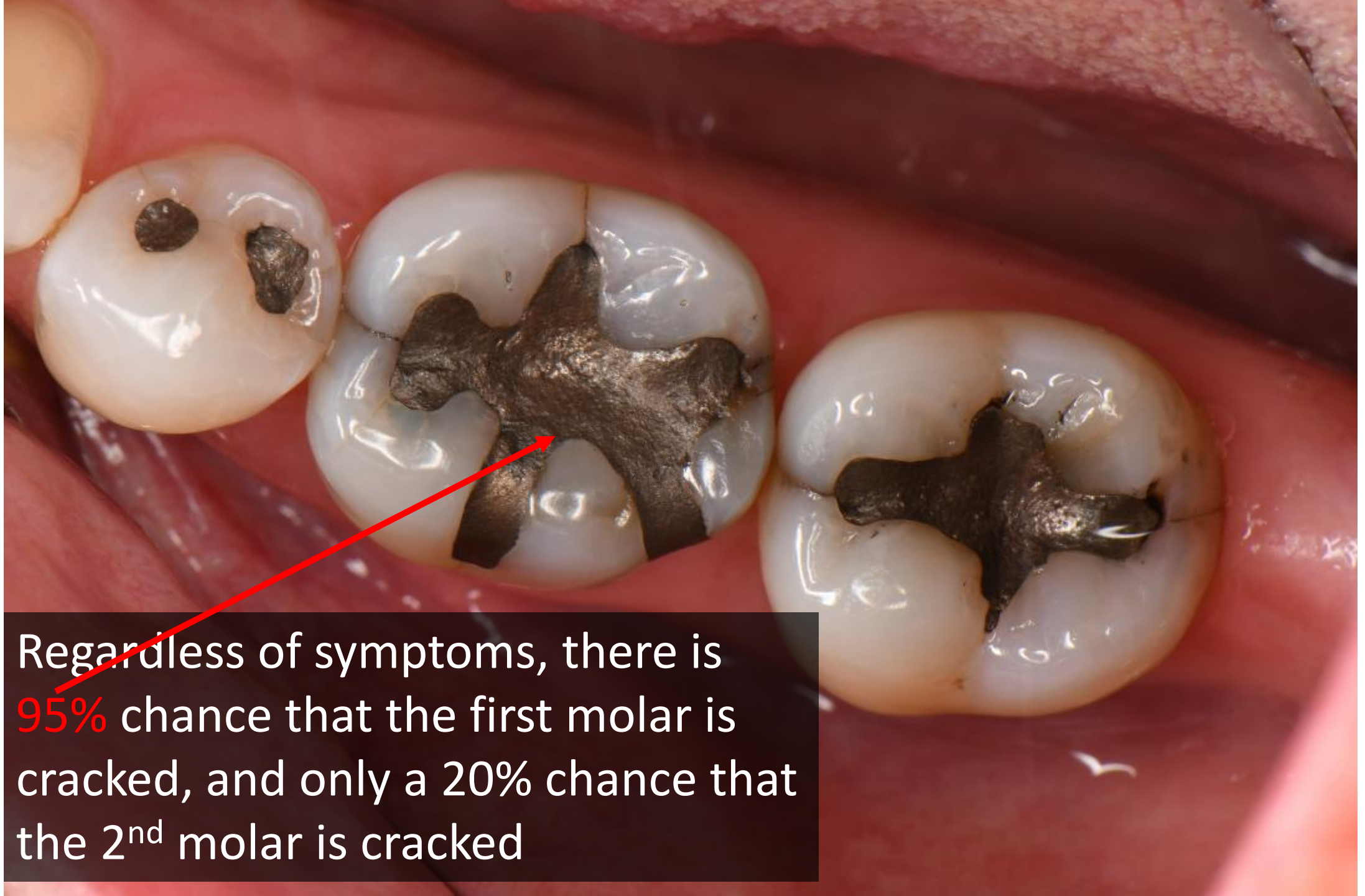
Meet Julia











Regardless of symptoms, there is **95%** chance that the first molar is cracked, and only a 20% chance that the 2nd molar is cracked



Regardless of symptoms, there is **95%** chance that the first molar is cracked, and only a **20%** chance that the 2nd molar is cracked





Julia: The wet cotton roll test **benefits:**

- **Trust:** Patient owns the diagnosis
- **Time:** Patients are often confused about which tooth is the problem, this saves time consuming and trust degrading debate
- **Efficiency and Prevention:** You may find two or more cracked teeth

Julia: The wet cotton roll test:

- For reversible pulpitis (RP) cases
- Irreversible pulpitis (IP) gets the percussion test
- Get one end of the cotton roll wet
- Patient holds on to the dry end
- Start at the canine (a negative control)
- Repeat the full test at least once

Julia: The patient driven wet
cotton roll test

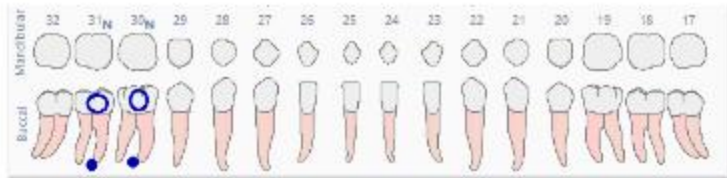


Julia: The wet cotton roll test:

- For reversible pulpitis (RP) cases (irreversible pulpitis (IP) gets the percussion test)
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- Start at the canine (a negative control)
- Repeat the full test at least once

Patient Name: Julian R.
Treating Doctor: David Clark
TX Date: 10/23/2023

Lower Arch



OPTION A

Existing restorations will be removed to place the Bioclear restoration. Important step to ensure monolithic color unity and strength to the Bioclear restoration.

- **Disassembly**

- Tooth # 30 \$150
- Tooth # 31 \$150

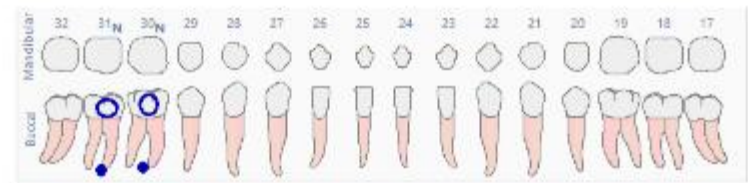
Posterior Overlay: Replace existing failing restorations, cracked tooth, rejuvenation of tooth appearance and color.

- **Bioclear Posterior Overlay**

- Tooth # 30 \$836
- Tooth # 31 \$836

Patient Name: Julian R.
Treating Doctor: David Clark
TX Date: 10/23/2023

Lower Arch



OPTION A

Existing restorations will be removed to place the Bioclear restoration. Important step to ensure monolithic color unity and strength to the Bioclear restoration.

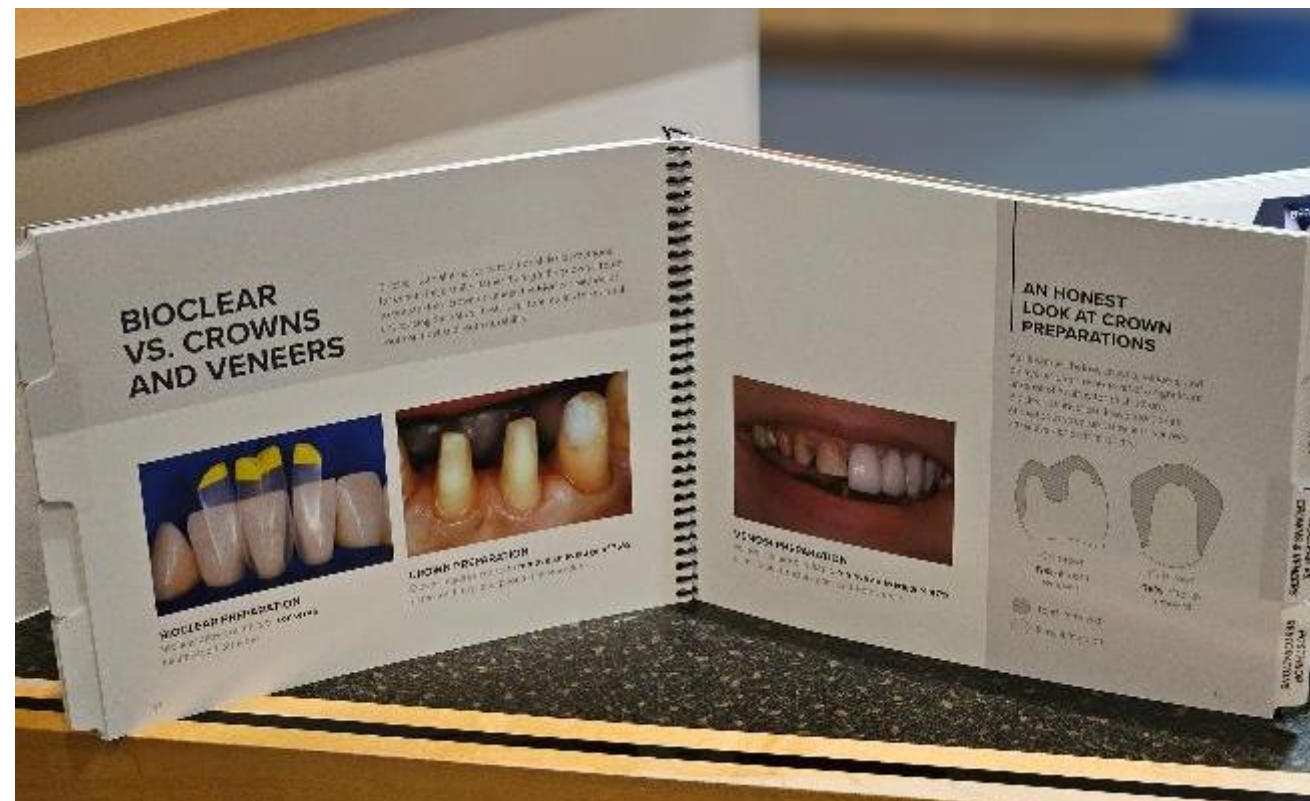
- **Disassembly**

- Tooth # 30 \$150
- Tooth # 31 \$150

Posterior Overlay: Replace existing failing restorations, cracked tooth, rejuvenation of tooth appearance and color.

- **Bioclear Complex Posterior Overlay**

- Tooth # 30 \$1,200
- Tooth # 31 \$1,200



We show her the patient book and cracked teeth pamphlet. Go straight to page 42. Then she chooses a crown or Bioclear. She will get a little insurance coverage for Bioclear. (We are PPO)

Getting paid to be conservative

BIOCLEAR VS. CROWNS AND VENEERS

Bioclear is an alternative to traditional dental methods for enhancing a smile. Rather than grinding down a tooth to prepare for a crown or veneer, the Bioclear Method of encasing the natural tooth structure retains the natural tooth enamel and tooth durability.



BIOCLEAR PREPARATION
Bioclear allows dentists to **conserve** healthy tooth structure



CROWN PREPARATION
Crowns require dentists to **remove an average of 76%** of the tooth structure prior to the procedure

AN HONEST LOOK AT CROWN PREPARATIONS

As Bioclear clear crowns, veneers and all-ceramic crowns are applied, a significant amount of the tooth structure is preserved. Traditional crown preparations remove 76% of the tooth structure. Bioclear only removes 4% of the tooth structure.

Preparation Method	Tooth Structure Removed
All Crowns	76% of tooth structure
Full Crowns	76% of tooth structure

VENEER PREPARATION
Bioclear clear crowns require an average of 4% of the tooth structure prior to the procedure.

- work crown
- grinding tooth



Julia's overlay treatment images





































Time to *harmonize* the occlusion





Before Harmonizing



After Harmonizing

Remember that composite absorbs 1% of its volume in water in 24 hours, so you need HYPO OCCLUSION on composite





What are the **modern occlusal** cavity preps?

1. Fissurotomy
2. Calla Lily
3. Flattened Calla Lily
4. Cuspal Overlay

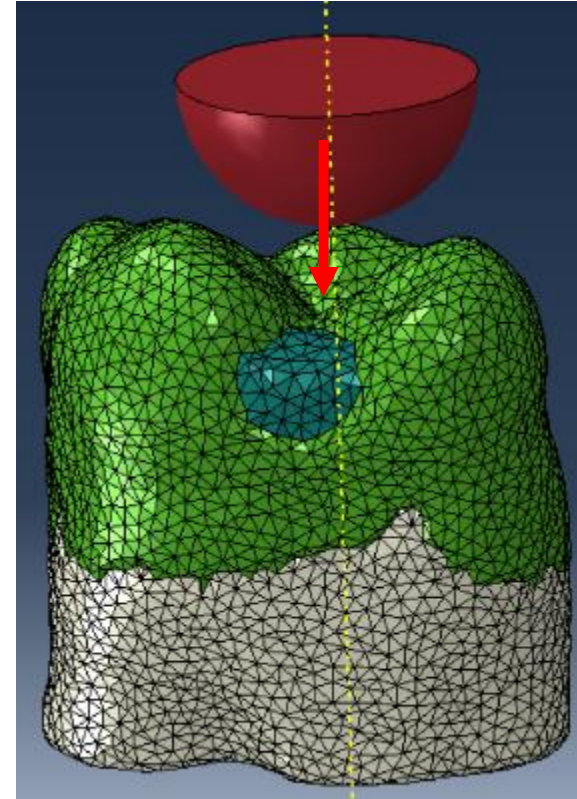
What are the modern Interproximal cavity preps?

1. Opportunistic Class II
2. Clark Class II...double serpentine,
additive and compression based
3. Clark Class II plus Lateral Partial
Cuspal Overlay

2. Finite Element Analysis of Stresses in Restorations due to Occlusal Loading

Methods

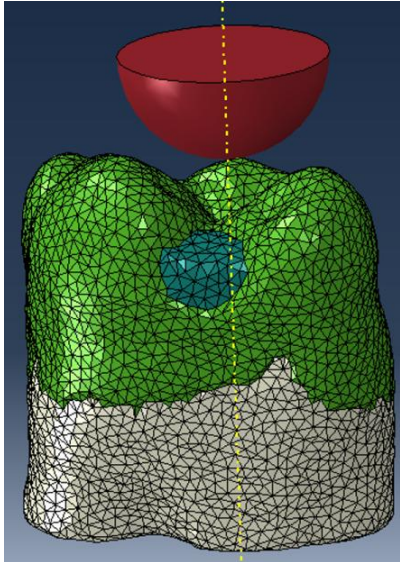
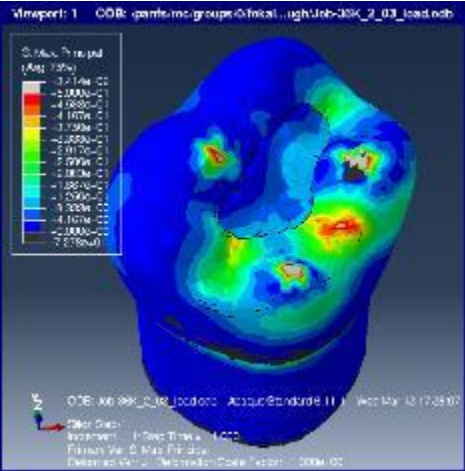
- Occlusal stress simulated by adding a hemisphere as an antagonist to the occlusal surface with downward vertical force (1000N) , resulting in three occlusal areas
- Principal stresses on the restorations and tooth were compared.



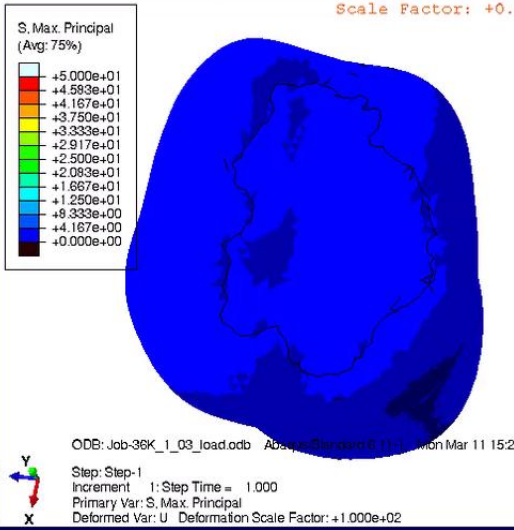
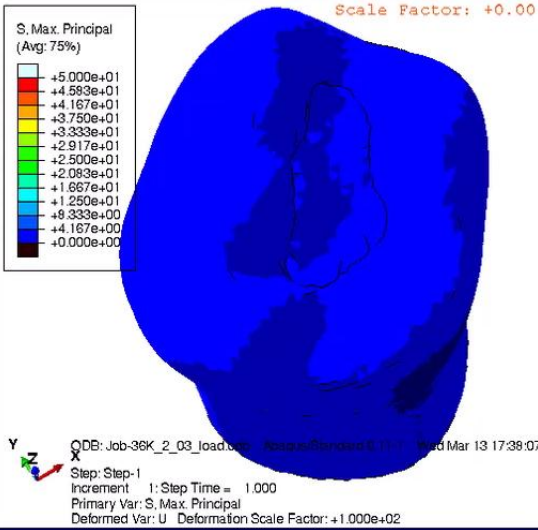
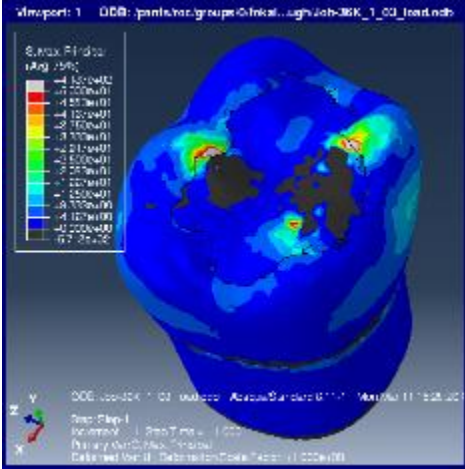
2. 3D Finite Element Analysis of Stresses in Class I Restorations due to Occlusal Loading

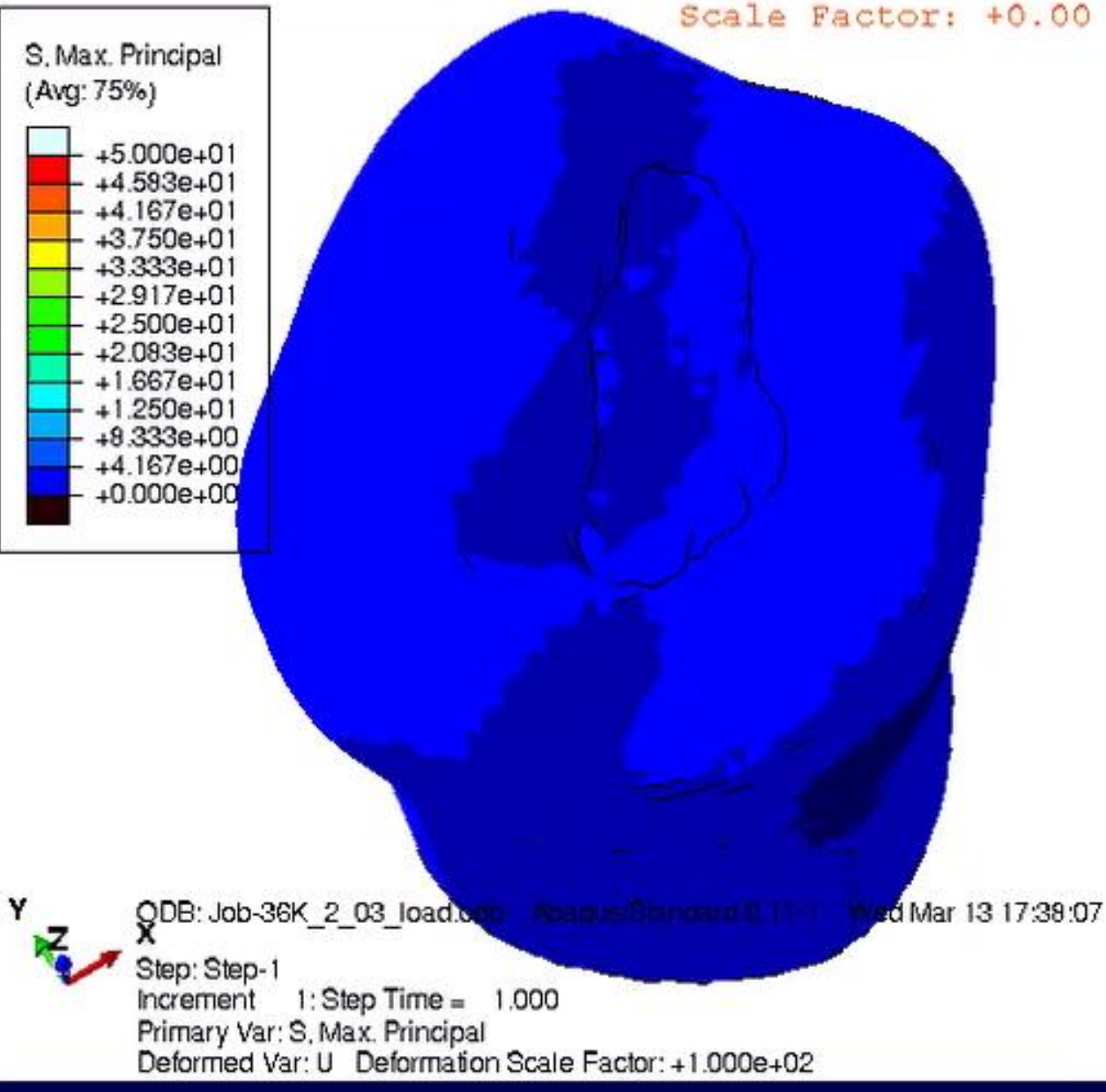
Max principal stress contours

Black

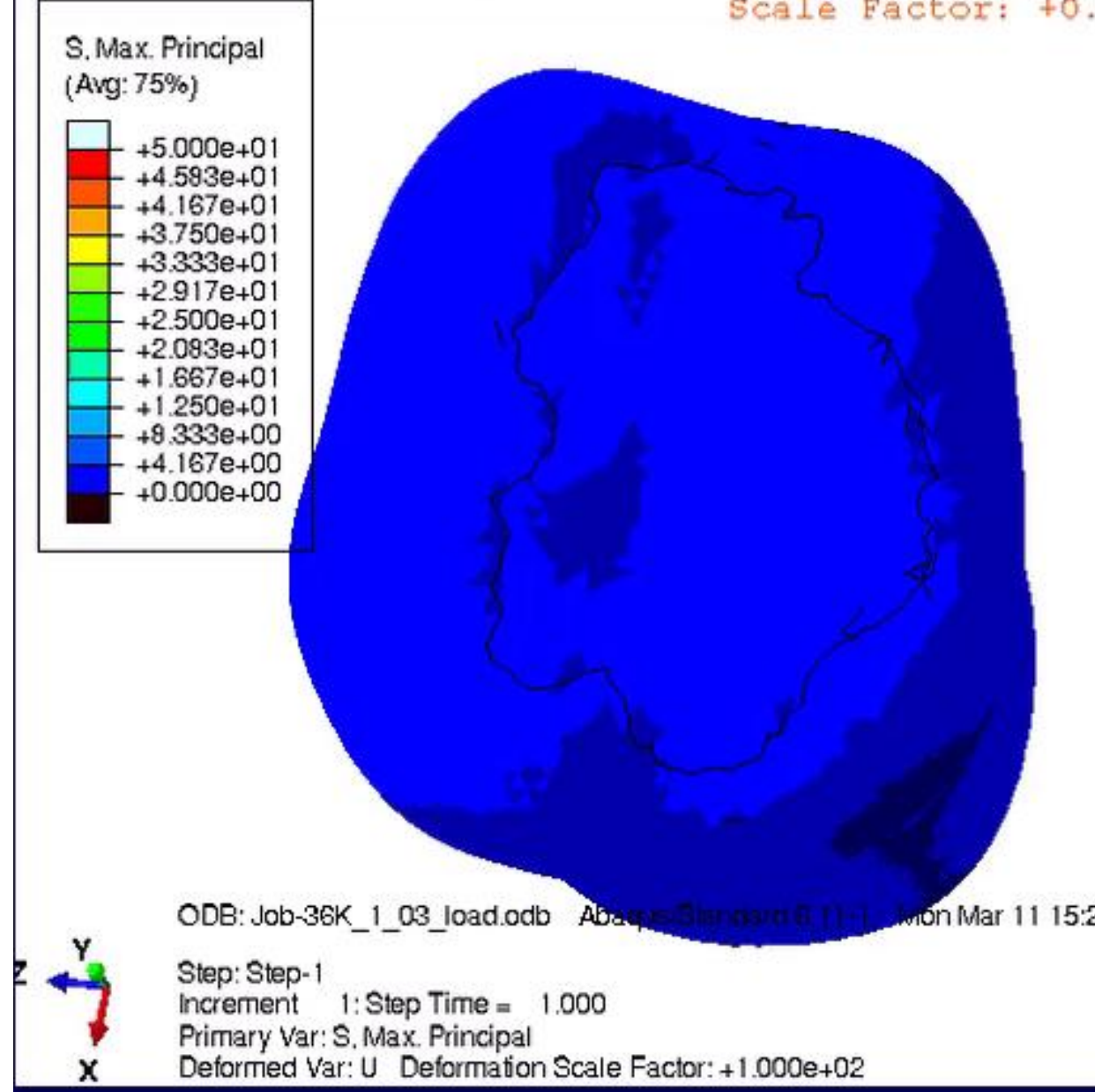


Clark





Black



Clark



Preliminary Mechanical Assessments of the Bioclear Method

Ning Ye BSc, MS

Hooi Pin Chew BDS, FDSRCS, PhD

Alex Fok PhD

Minnesota Research Center for Biomaterials and Biomechanics

Disclosure: This study was funded by 3M



UNIVERSITY OF MINNESOTA

Driven to Discover®













Pre-op



1 year follow up



1 year follow up



2 year follow up



7 year follow up



9 year follow up



9 year follow up



12 year follow up



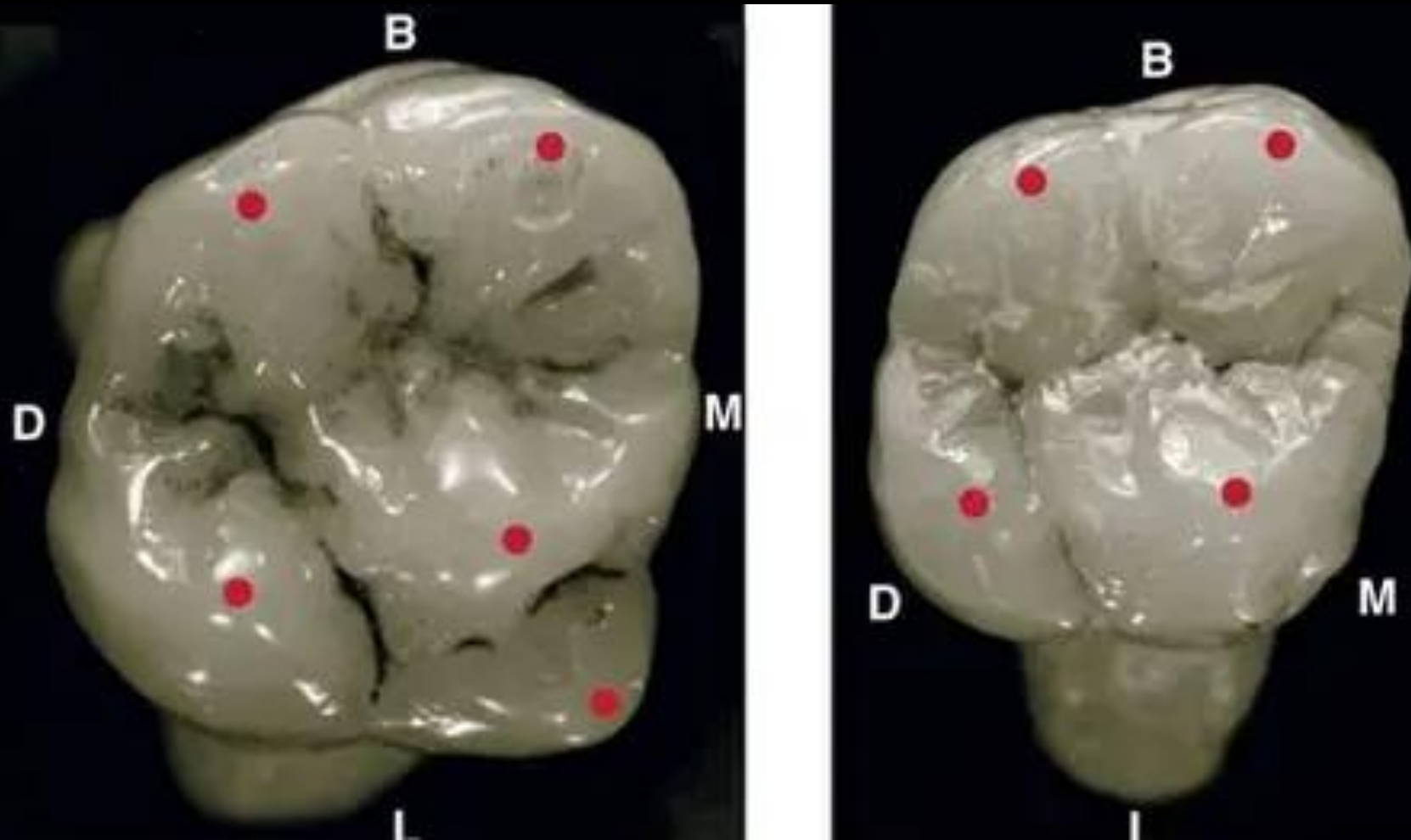
Pre-op



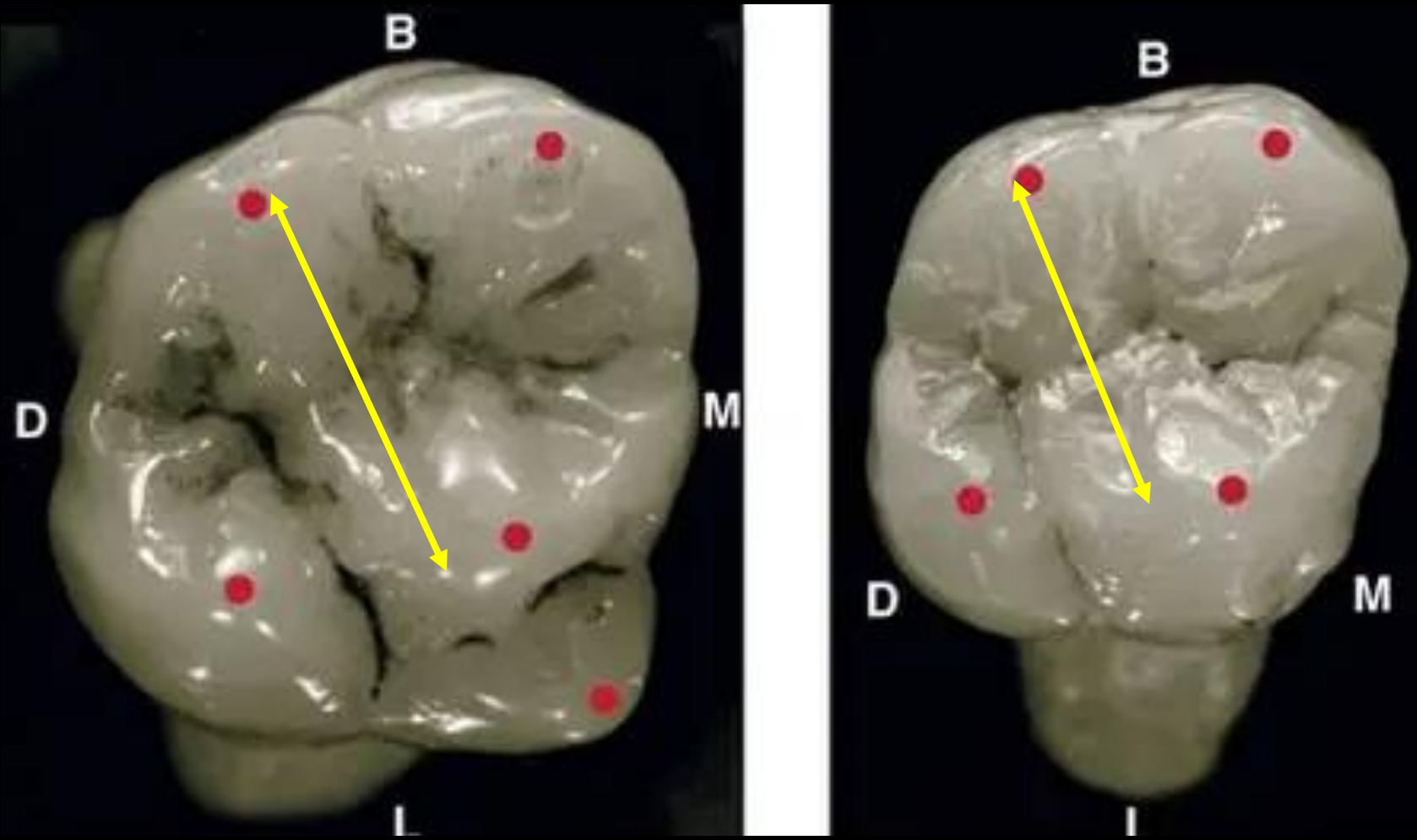
12 year follow up



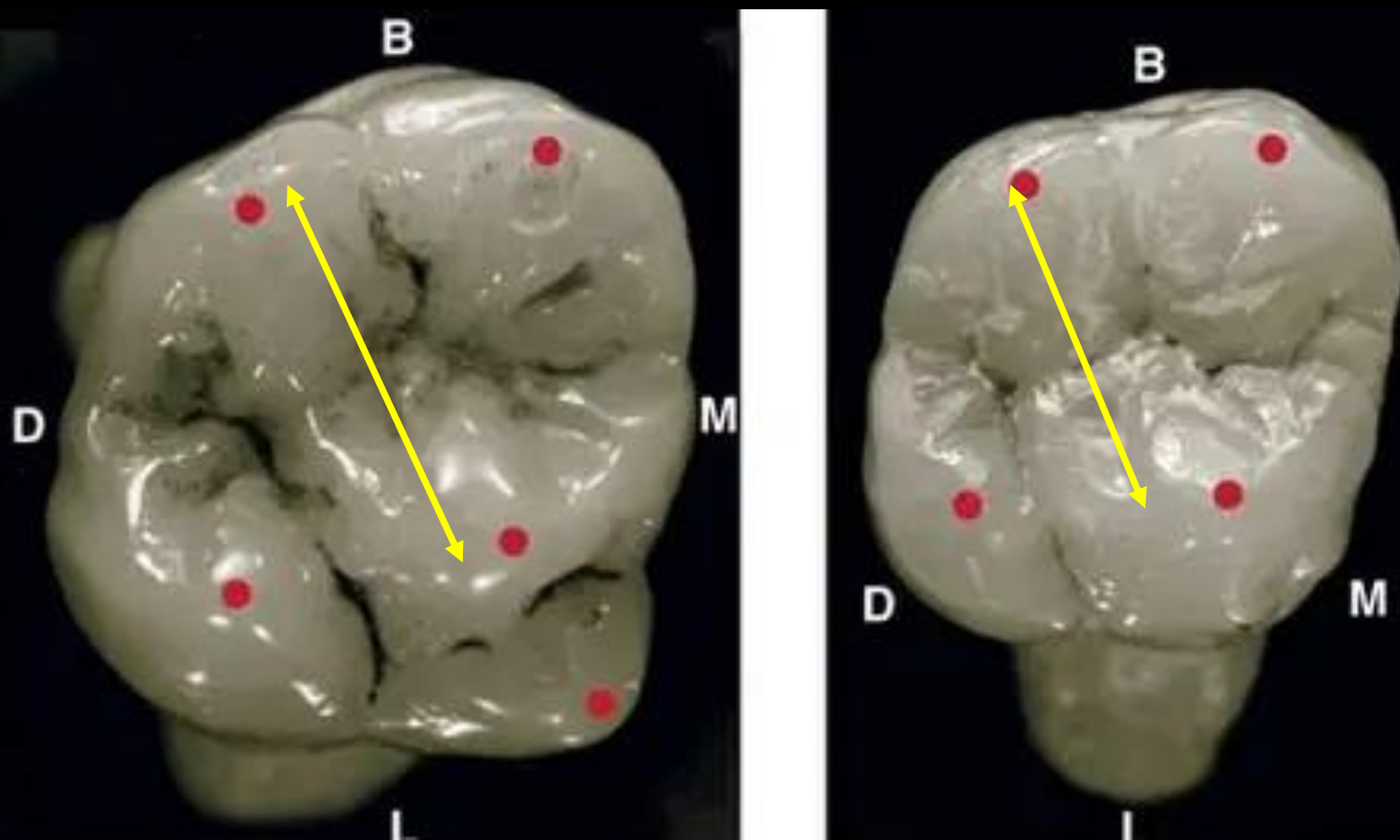
What unique trait does a maxillary first molar possess that protects it from cracking?



The oblique ridge



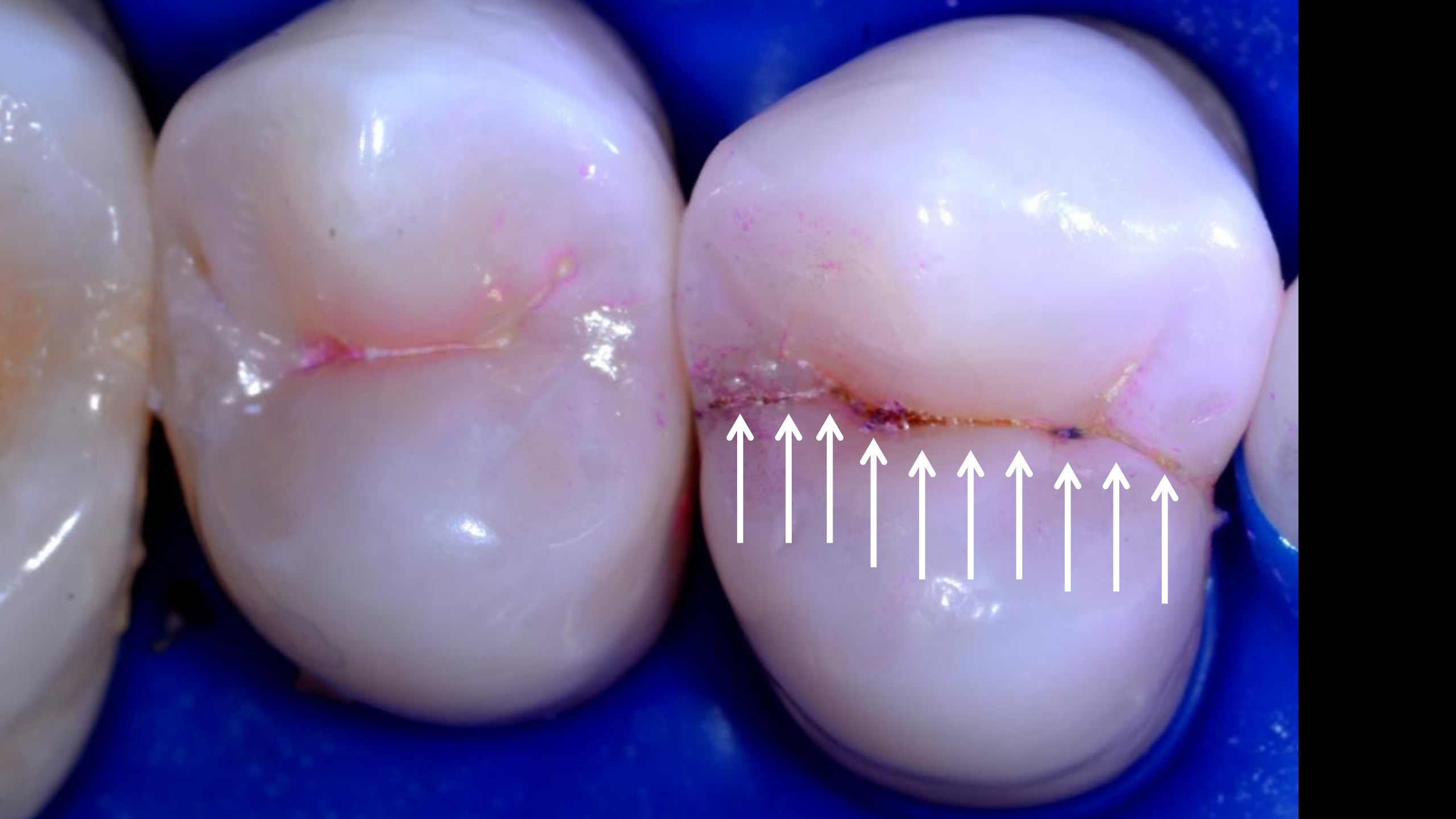
The oblique bridge



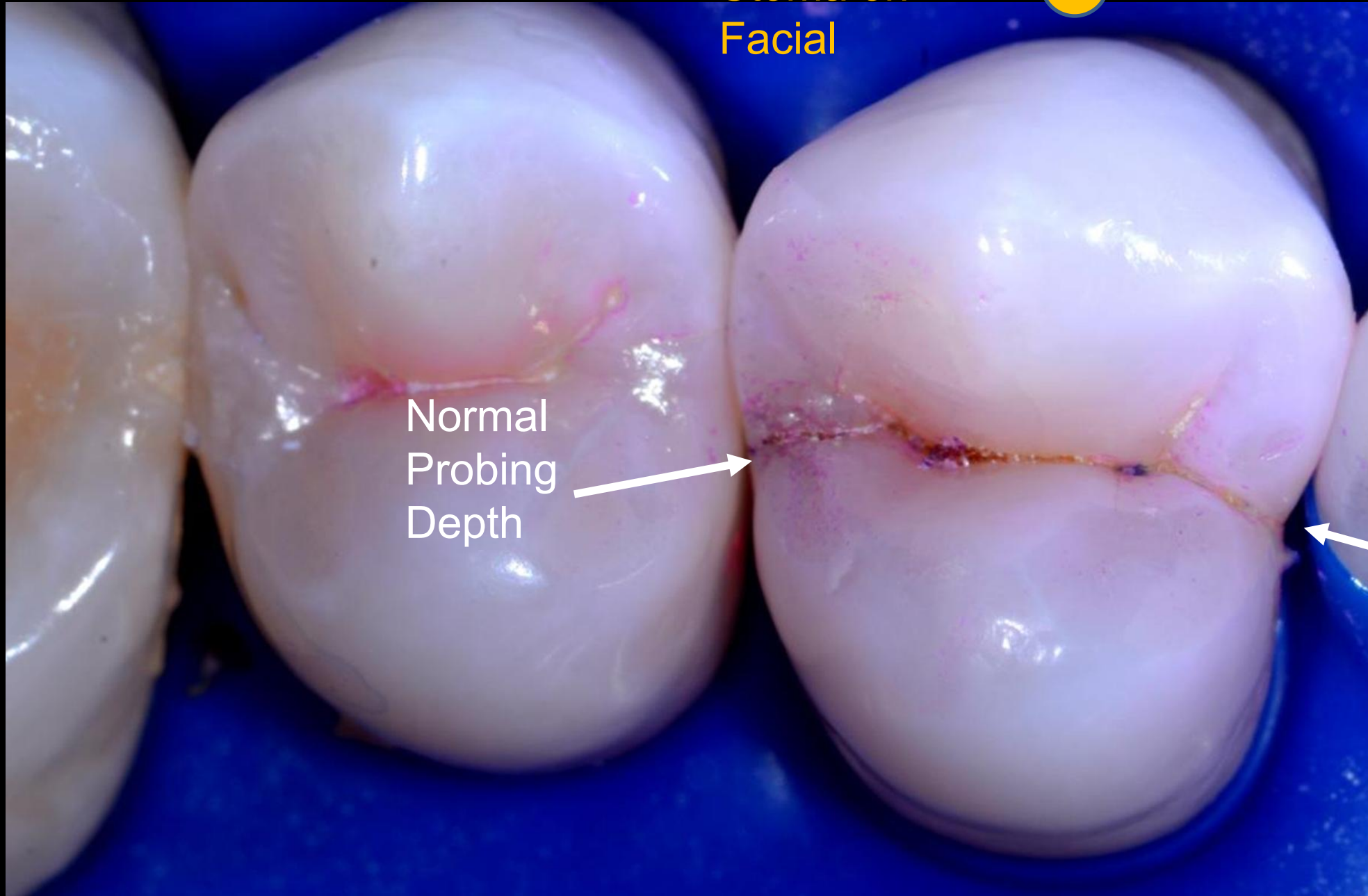
An Extreme Calla Lily Clinical Case

Patient heard a loud *snap* when he bit on a seed and now has severe cold and percussion pain





Stoma on Facial

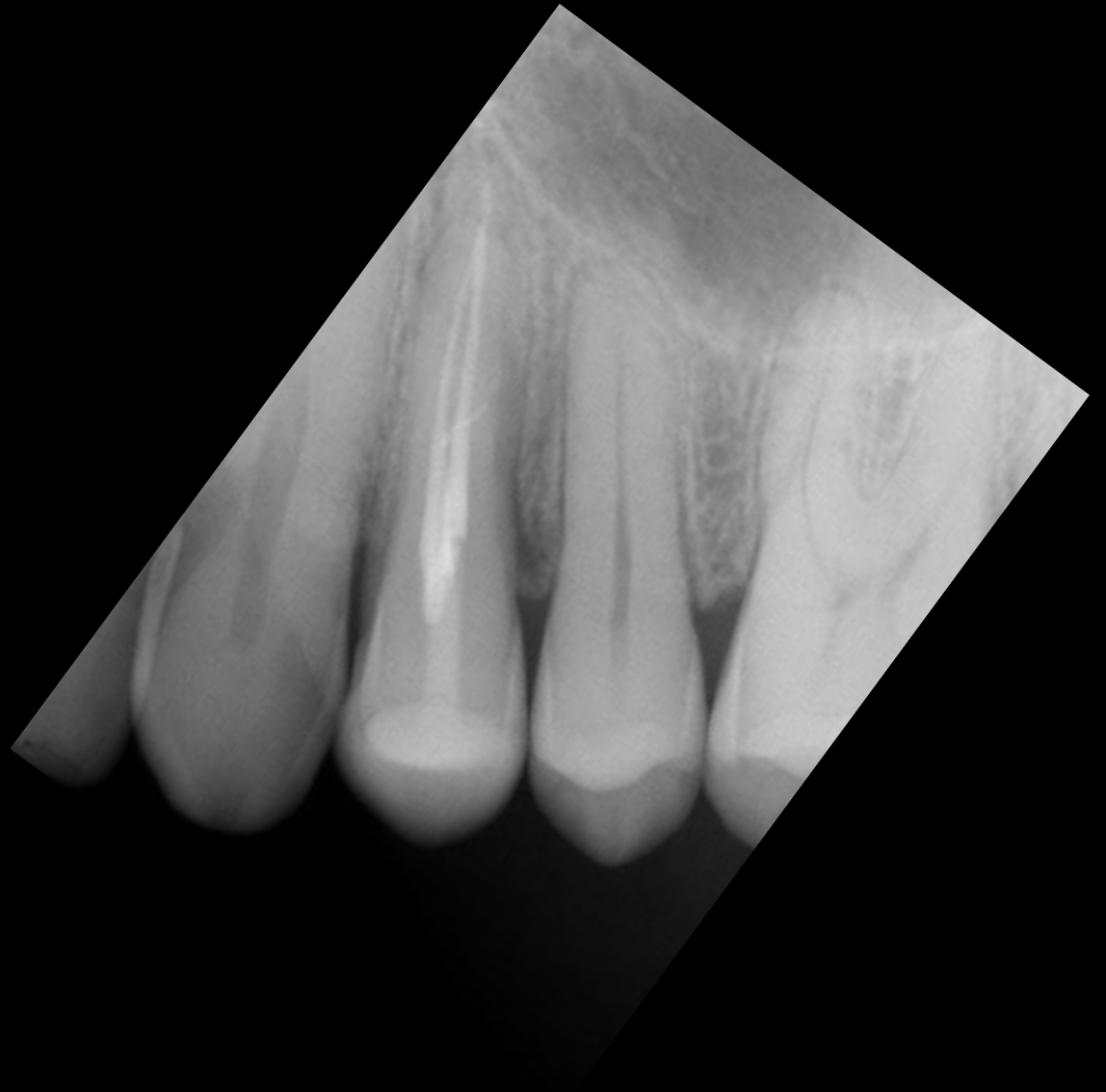


Normal Probing Depth



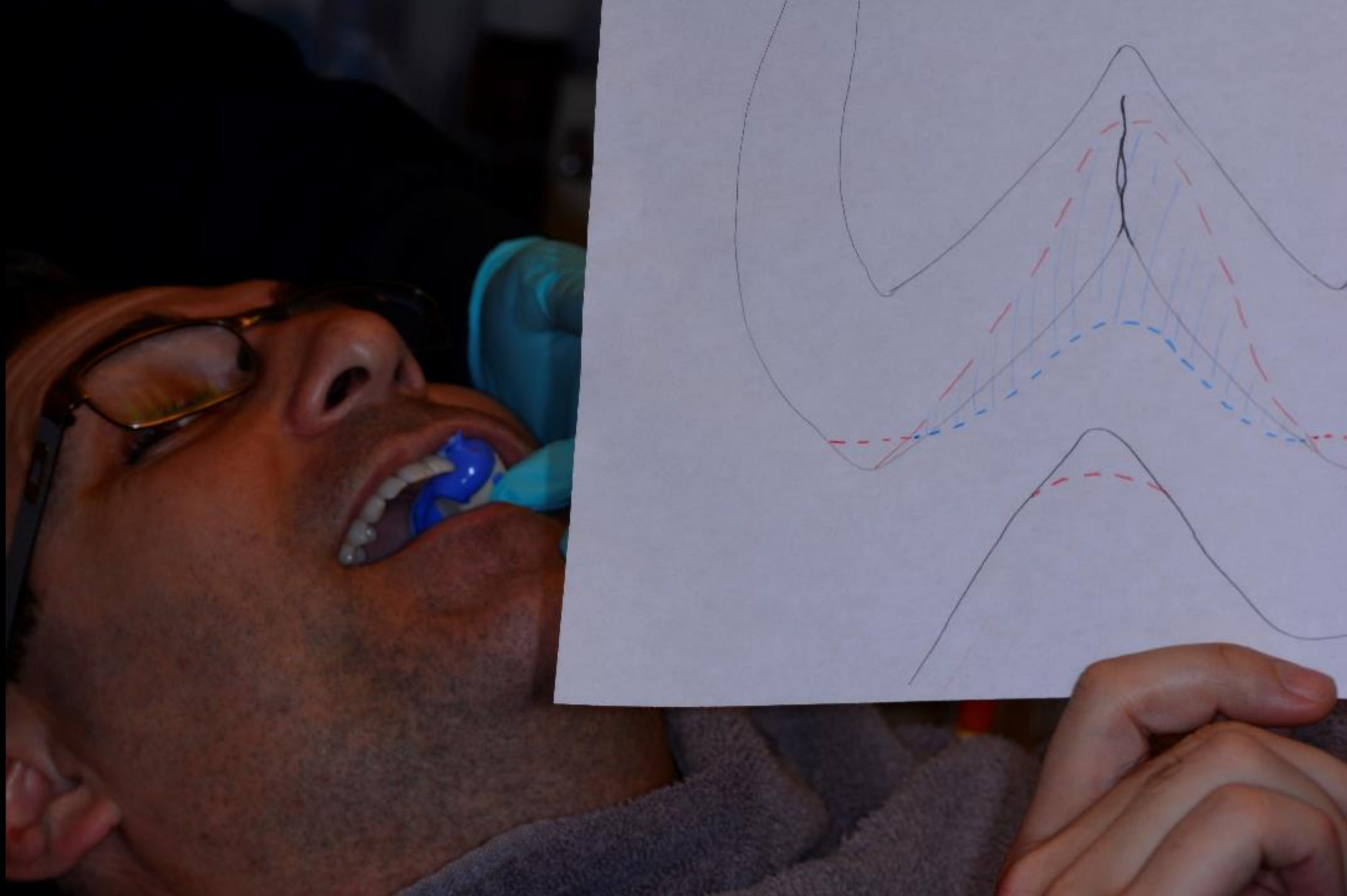
Normal Probing Depth











18 month follow up









“Build a bridge from buccal to lingual, and the crack(s) becomes dormant.”



Before



Before

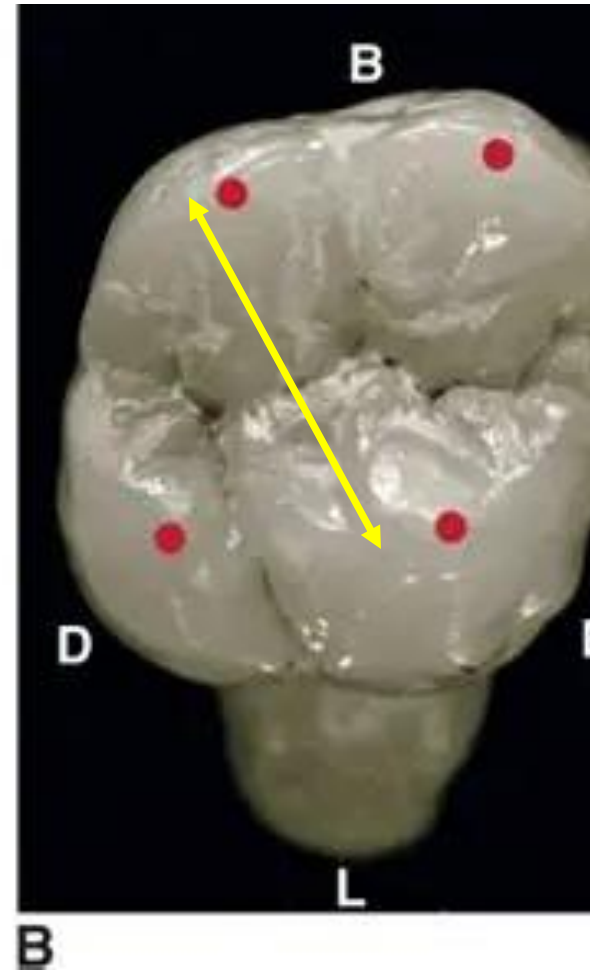
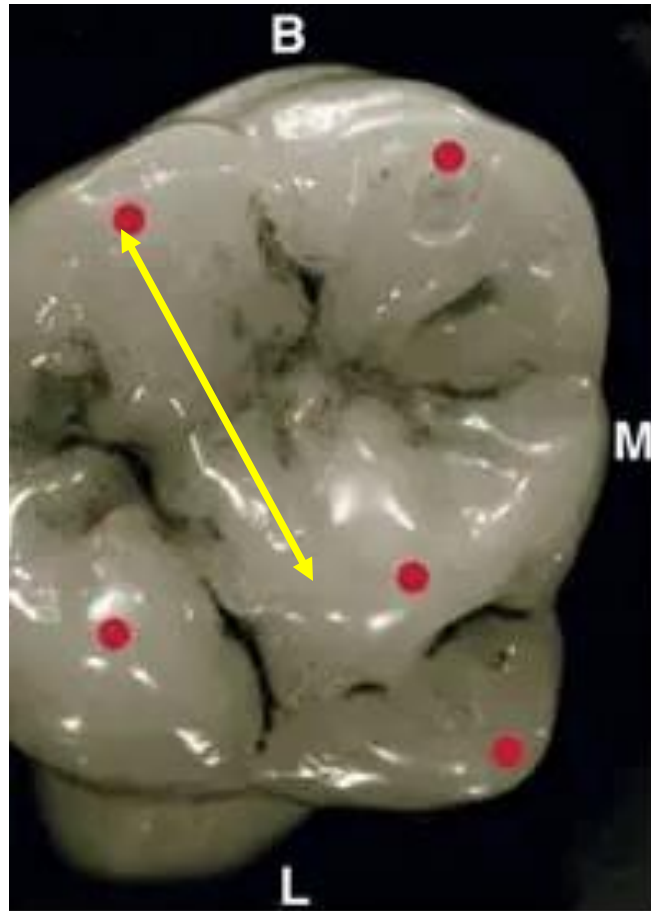
“That’s it”



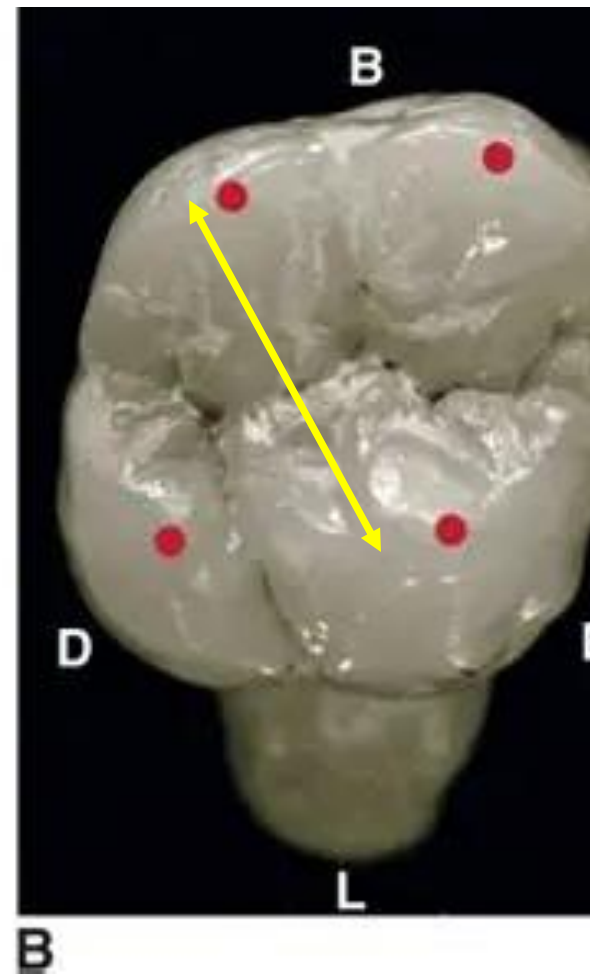
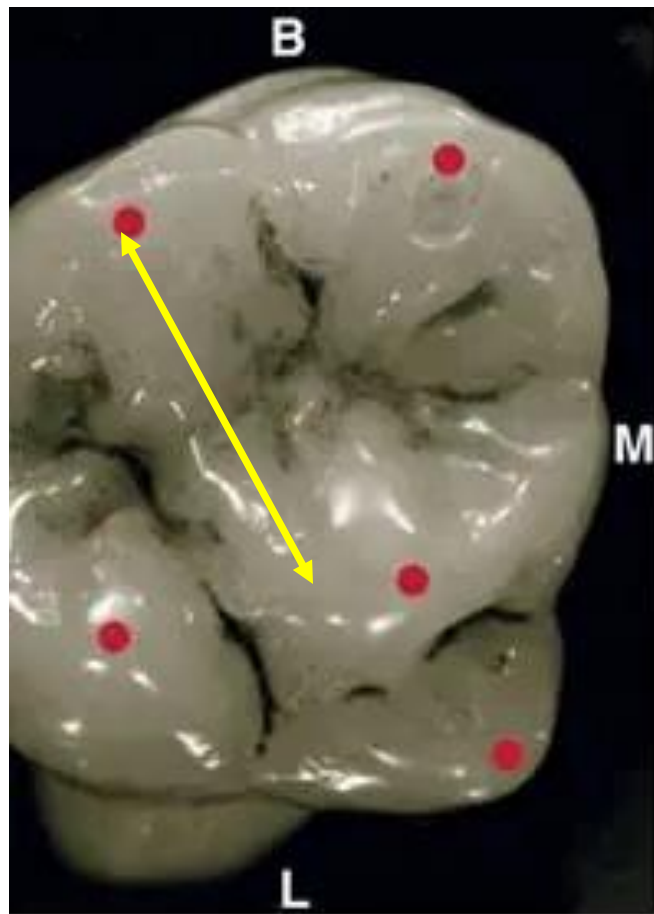
DR. ALEX FOK



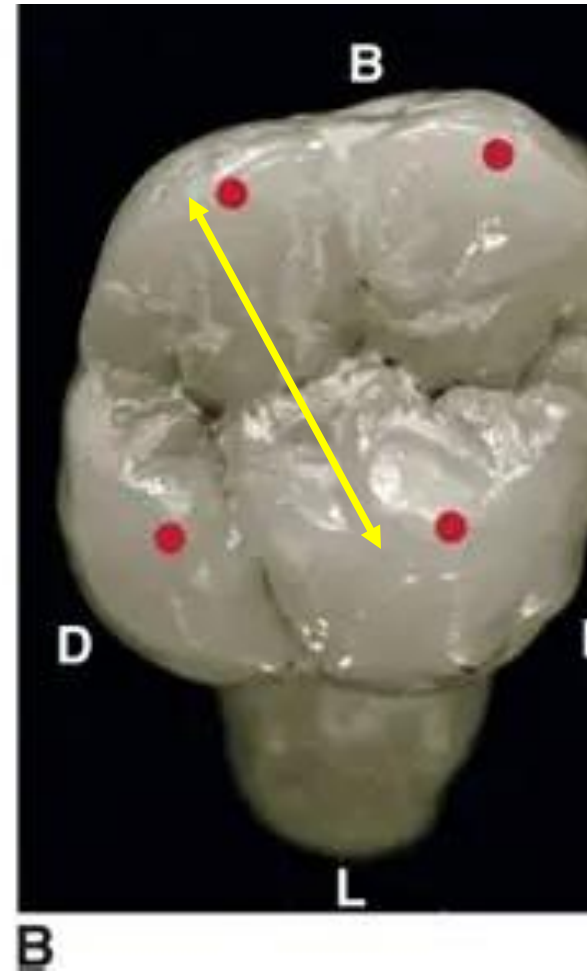
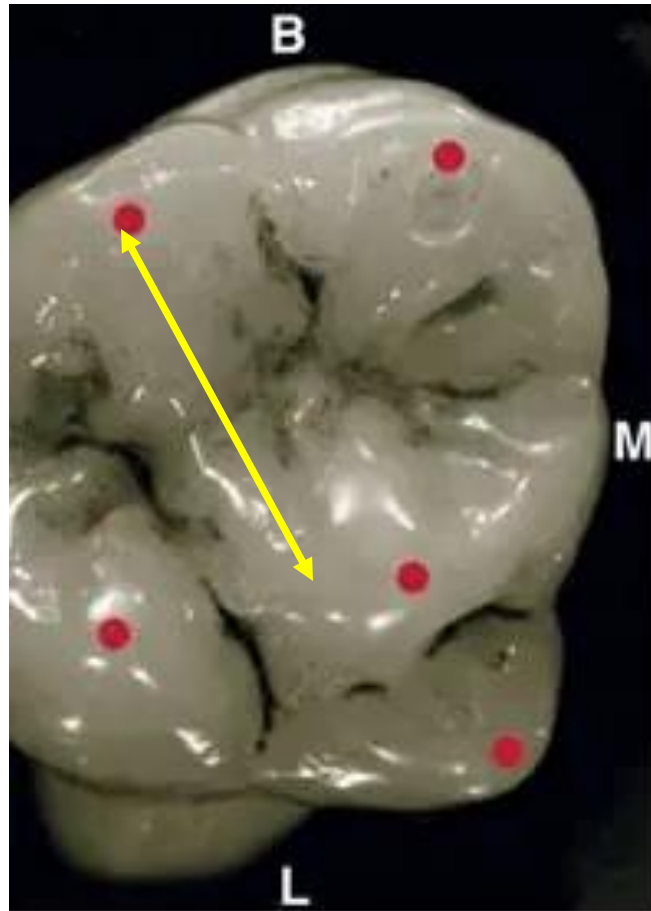
What unique anatomic feature exists in a maxillary first molar that protects the tooth from fracturing?



The Oblique Ridge



The Oblique Bridge



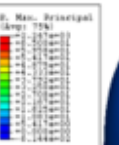
“David that’s not going to work, do a crown.”



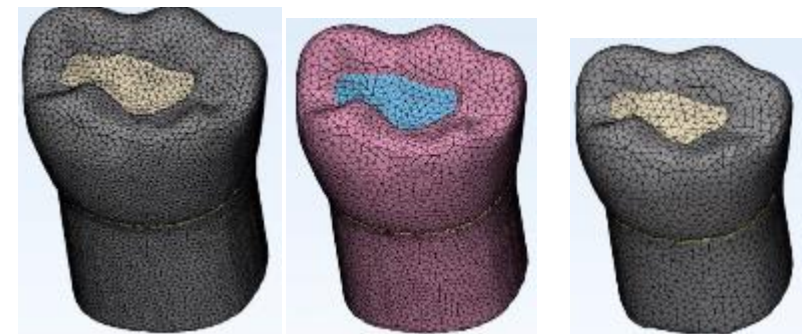
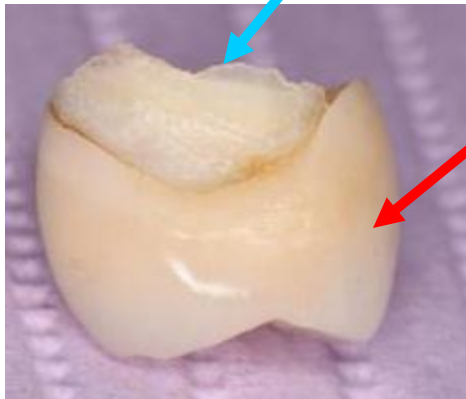
7 years post-op

Stress/Strain Concentration

- Abrupt changes in geometry
- Mismatches in mechanical properties
- Concentrated loads



	Elastic Modulus (GPa)	Poisson's Ratio	Effective Shrinkage Strain*
Composite	10	0.3	0.34%
Dentin	18	0.2	NA
Enamel	48-80	0.23	NA
Gold	79		
Zirconia	200		



[1] Alex SL Fok, Dent Mater, 2013

- Why things break...
- Modern cavity preparations
- Injection Molding of composite
- FEA of both load and shrinkage
- Long term outcomes & case studies
- The Bioclear Method as a “3rd option”

■ When to do endo, when to extract



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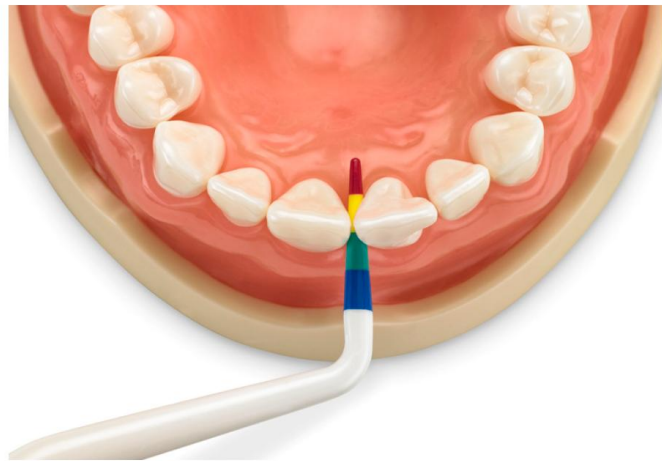
Tacoma USA · Solihull UK
Varberg Sweden · Cairo Egypt
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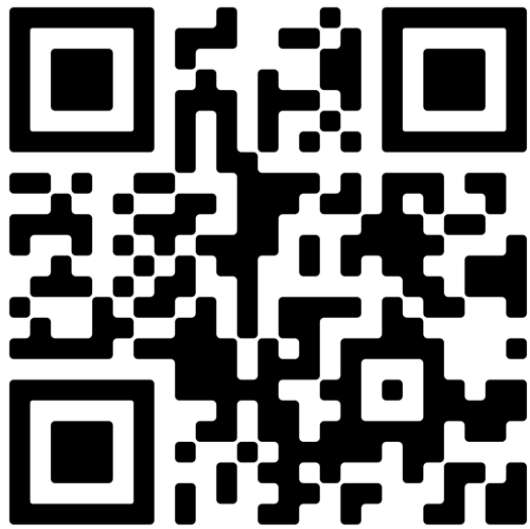
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- Why things break...
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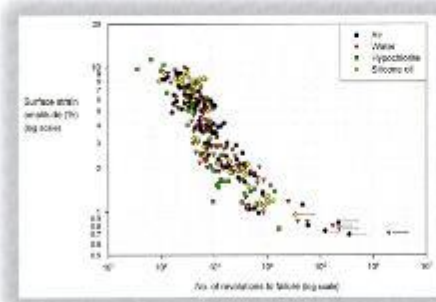
■ When to do endo, when to extract

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2007



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Association of Pulpitis in a Cohort of 796 Cracked Teeth

Basic page 1430

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Case Report page 1484

Nerve Damage Associated with Overextended Obturating Material



Official Journal of the American Association of Endodontists

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Key Words

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doi:10.1016/j.joen.2007.08.015

The Fall/Winter 1997 AAE Colleagues for Excellence article entitled "Cracking the Cracked Tooth Code" (<http://www.aae.org/NR/rdonlyres/7D73B05C-FEE4-4B00-AB57-086056F163BC/0/bw97ecfc.pdf>) defined 5 types of tooth cracks. Four of the 5 cracks are associated with coronal defects generated from chewing and biting events (1). Teeth with craze lines have no pain, show lines in the enamel, but no "shadows" in the dentin with transillumination. Teeth with fractured cusps have mild pain to biting on a specific cusp, usually a marginal ridge and buccal or lingual groove crack in the dentin, seen as a shadow with transillumination and a Class II restoration. Removal of the restoration might result in the cusp breaking off. Cracked teeth might or might not have a restoration, will exhibit acute pain on mastication, early brief pain to cold, centrally located mesial-to-distal marginal ridge crack(s) seen in the dentin as a shadow(s) with transillumination, normal-to-deep periodontal probing associated with the crack, no detectable movement of cusps with an explorer, and might require removal of existing restorations to definitively diagnose. The pulpal and periapical diagnoses are dependent on the extent of the crack and duration of the symptoms. Split teeth usually have marked pain to chewing, can be considered an extension of the cracked tooth, have mesiodistal cracks extending across both marginal ridges with detectable buccal and lingual cusp separation with an explorer, and deep probing with both marginal ridges. Vertical root fractures begin in the roots of teeth that usually have had endodontic treatment, extend in the buccal-to-lingual plane, usually have minimal signs or symptoms, might have normal probing, and require surgical assessment to complete the diagnosis.

The treatment of teeth diagnosed as a cracked tooth has largely been variable and empirical. The Fall/Winter 1997 AAE Colleagues for Excellence article entitled "Cracking the Cracked Tooth Code" suggested "the treatment plan will vary depending on the location and extent of the crack" and noted that "any thermal sensitivity probably indicates the crack extends near or into the pulp, and root canal treatment will be necessary prior to restoring the tooth with a crown" (1). The juxtaposition to assuming the tooth will need root canal treatment before the crown is to place the crown first, see whether symptoms subside, and only perform root canal treatment when the pulpal and periradicular status dictates treatment. Ailor (2) presented a "flow chart" that took into consideration the pulp status at the time of discovery of the crack. He suggested temporizing the tooth with a temporary crown and monitoring it for symptoms.

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Dec 2007



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6 year
evaluation
.....the first
study of
its kind



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127 teeth
with R.P.
were
restored
with crowns
and NO
ENDO

TABLE 1. The Number and Percentage of Cracked Teeth by Tooth Position in the Mouth

	Maxillary Second Molar	Maxillary First Molar	Maxillary Second Premolar	Maxillary First Premolar	Mandibular Second Molar	Mandibular First Molar	Mandibular Second Premolar	Mandibular First Premolar	Totals
Cracked	71	167	46	25	243	231	12	1	796
Total	835	1879	754	549	1380	2100	456	222	8175
%	8.50	8.89	6.10	4.55	17.61	11.00	2.63	0.45	9.74

Materials and Methods

There were 8175 patients included in this study from a private endodontic practice population during a 6-year period. The patients were recorded consecutively as they were referred to the endodontist for evaluation and appropriate treatment during the 6-year period. Besides the standard medical history and subjective history, the endodontist was responsible for the diagnosis of all teeth and recorded the following information for all teeth:

- (1) Pulpal response to cold or hot.
- (2) Periapical response to pressure, palpation, and percussion.
- (3) Buccal and lingual periodontal probings were recorded in the mesial and distal interproximal spaces and furca. These interproximal probings would be directed precisely where marginal ridge cracks were identified to indicate the deepest probing of the crack. A total of 6 probing points were recorded for each tooth.
- (4) Identification of a crack(s) with direct transillumination and visualization with and without magnification. The identified crack had to block light transmission and show a definite shadow with both the buccal and lingual coronal light placement. Teeth not exhibiting a shadow were considered to have "crazings" and were not included in this study.
- (5) Responses to biting on various cusps of the diagnosed tooth, with at least 1 cusp exhibiting pain to biting on either a burlew wheel or Tooth Slooth (Professional Results, Inc, Laguna Hills, Calif).

Teeth were diagnosed with RP if (1) there was no history of spontaneous pain; (2) the response to cold went away in less than 3–5 seconds; (3) there was no radiographic pathology.

No teeth were included in this part of the study that could not be confirmed by visualization as having an identifiable crack even if biting sensitivity was present. Restorations were removed only for patients with pulpal diagnoses that required root canal treatment. Teeth diagnosed as cusp fractures, split teeth, and vertical root fractures were also excluded from this study (6). All patients were recalled at 1 year unless root canal treatment was needed before the anniversary, then recall was 1 year later after treatment. The recall therefore extended into a seventh year of the data collection.

All cases were treatment planned according to the pulpal and periapical diagnosis. Cases with RP were treatment planned for crowns only, regardless of periapical diagnosis.

TABLE 2. The Number and Percentage of Cracked Teeth by Tooth Position with RP Eventually Requiring Root Canal Treatment

	Maxillary Second Molar	Maxillary First Molar	Maxillary Second Premolar	Maxillary First Premolar	Mandibular Second Molar	Mandibular First Molar	Mandibular Second Premolar	Mandibular First Premolar	Totals
Cracked	12	33	8	4	29	41	0	0	127
REV. > IP or NEC.	3	9	0	0	8	7	0	0	27
%	25	27	0	0	28	17	0	0	21

REV, reversible pulpitis; IP, irreversible pulpitis; NEC, necrosis.

Results

Of the 8175 cases seen during the 6-year period, 796 cases were diagnosed as cracked teeth (9.7%). Mandibular second molars (243/796, 30%) had the largest incidence followed by mandibular first molars (231/796, 29%) and maxillary first molars (167/796, 21%). All teeth are included in Table 1.

Cases with RP had the following distribution: mandibular first molars (41/127, 32%), maxillary first molars (33/127, 25%), and mandibular second molars (29/127, 23%). All teeth are included in Table 2.

Of 127 patients specifically diagnosed with RP, 27 converted to irreversible pulpitis (N = 21) in 58 days or to necrotic pulp (N = 6) in 149 days. The distribution of teeth requiring root canal therapy was as follows: maxillary first molars (9/27, 33%), mandibular second molars (8/27, 29%), mandibular first molars (7/27, 26%), and maxillary second molars (3/27, 11%).

All teeth had initial interproximal probings less than 3 mm in the space associated with the identified crack. Increased interproximal probings were associated with the fractured marginal ridge for only 5 of the 27 teeth requiring root canal treatment. The greatest increase in probing depth was 2 mm for 2 of 5 teeth.

The teeth requiring root canal treatment had the crack located on the distal marginal ridge in 15 of the 27 cases (56%). The distribution was mandibular second molars (6/27, 27%), mandibular first molars (3/27, 11%), maxillary first molars (3/27, 11%), maxillary second premolars (2/27, 7%), and maxillary second molars (1/27, 4%). The crack was located only on the mesial marginal ridge in 4 of the 27 cases (15%). The distribution was the maxillary first molars (3/27, 11%) and maxillary first premolars (1/27, 4%). Both marginal ridges were involved in 8 of the 27 cases (29%). The distribution was mandibular first molars (5/27, 19%), maxillary first molars (2/27, 7%), and maxillary second molars (1/27, 4%). None of the teeth had fractures that extended into the floor of the chamber or rendered them "non-restorable".

None of the original remaining 100 cases of RP required root canal treatment.

Discussion

The patients who composed this database were all patients referred to a private practice endodontist. Our incidence data are in agreement with the findings of Weine et al (5), which were also derived from an endodontist's practice. The difference in percentages from

What are the 5 questions you ask to distinguish R.P. ?



Discussion

Table 1. Mean values of the variables measured in the study.

Variable	Mean	SD	Min	Max
Age (years)	35.2	10.5	20	65
Gender (male/female)	15/15			
Smoking status (smoker/nonsmoker)	10/10			
Duration of disease (years)	12.5	8.5	2	35
Number of teeth affected	1.8	1.2	1	3
Number of teeth restored	1.5	1.0	1	2
Number of teeth extracted	0.5	0.8	0	2
Number of teeth with root canal treatment	0.2	0.4	0	1
Number of teeth with periodontitis	0.1	0.2	0	1
Number of teeth with pulpitis	0.3	0.5	0	1
Number of teeth with periapical abscess	0.1	0.2	0	1
Number of teeth with periodontal abscess	0.1	0.2	0	1
Number of teeth with root fracture	0.1	0.2	0	1
Number of teeth with root resorption	0.1	0.2	0	1
Number of teeth with root caries	0.1	0.2	0	1
Number of teeth with root decay	0.1	0.2	0	1
Number of teeth with root fracture	0.1	0.2	0	1
Number of teeth with root resorption	0.1	0.2	0	1
Number of teeth with root caries	0.1	0.2	0	1
Number of teeth with root decay	0.1	0.2	0	1



2) Does the pain to cold and biting linger? (past 5 seconds)

3) Has the pain ever woken
you?

4) Lingering pain to heat?

Table 1.1 The following table shows the relative atomic masses of the elements.

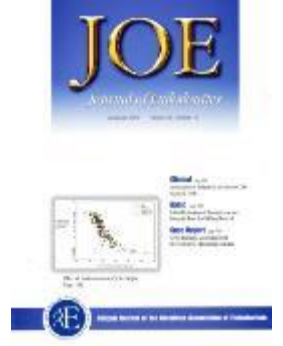
Element	Relative Atomic Mass
H	1
He	4
C	12
N	14
O	16
F	19
Ne	20
Na	23
Mg	24
Al	27
Si	28
P	31
S	32
Cl	35.5
Ar	40
K	39
Ca	40
Sc	45
Ti	48
V	51
Cr	52
Mn	55
Fe	56
Ni	59
Cu	63.5
Zn	65
Ga	69
Ge	72.6
As	75
Se	79
Br	80
Kr	84
Rb	85.5
Sr	88
Y	89
Zr	91
Nb	93
Mo	96
Tc	98
Ru	101
Rh	103
Pd	106
Ag	108
Cd	112
In	115
Sn	119
Pb	207



5) Is there “radiographic pathosis”? (Krell’s lexicon)

Table 1

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020																																																																				
Number of cases	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280	285	290	295	300	305	310	315	320	325	330	335	340	345	350	355	360	365	370	375	380	385	390	395	400	405	410	415	420	425	430	435	440	445	450	455	460	465	470	475	480	485	490	495	500



- Spontaneous Pain? Do the endo
- Pain to heat that lingers? Do the Endo
- Pain that wakes you at night? Do the endo
- Pain to cold and chewing that lingers for more than a minute or two? Do the endo

TABLE 1. The Number and Percentage of Cracked Teeth by Tooth Position in the Mouth

	Maxillary Second Molar	Maxillary First Molar	Maxillary Second Premolar	Maxillary First Premolar	Mandibular Second Molar	Mandibular First Molar	Mandibular Second Premolar	Mandibular First Premolar	Totals
Cracked	71	167	46	25	243	231	12	1	796
Total	835	1879	754	549	1380	2100	456	222	8175
%	8.50	8.89	6.10	4.55	17.61	11.00	2.63	0.45	9.74

Materials and Methods

There were 8175 patients included in this study from a private endodontic practice population during a 6-year period. The patients were recorded consecutively as they were referred to the endodontist for evaluation and appropriate treatment during the 6-year period. Besides the standard medical history and subjective history, the endodontist was responsible for the diagnosis of all teeth and recorded the following information for all teeth:

- (1) Pulpal response to cold or hot.
- (2) Periapical response to pressure, palpation, and percussion.
- (3) Buccal and lingual periodontal probings were recorded in the mesial and distal interproximal spaces and furca. These interproximal probings would be directed precisely where marginal ridge cracks were identified to indicate the deepest probing of the crack. A total of 6 probing points were recorded for each tooth.
- (4) Identification of a crack(s) with direct transillumination and visualization with and without magnification. The identified crack had to block light transmission and show a definite shadow with both the buccal and lingual coronal light placement. Teeth not exhibiting a shadow were considered to have "crazings" and were not included in this study.
- (5) Responses to biting on various cusps of the diagnosed tooth, with at least 1 cusp exhibiting pain to biting on either a burlew wheel or Tooth Slooth (Professional Results, Inc, Laguna Niguel, CA).

Teeth were diagnosed with RP if (1) there was no history of spontaneous pain; (2) the response to cold went away in less than 3–5 seconds; (3) there was no radiographic pathology.

No teeth were included in this part of the study that could not be confirmed by visualization as having an identifiable crack even if biting sensitivity was present. Restorations were removed only for patients with pulpal diagnoses that required root canal treatment. Teeth diagnosed as cusp fractures, split teeth, and vertical root fractures were also excluded from this study (6). All patients were recalled at 1 year unless root canal treatment was needed before the anniversary, then recall was 1 year later after treatment. The recall therefore extended into a seventh year of the data collection.

All cases were treatment planned according to the pulpal and periapical diagnosis. Cases with RP were treatment planned for crowns only, regardless of periapical diagnosis.

TABLE 2. The Number and Percentage of Cracked Teeth by Tooth Position with RP Eventually Requiring Root Canal Treatment

	Maxillary Second Molar	Maxillary First Molar	Maxillary Second Premolar	Maxillary First Premolar	Mandibular Second Molar	Mandibular First Molar	Mandibular Second Premolar	Mandibular First Premolar	Totals
Cracked	12	33	8	4	29	41	0	0	127
REV. >IP or NEC.	3	9	0	0	8	7	0	0	27
%	25	27	0	0	28	17	0	0	21

REV, reversible pulpitis; IP, irreversible pulpitis; NEC, necrosis.

Results

Of the 8175 cases seen during the 6-year period, 796 cases were diagnosed as cracked teeth (9.7%). Mandibular second molars (243/796, 30%) had the largest incidence followed by mandibular first molars (231/796, 29%) and maxillary first molars (167/796, 21%). All teeth are included in Table 1.

Cases with RP had the following distribution: mandibular first molars (41/127, 32%), maxillary first molars (33/127, 25%), and mandibular second molars (29/127, 23%). All teeth are included in Table 2.

Of 127 patients specifically diagnosed with RP, 27 converted to irreversible pulpitis (N = 21) in 58 days or to necrotic pulp (N = 6) in 149 days. The distribution of teeth requiring root canal therapy was as follows: maxillary first molars (9/27, 33%), mandibular second molars (8/27, 29%), mandibular first molars (7/27, 26%), and maxillary second molars (3/27, 11%).

All teeth had initial interproximal probings less than 3 mm in the space associated with the identified crack. Increased interproximal probings were associated with the fractured marginal ridge for only 5 of the 27 teeth requiring root canal treatment. The greatest increase in probing depth was 2 mm for 2 of 5 teeth.

The teeth requiring root canal treatment had the crack located on the distal marginal ridge in 15 of the 27 cases (56%). The distribution was mandibular second molars (6/27, 27%), mandibular first molars (3/27, 11%), maxillary first molars (3/27, 11%), maxillary second premolars (2/27, 7%), and maxillary second molars (1/27, 4%). The crack was located only on the mesial marginal ridge in 4 of the 27 cases (15%). The distribution was the maxillary first molars (3/27, 11%) and maxillary first premolars (1/27, 4%). Both marginal ridges were involved in 8 of the 27 cases (29%). The distribution was mandibular first molars (5/27, 19%), maxillary first molars (2/27, 7%), and maxillary second molars (1/27, 4%). None of the teeth had fractures that extended into the floor of the chamber or rendered them "non-restorable".

None of the original remaining 100 cases of RP required root canal treatment.

Discussion

The patients who composed this database were all patients referred to a private practice endodontist. Our incidence data are in agreement with the findings of Weine et al (5), which were also derived from an endodontist's practice. The difference in percentages from

How many pulps eventually died?



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Discussion

The patients who composed this database were all patients referred to a private practice endodontist. Our incidence data are in agreement with the findings of Weine et al (5), which were also derived from an endodontist's practice. The difference in percentages from

How many pulps eventually died? 20%



other studies might be largely due to the nature of general dental populations versus an endodontic specialty population. Hiat (5) and Cameron (4) reported maxillary premolars having the second highest incidence of cracks, which represents a periodontist and general dental practice. Therefore, this study's population might be under-represented with respect to premolars and the actual incidence of cracked teeth in the population at large.

This study found that 21% of the cases diagnosed with RP and a crack eventually required root canal treatment. Although no other studies have reported this finding, there have been studies examining the necessity for root canal treatment on teeth restored with crowns. Saunders and Saunders (7) reported that 19% of crowned teeth in a Scottish dental school population had root canal treatment after crown placement. This study was unable to report whether cracks were present before the crown was placed.

Cheung et al (8) found that 15% (19/122) of teeth restored with a ceramo-metallic crown required root canal treatment after crown placement in a population in Asia. They also found that of those serving as an abutment of a fixed-fixed bridge (25/77), 32% required root canal treatment after final cementation of the bridge.

Although the populations in these 2 studies are quite diverse, the similar percentages for teeth requiring root canal treatment after crown placement suggest that 15%–19% of their patients are to be expected for all crowns. The 21% of the cases in this study with RP and cracks that were crowned and subsequently required root canal treatment is only slightly higher than the 15%–19% and suggests similar incidence data.

When examining a tooth with both mesial and distal marginal ridge fractures, the natural assumption would be that more of these teeth

would eventually require root canal treatment. Our data showed more teeth with a single marginal ridge crack, either mesial or distal, eventually required root canal treatment. This underlines the difficulty in predicting the eventual need for root canal treatment in teeth with RP and a cracked marginal ridge.

Conclusions

The outcomes of this study suggest that if a crack is identified early enough in cases with a diagnosis of RP and a crown is placed, root canal treatment will be necessary in about 20% of these cases within a 6-month period. Progression of interproximal periodontal defects associated with the crack(s) will occur in a very small percentage of the cases (5/127, 4%).

References

1. Cracking the cracked tooth code. Endodontics: Colleagues for Excellence 1997 (Fall/Winter):1–13.
2. Aizer JJ Jr. Margging incomplete tooth fractures. J Am Dent Assoc 2000;131:1168–74.
3. Hiat NH. Incomplete crown root fracture in pulpal periodontal disease. J Periodontol 1973;44:369–79.
4. Cameron GE. The cracked tooth syndrome: additional findings. J Am Dent Assoc 1976;93:971–5.
5. Wene FS, Detharry Jr, James A. Cracked tooth syndrome: vertical fractures of posterior teeth. In: Wene FS, ed. Endodontic therapy, 3rd ed. St Louis: Mosby, 1982:8–15.
6. Rivera EM, Walton BE. Longitudinal fractures. In: Torabinejad M, Walton BE, eds. Principles and practice of endodontics, 4th ed. Philadelphia: Saunders, in press.
7. Saunders WP, Saunders EM. Prevalence of periradicular periodontitis associated with crowned teeth in an adult Scottish subpopulation. Br Dent J 1998;185:137–40.
8. Cheung GS, Lee SC, Ng RP. Fate of vital pulps beneath a metal-ceramic crown or a bridge retainer. Int Endod J 2005;38:521–30.

What is the
pulpal death
rate for any
tooth w/ a
crown? 15-
19%



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What is the pulpal death rate for bridge abutments? 32%



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Big picture:
Cracked teeth
with R.P. don't
necessarily
need endo.



Big picture:
Prepare,
impress and
temporize
normally but
wait 6-8 weeks
to seat crown



Big picture:

For smaller ICF's
with mild symptoms,
a gold or porcelain
onlay may obviate
the wait period for
the crown seat.



Big picture:

Bioclear

Composite

Overlays have
shown immediate
elimination of
symptoms*

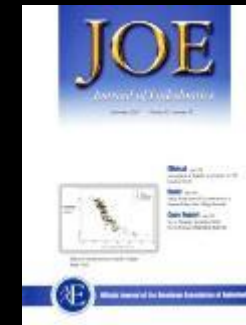


Big picture:

PROBE!

PROBE!

PROBE!



What is our most
reliable clinical test for
irreversible pulpitis?

**PERCUSSION TEST,
and REPEAT**



Which tooth is cracked?



Which tooth is cracked?



Which tooth is cracked?

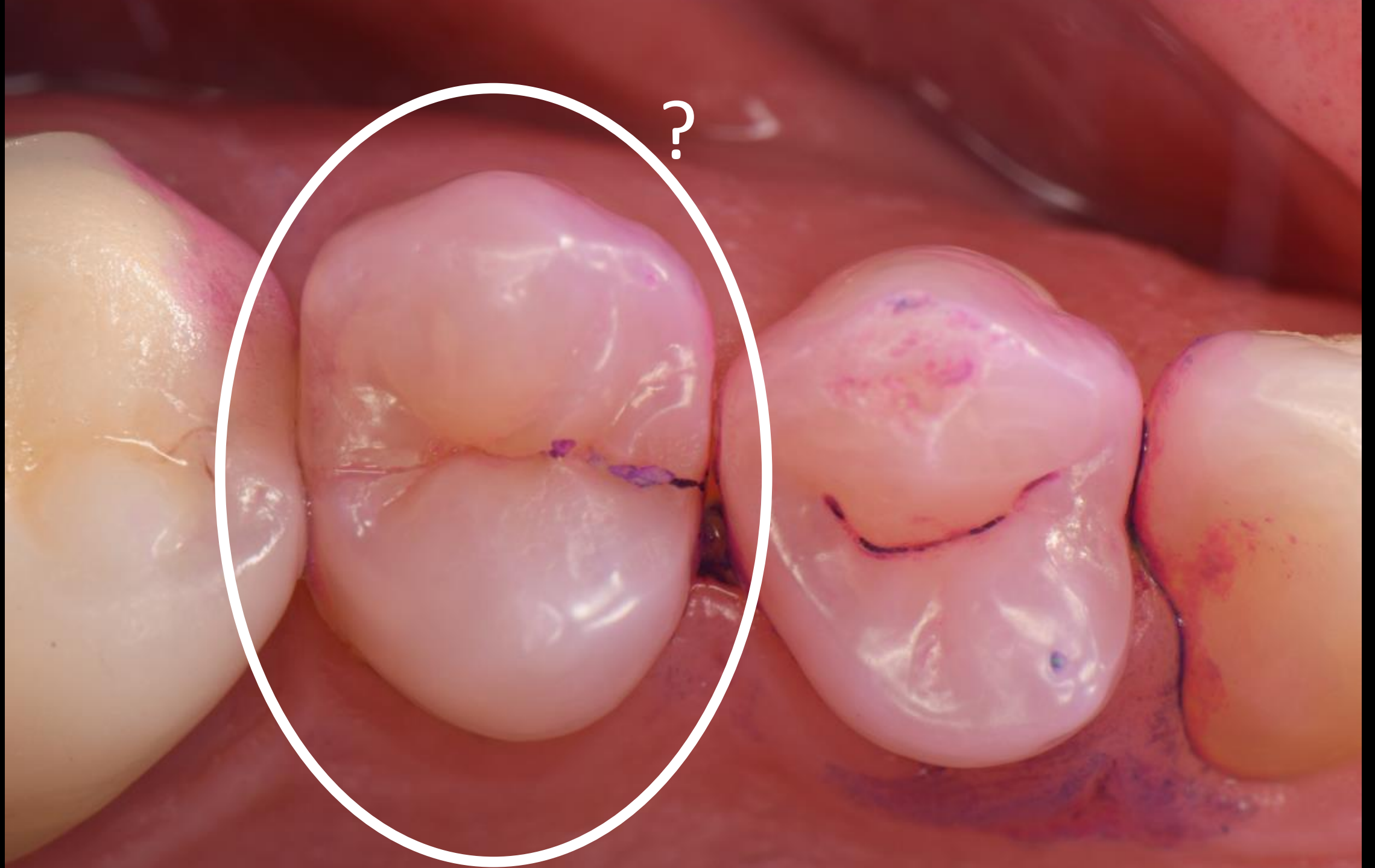


Which tooth is cracked?



?

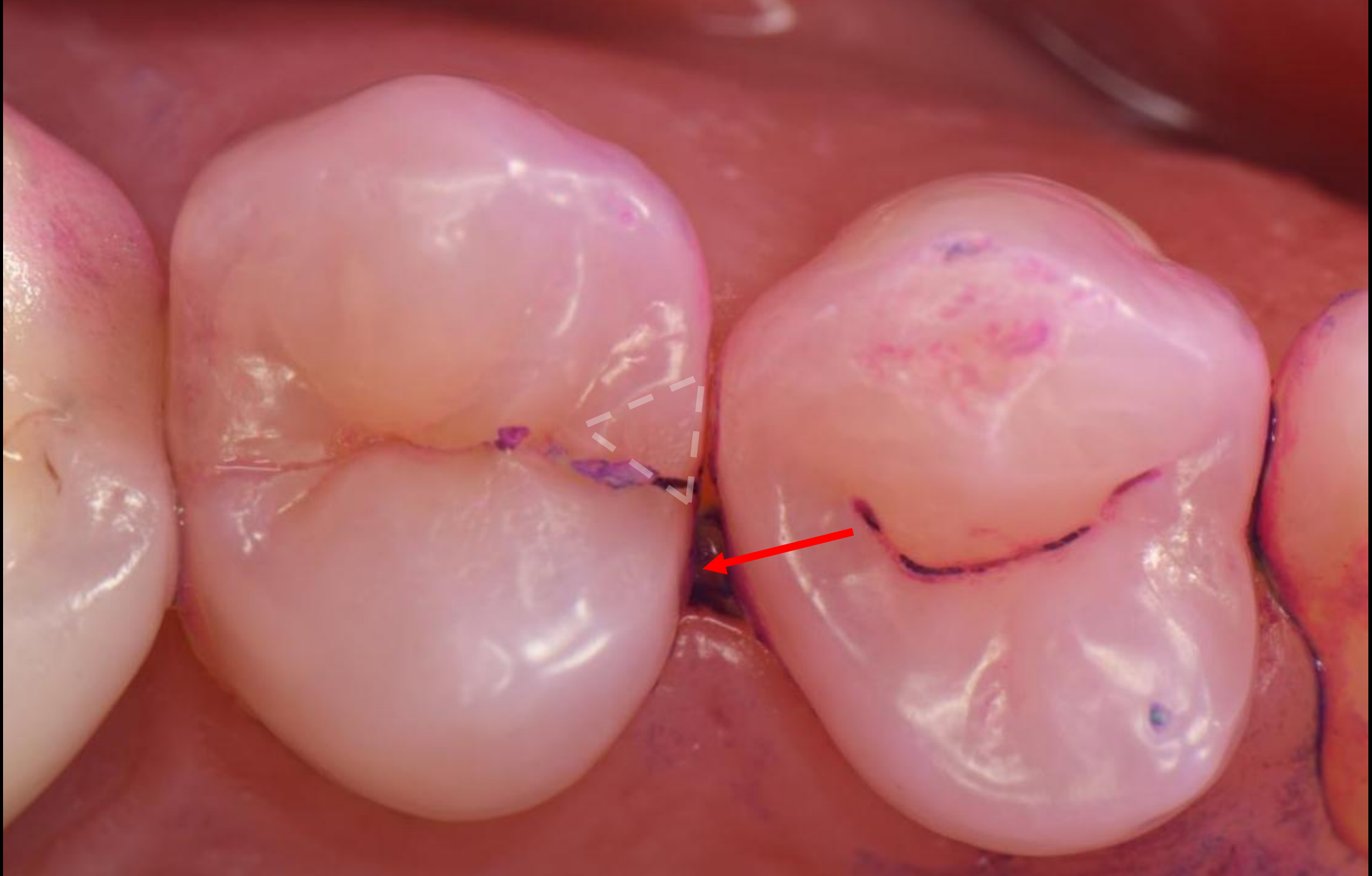










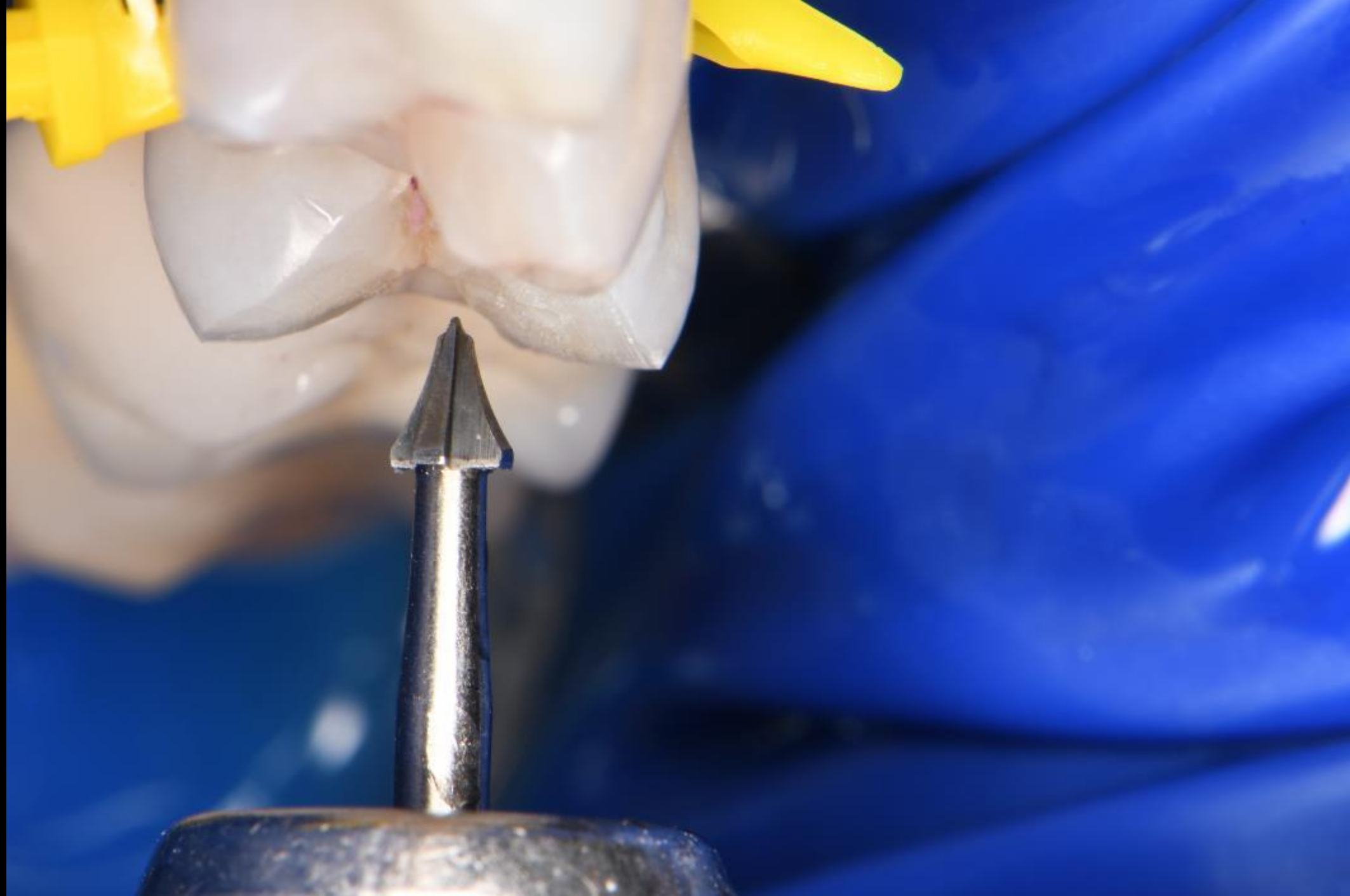




























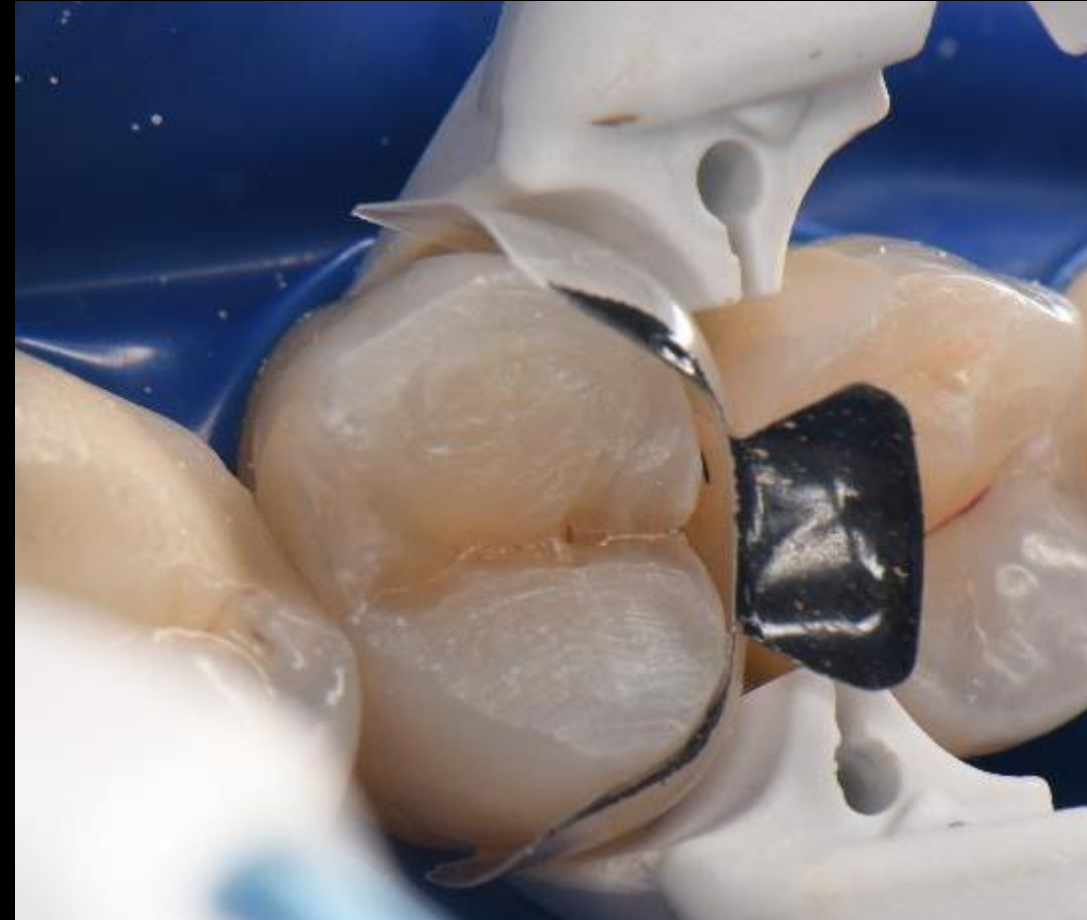






Learning Objectives from the Case:

- Don't sweep the contacts*
- 3 mm thickness over the crack
- Build a bridge from buccal to lingual
- The crack becomes dormant
- "Harmonize" the opposing w/ consent
- If food impaction continues, so will pain and pocketing
- Contact technique works for other problems**
- We need a powerful separator



Modern Restoration
Design=**I.C.E.**

Infinity edge

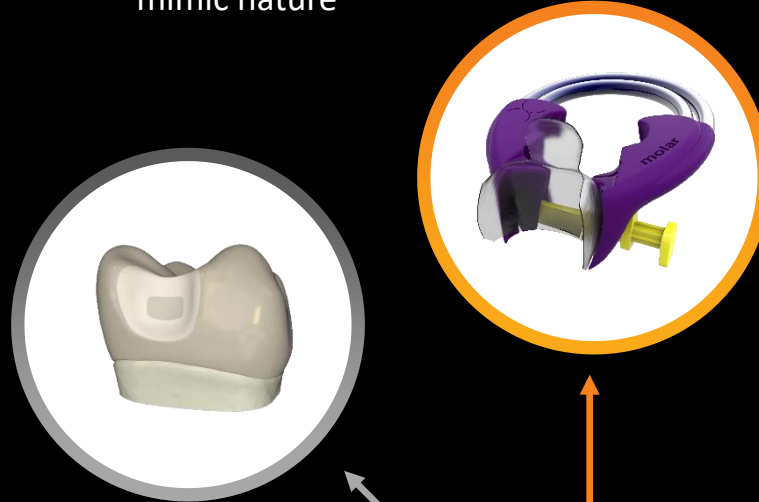
Compression based

Enamel driven

Modern Method for Composite Restorations

Clear Anatomic Matrices

- Anterior & Posterior Matrices designed to mimic nature



Injection Mold Composite

- Injection mold warmed Restorative materials
- Industry leading polish, esthetic, strength & wear



Preparation Design

- Designed for composite
- Minimizes stress concentration
- Maximizes enamel involvement



Biofilm Removal

- Remove biofilm before bonding
- Allows bonding to uncut enamel
- Allows infinity edge margins



Systematic restorative protocol for esthetic long-term clinical outcomes

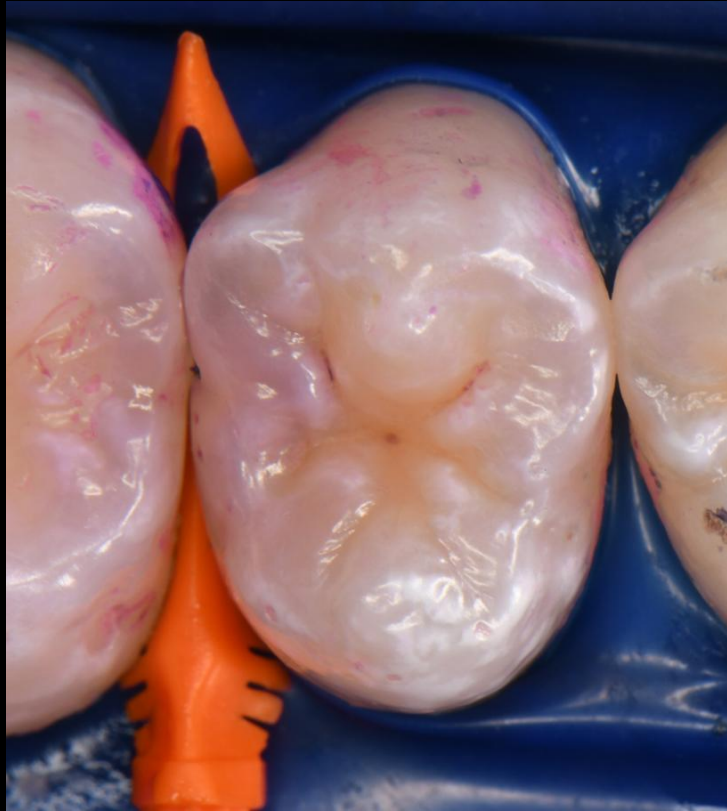
Final Polish

- 3M™ Sof-Lex™ XT coarse discs for reduction
- “Rock Star” polish with Bioclear Magic Mix & RS Polisher



Pre-op, post op, and 3 year follow up

∞ BIOCLEAR



Are all
Separators
Equal?

NO!



Stretched to 20mm ONCE!!!





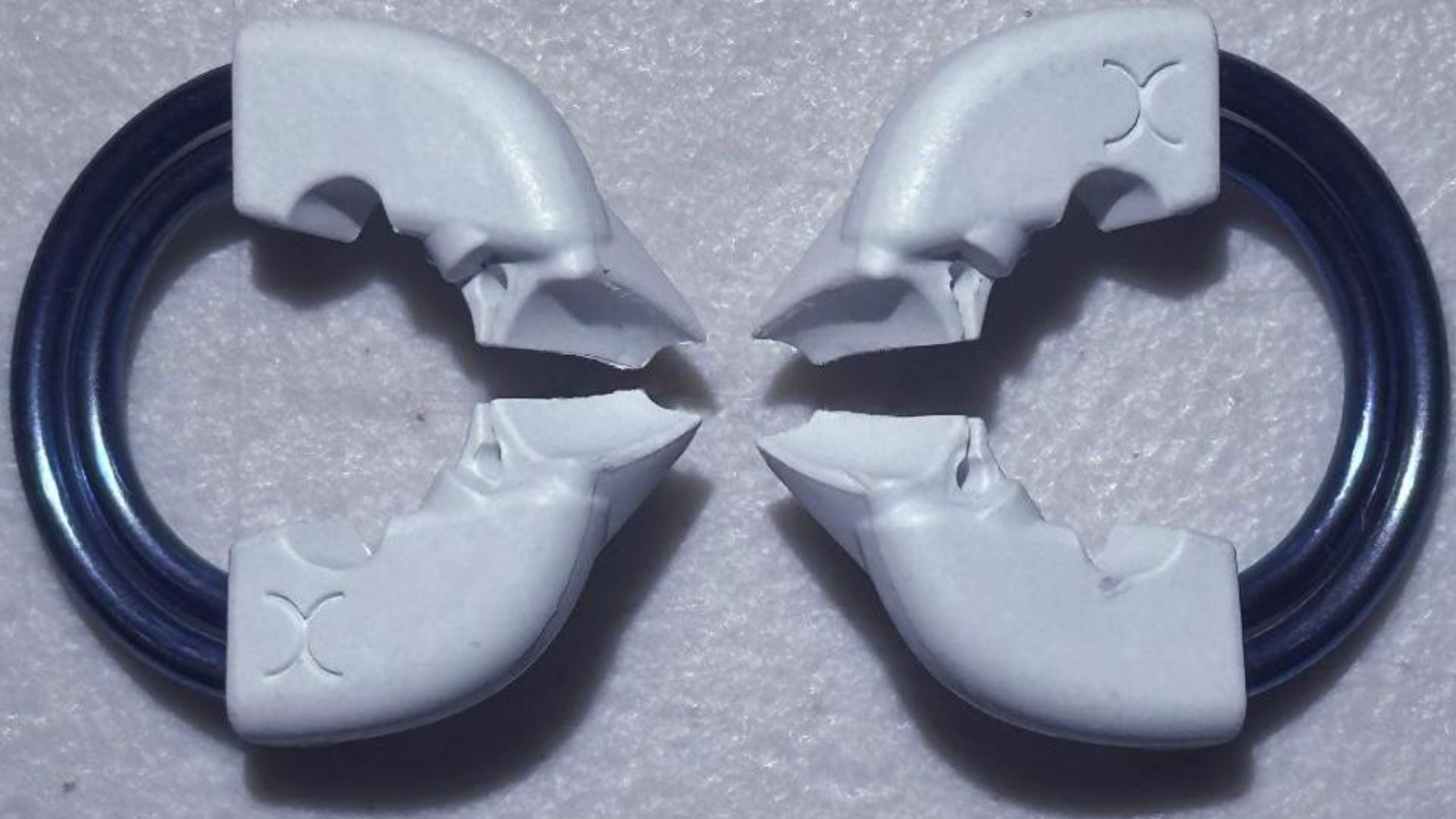
And now most of
the power is
permanently lost

Once the yield of the metal/shape is reached, the
metal undergoes plastic deformation

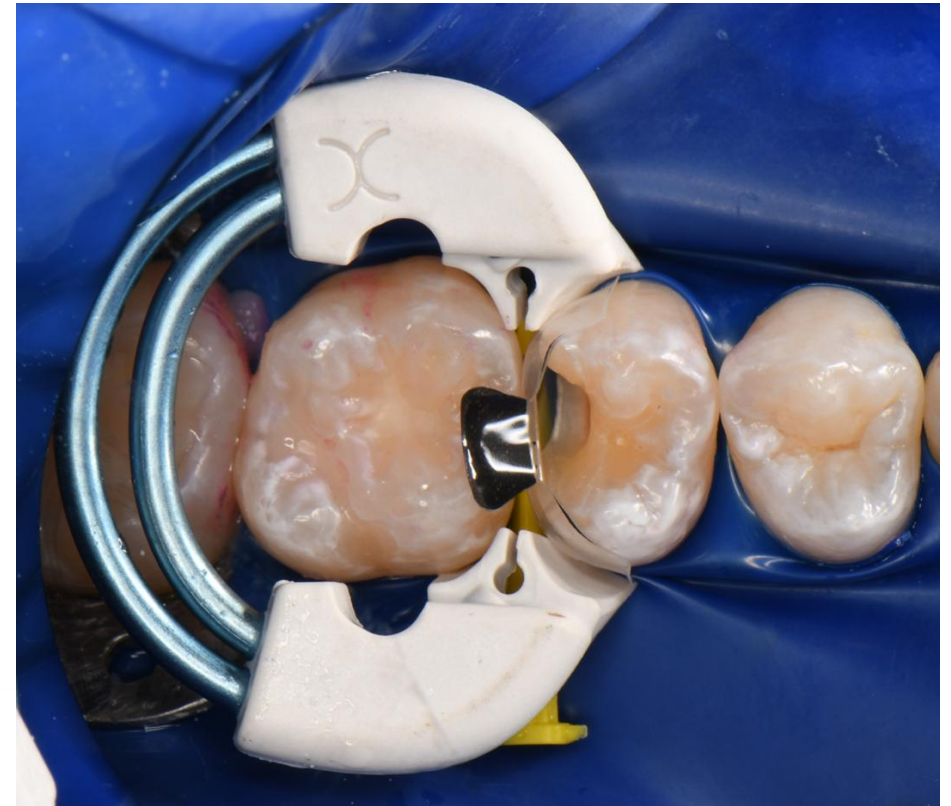
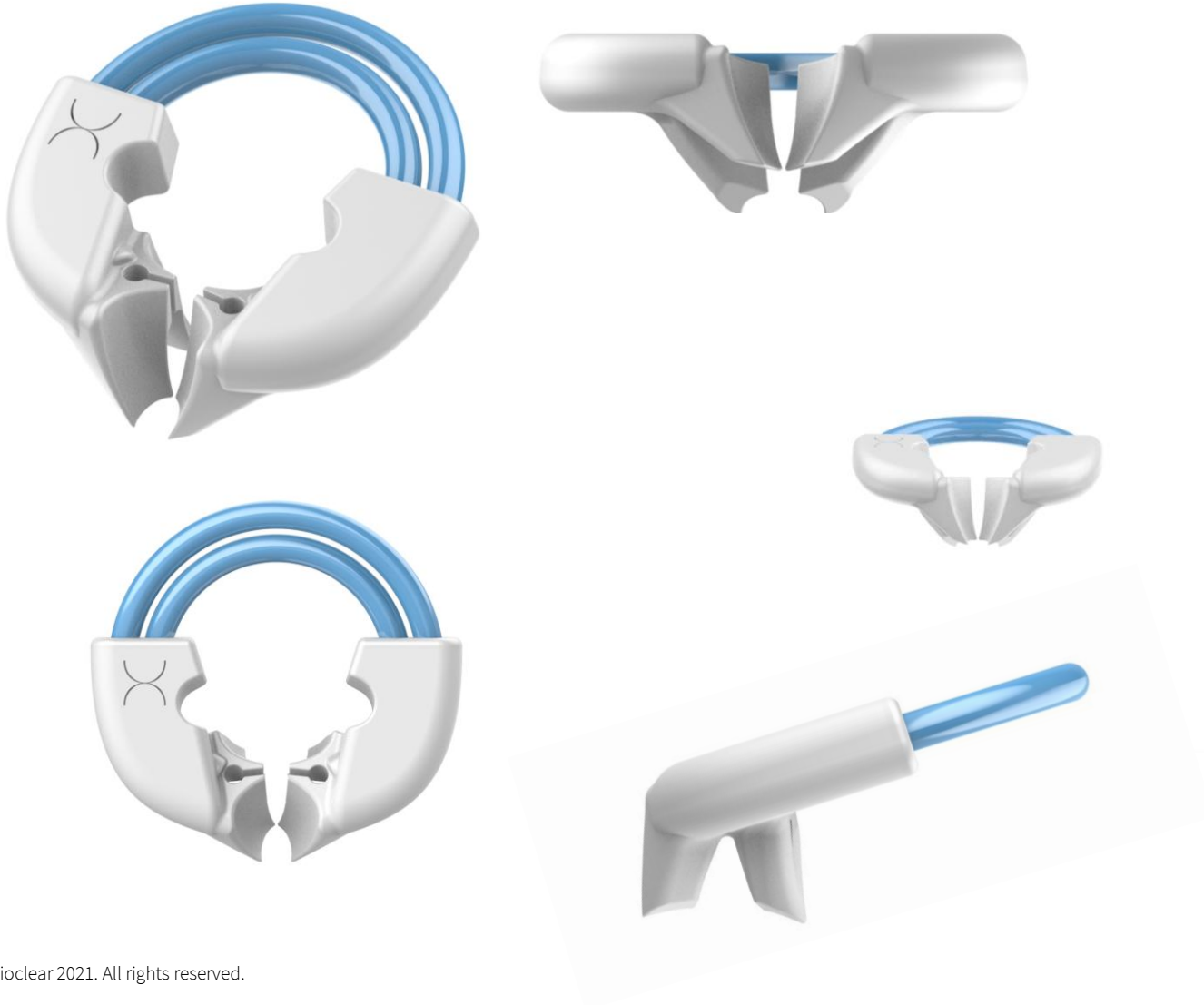
Stretched to 20mm Twenty Times



Stretched to 20mm Twenty Times



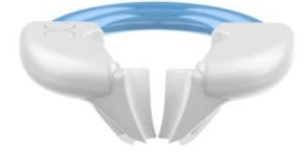
TwinRing Universal





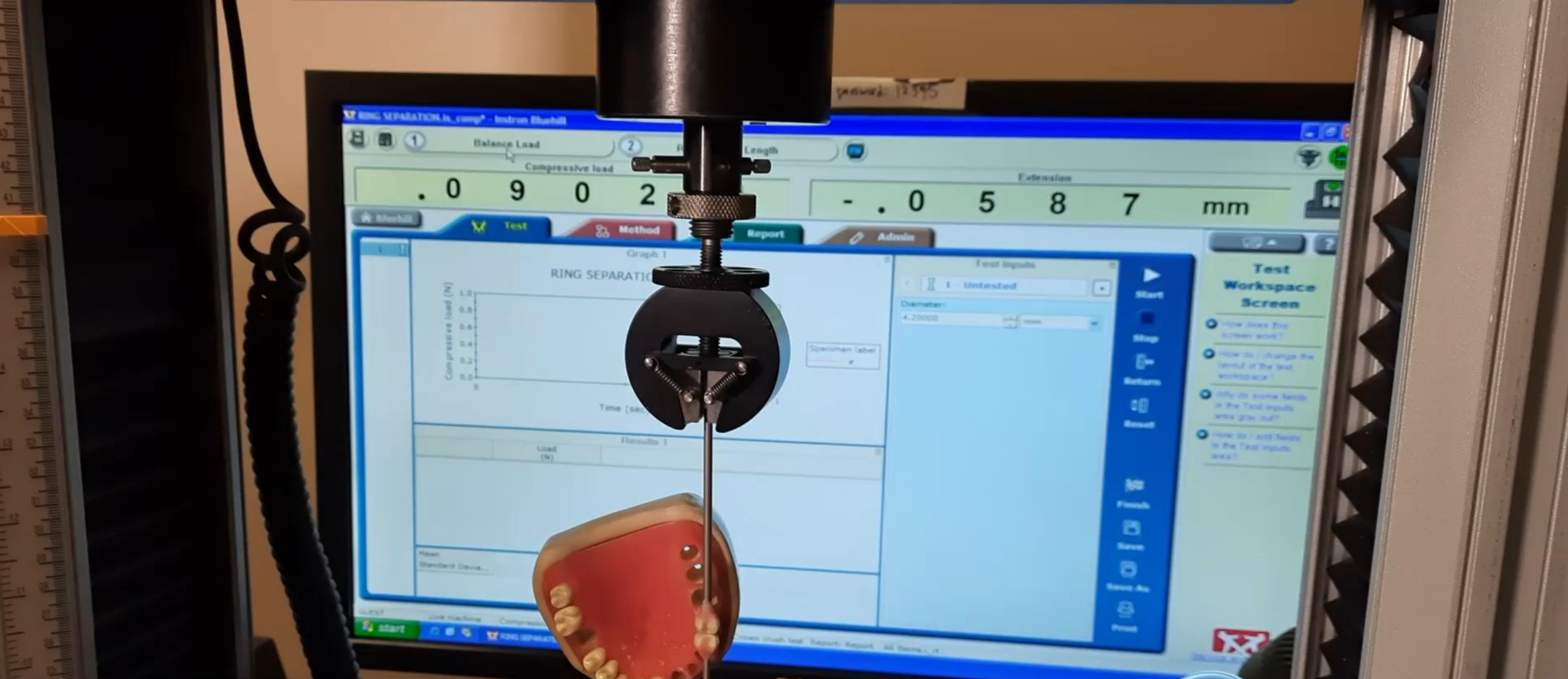
How do we win the *Snug Contact Game?*

- Power
- Strategy
- Technique



How do we win the *Snug Contact Game?*

- Power
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- Technique



Nate Lawson DMD PhD

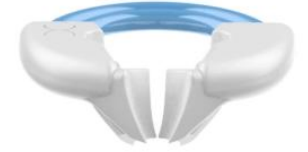
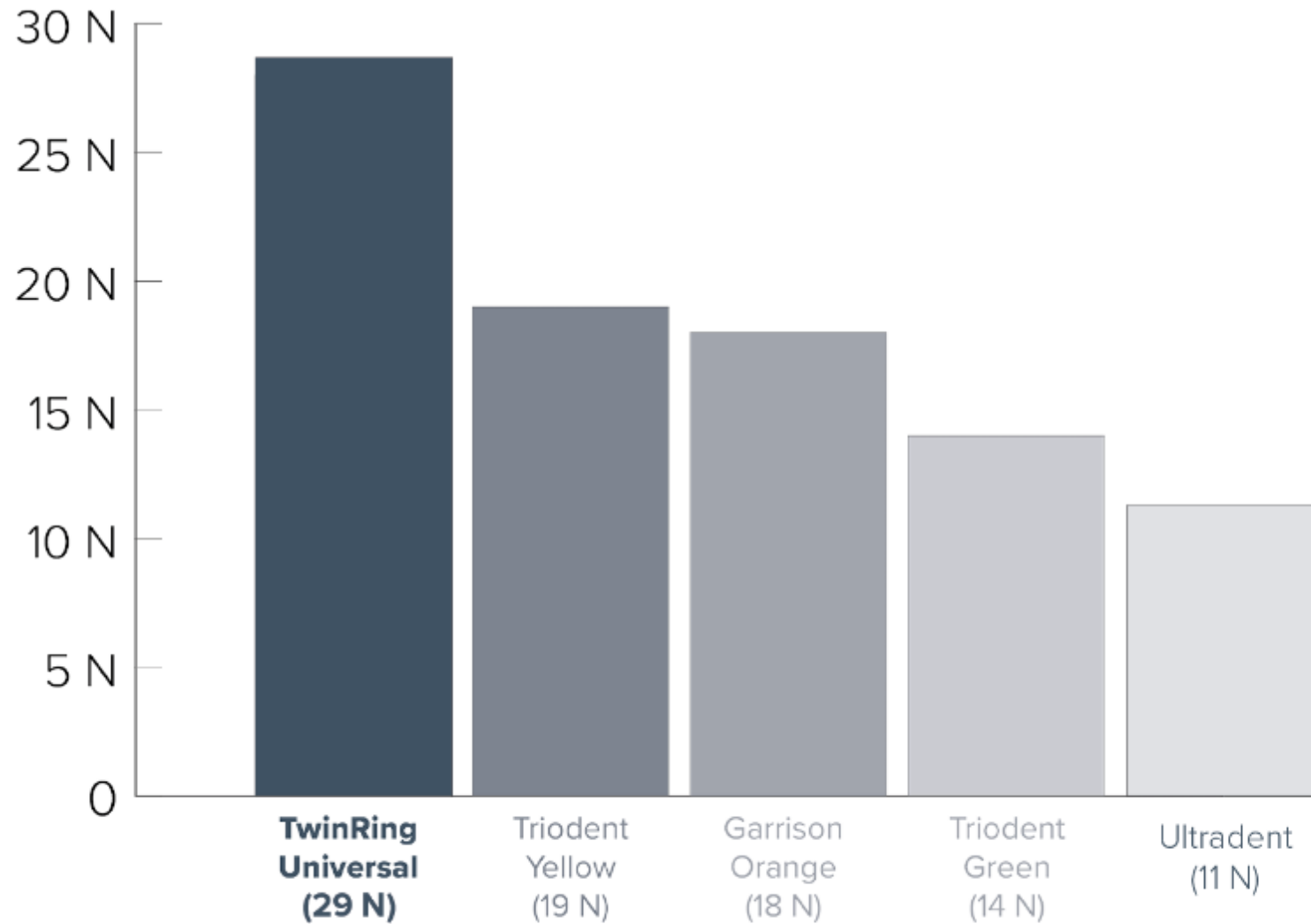
Director of the Division of Biomaterials and Pranit Bora. BDS, MDS.

Resident, Division of Biomaterials UAB School of Dentistry



TwinRing Universal
28 N

TwinRing Universal Instron Comparison



Note: Rings tested are not new and some rings stretch out quickly and lose up to half of their power after multiple uses. 1N = 1kg (m/s/s)

The slip-off test



 BIOCLEAR

Bioclear Matrices - Posterior





EVOLVE --- MATRIX

Premolar



Molar



EVOLVE
MATRIX

Pat's Bioclear Cuspal Overlay-Calla Lilly Combination Restoration















High risk (Clark classification) diagonal crack emanating from the corner of a restoration



























Disto-palatal cusp was later shortened to create 2 mm clearance























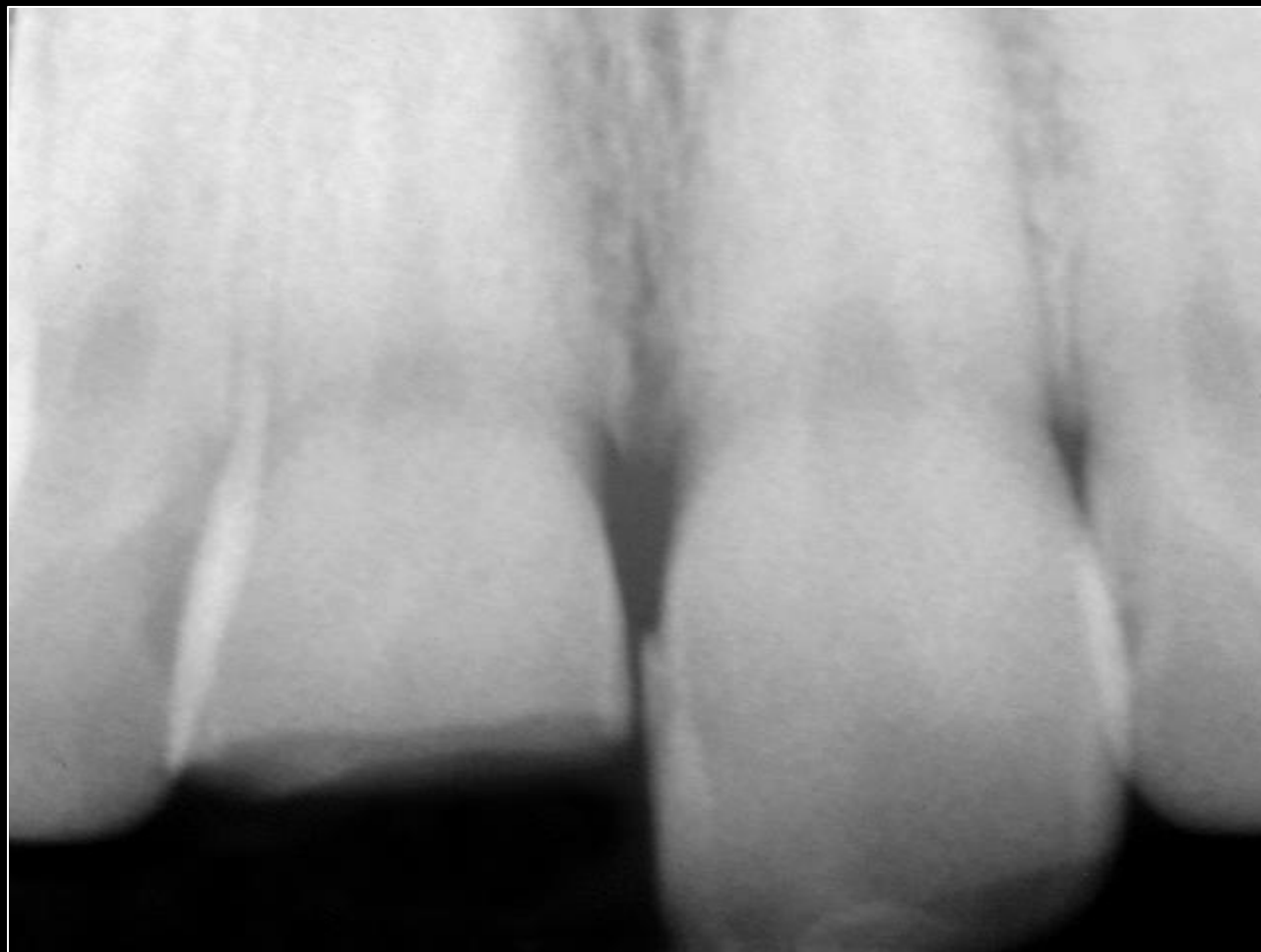




In this case based lecture today we explore:

- Coronal (vertical and cuspal) Fracturing
- Snap-Off Fracturing

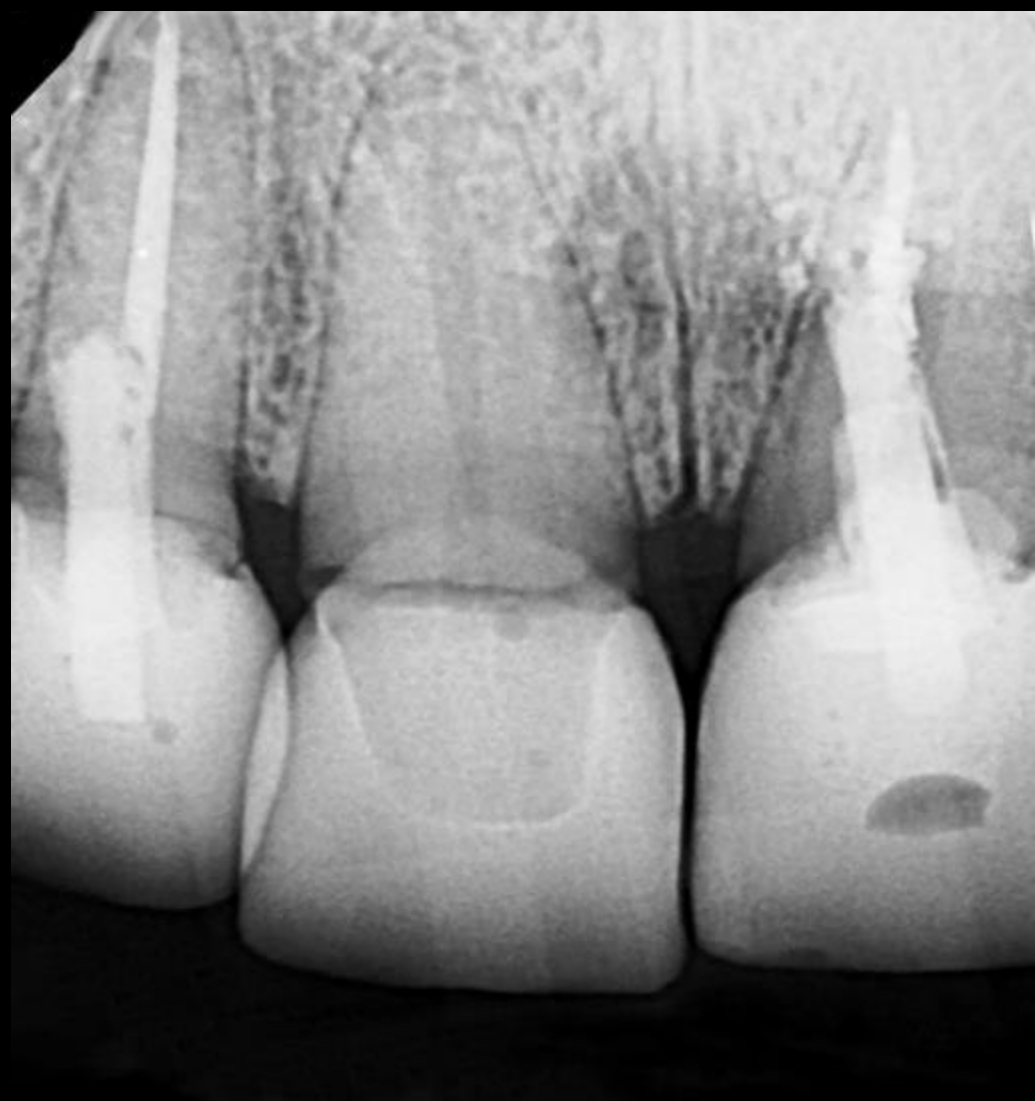




What Would You Do?

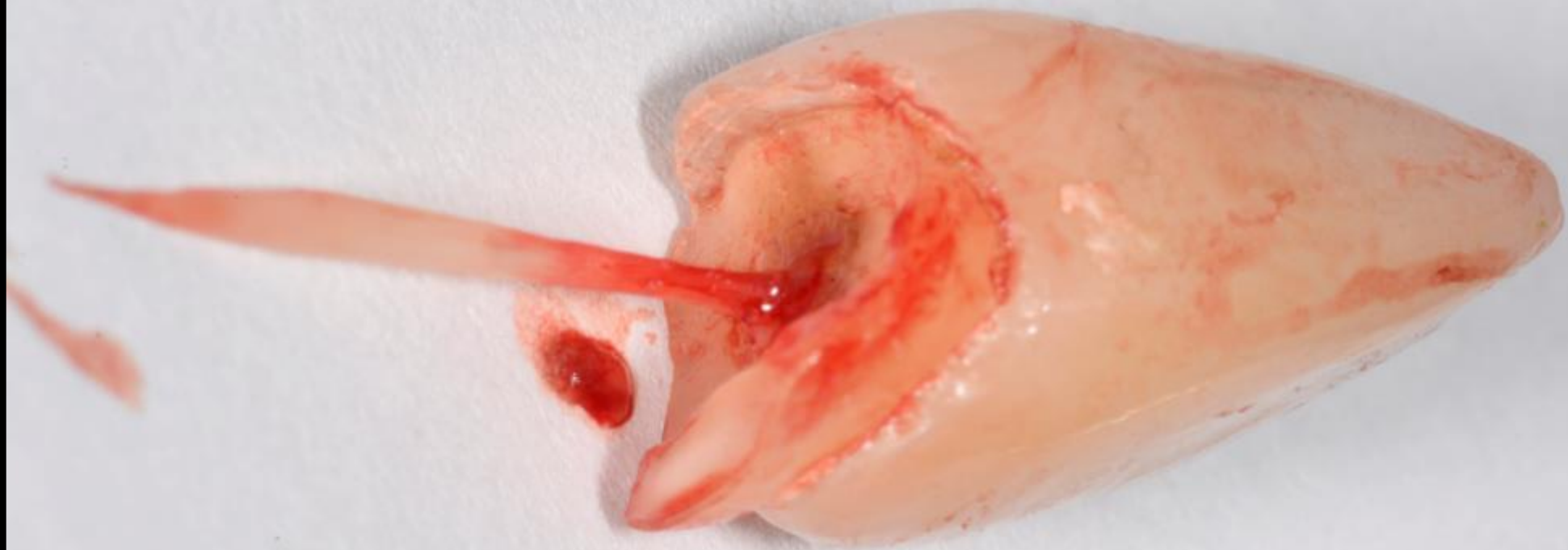


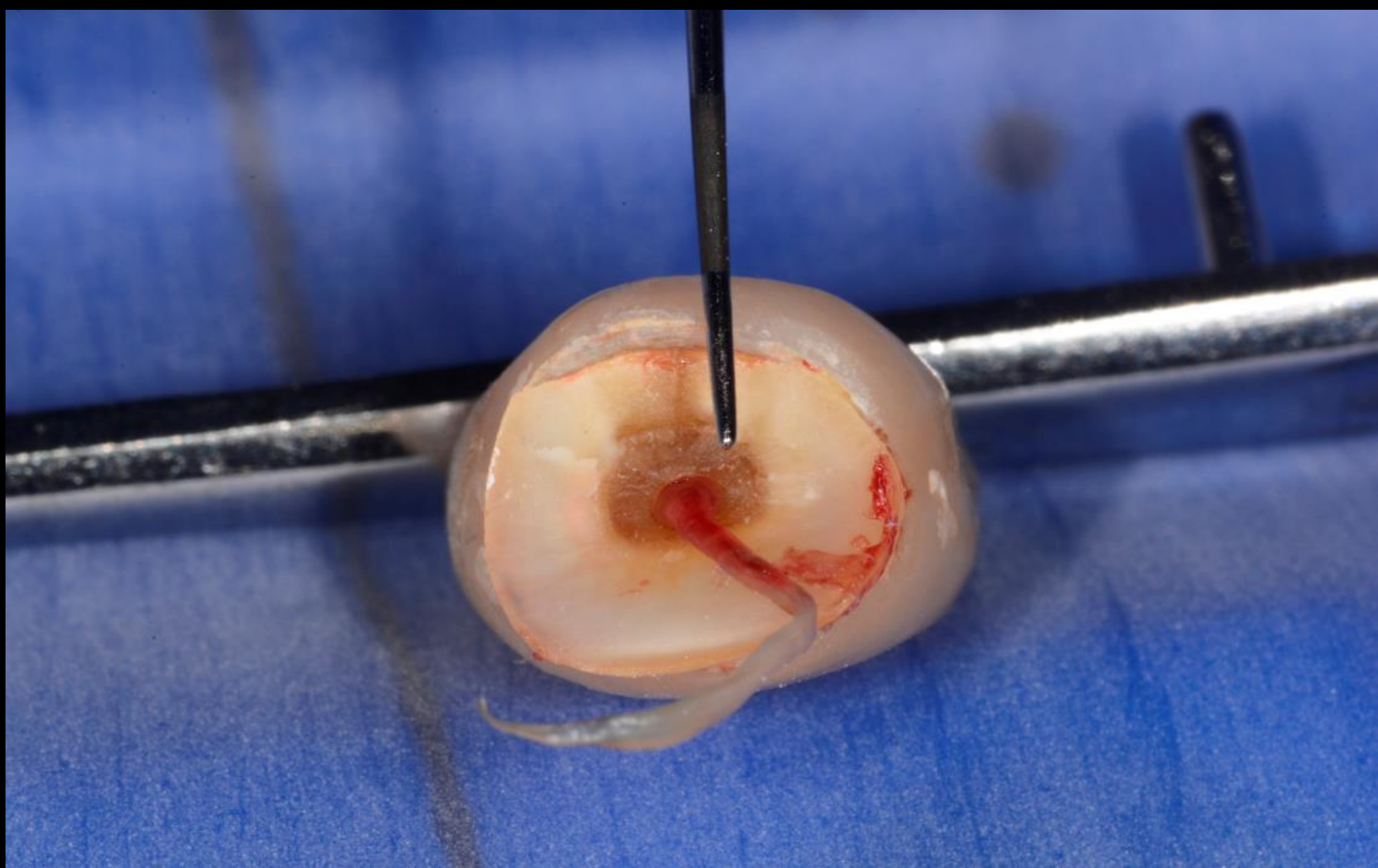
A different
toothache
patient we saw
recently...

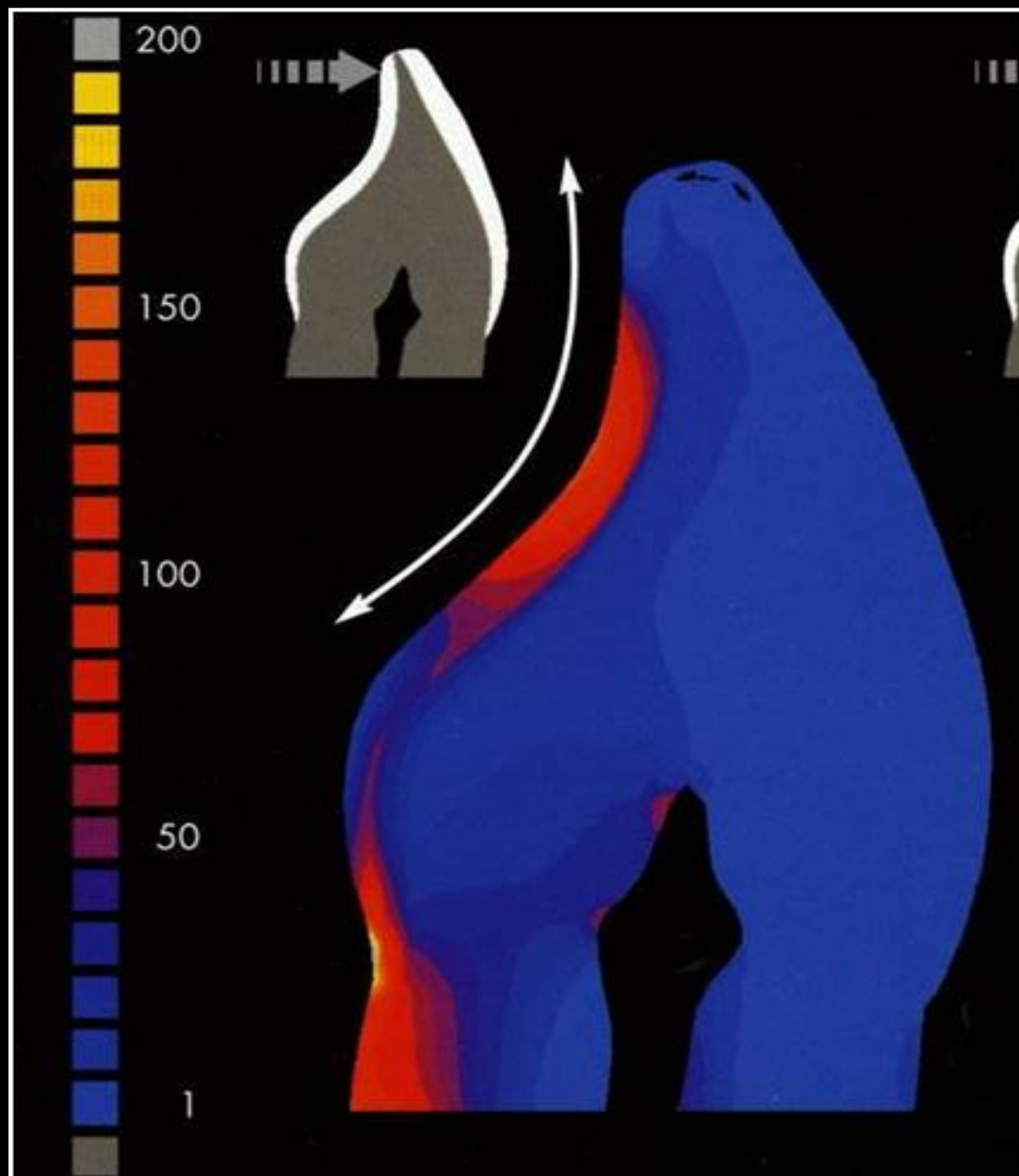




















What is the percent of coronal volume removed in a conservative full porcelain crown preparation?

~3/4 Crown

All Ceramic
.8 Margin

All Ceramic
1 mm Margin

All Ceramic
1.4 mm Margin



53.0

70.4

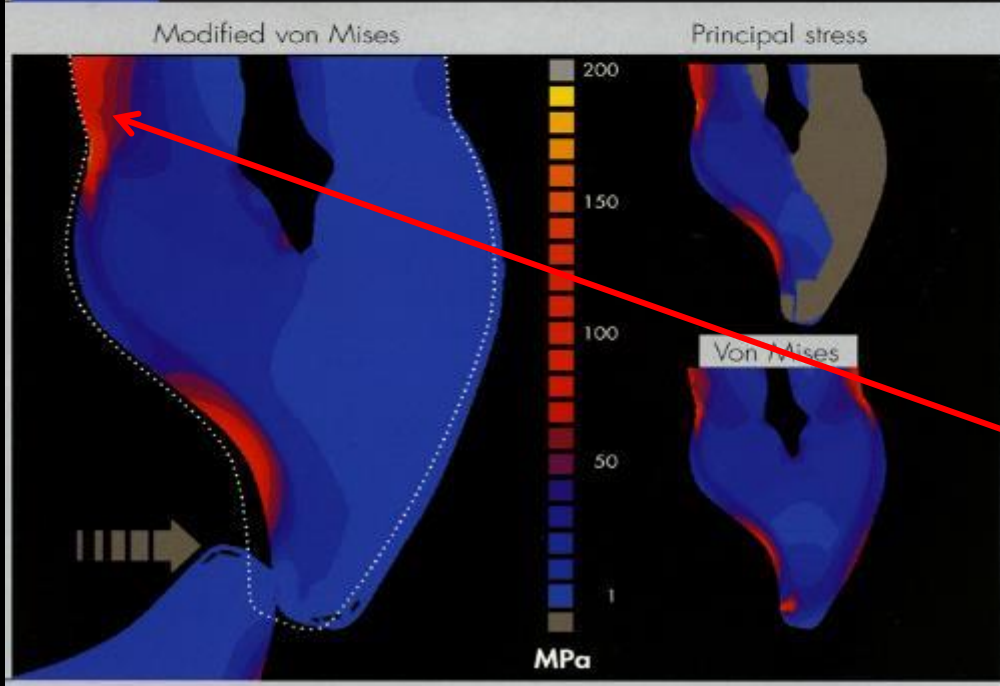
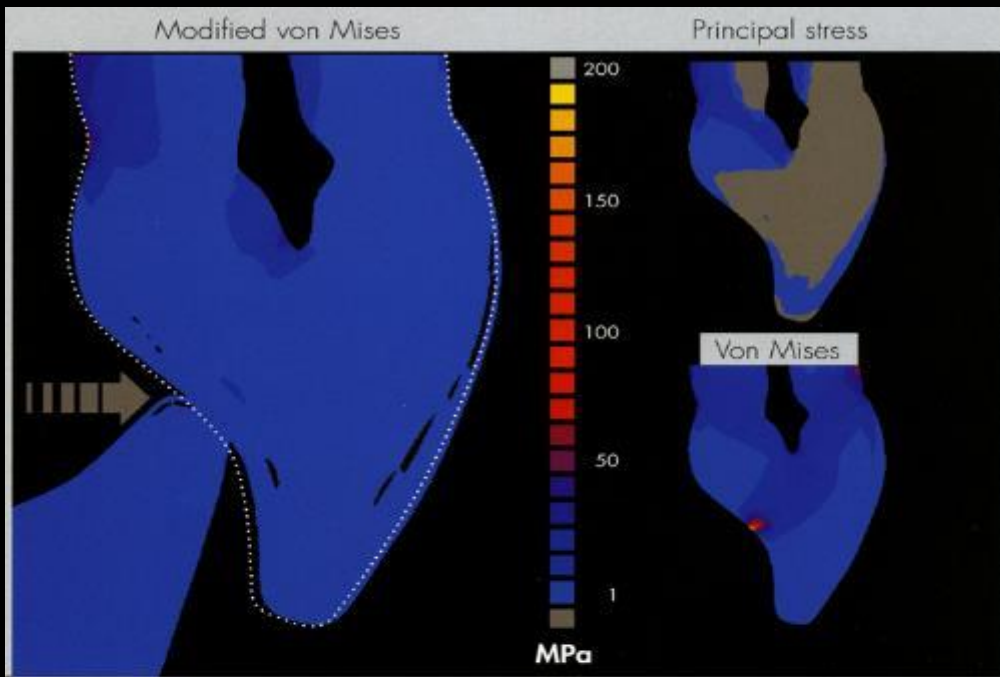
74.1

75.9

34 *

Edelhoff D, Sorensen JA.

1 Structure Removal Associated with Various Preparation Designs for Posterior Teeth.
Int J Periodontics Restorative Dent 2002; vol 22; 3: 240-249.



75.9% volume
gone + stress
concentration







Core anterior
course day
two





Last week's attendees at the certification course



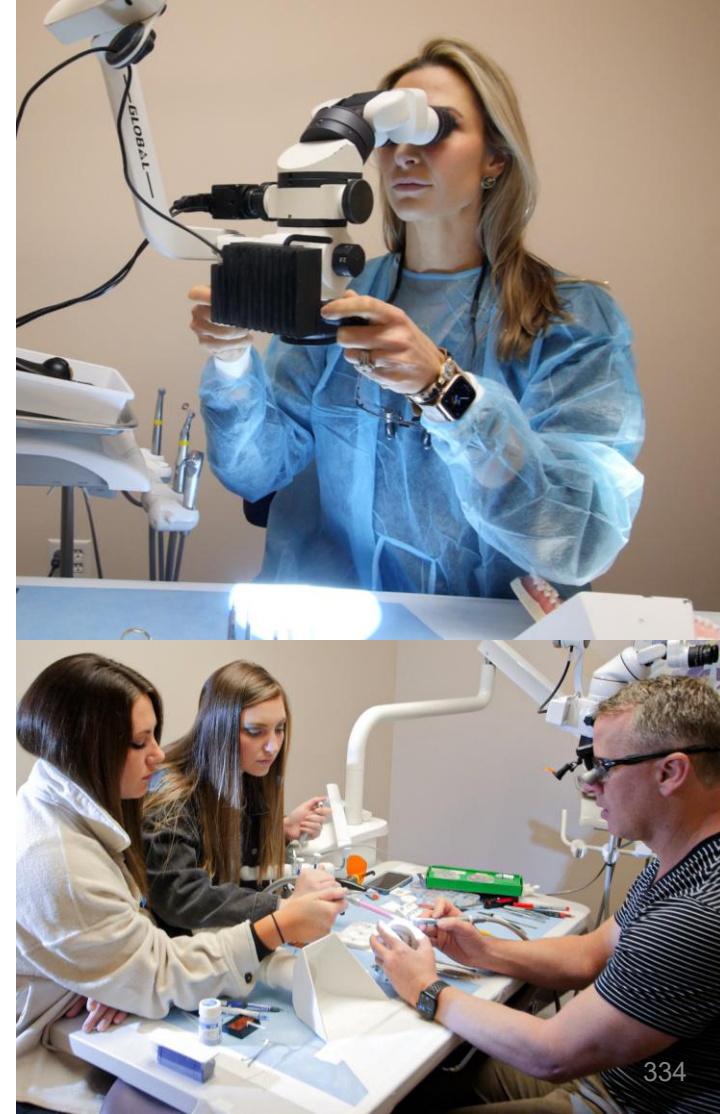
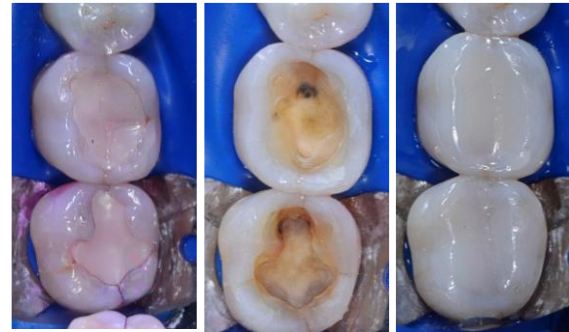
4-DAY CORE ANTERIOR & POSTERIOR COURSE

36 CE CREDITS

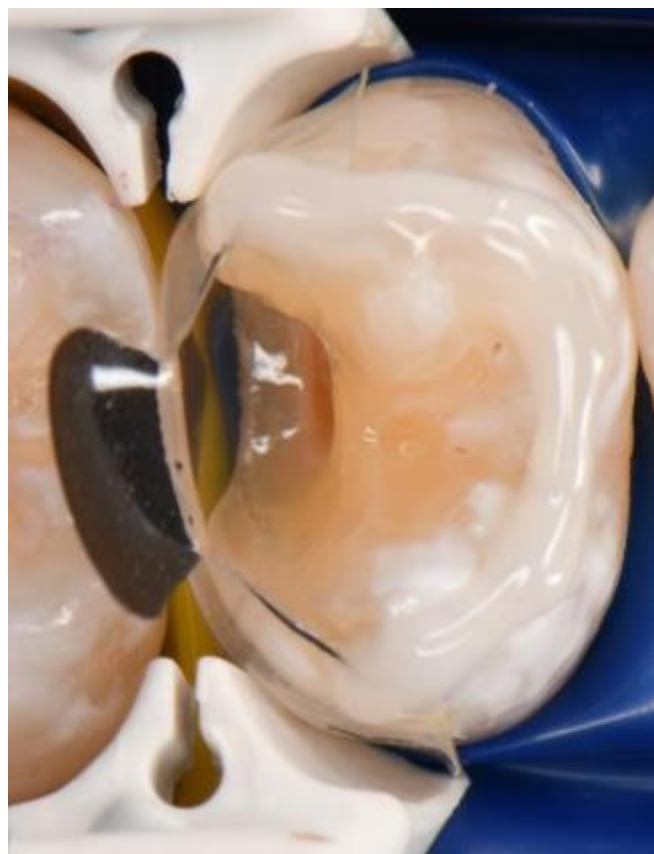
This course builds a strong foundation in the Bioclear Method and an understanding of Bioclear products. The focus of the course is indirect methods on adult dentitions as an alternative procedure to porcelain crowns and veneers.

Students will learn the foundation of posterior and anterior restorations and are introduced to the engineering principles involved in the design of the new non-retentive compression-based preps. Students collaboratively practice all applications of the Bioclear Method during intensive, hands-on exercises that simulate posterior and anterior restorations.

LEARN MORE



Core Posterior Solutions



Scan to learn more
& sign up for your
local BT Course!



BEFORE



AFTER



BEFORE



AFTER

Bioclear Anterior Matrices

Anterior Matrices



Original Bioclear Matrices

- 9 different matrices
- Treatment of various spacing and rotation issues
- Available in regular (50 um) and HD (75 um)



360 Veneer Matrix

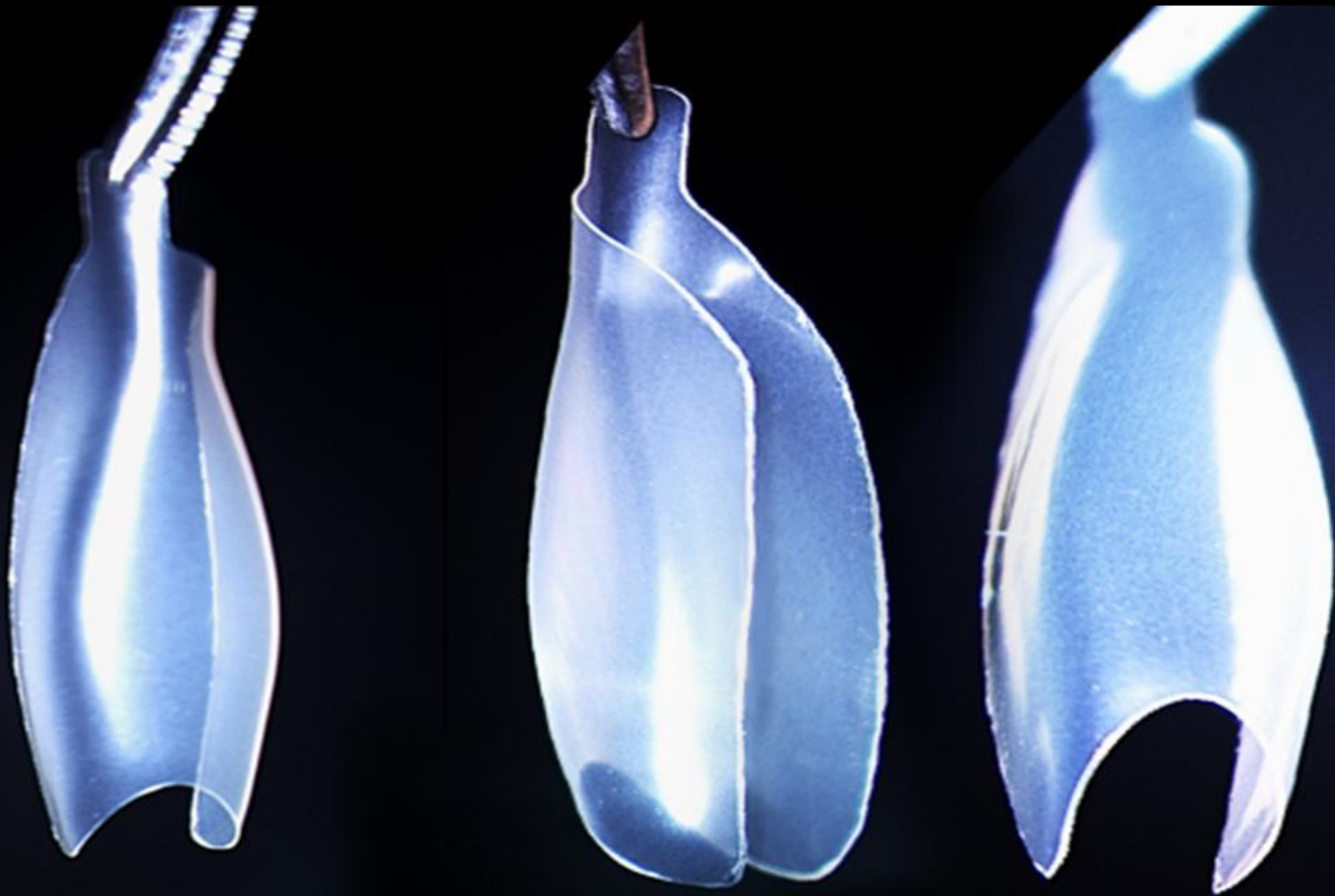
- 1 Size
- Pre-trimmed
- Specifically designed for injection over molding anterior teeth (Bioclear veneer)



Black Triangle Matrices

- 8 Matrices
- Customized for various tooth shapes
- Specifically designed for black triangle treatment
- Easy to install, small learning curve





Bioclear 360° Veneer Matrix

Karen - referred discretely by the orthodontist. The original referring dentist planned 3/4 crowns after 3 years of ortho. Patient wanted Bioclear









The Dahl "Light" Technique





Definitive Diagnosis of Early Enamel and Dentinal Cracks Based on Microscopic Evaluation

DAVID J. CLARK, DDS*
CHERYLYN G. SHEETS, DDS†
JACINTHE M. FAQUETTE, DDS‡

ABSTRACT

The diagnoses of cracked teeth and incomplete coronal fracture have historically been symptom based. The dental operating microscope at $\times 16$ magnification can fundamentally change a clinician's ability to diagnose such conditions.

Clinicians have been observing cracks under extreme magnification for nearly a decade. Patterns have become clear that can lead to appropriate treatment prior to symptoms or devastation to tooth structure occur. Conversely, many cracks are not structural and can lead to misdiagnosis and overtreatment. Methodic microscopic examination, an understanding of crack progression, and an appreciation of the types of cracks will guide a doctor to making appropriate decisions.

Teeth can have structural cracks in various stages. To date, diagnosis and treatment are very often at end stage of crack development.

CLINICAL SIGNIFICANCE

This article gives new guidelines for recognition, visualization, classification, and treatment of cracked teeth based on the routine use of $\times 16$ magnification. The significance of enamel cracks as they relate to dentinal cracks is detailed.

(*J Esthet Restor Dent* 15:XXX-XXX, 2003)

Macroscopic and symptom-driven diagnoses have been the accepted modalities for cracked teeth. The inherent limitations of the lack of visual confirmation result in therapies that often come too late in the treatment process. One lasting first impression of vision through a clinical microscope is the staggering array of cracks that exist within tooth structures. Traditional visualization (unaided

or ocular assisted) limits the clinician's ability to assess the presence or severity of the majority of these cracks (Figure 1).

At extreme magnification levels ($\times 14$ and greater), the translucent nature of enamel yields a wealth of information. Subtle color changes within the enamel may indicate early decay, microleakage, and a lack of structural integrity of dentin and

enamel. Being able to see previously invisible clues can lead restorative dentists to more appropriate early treatment of compromised teeth before devastating fractures, pulpal involvement, and periodontal breakdown occur. The value of early diagnosis of the structural breakdown of teeth will become even more significant with our aging population coupled with increased tooth retention in this population.

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†Co-executive director, Newport Coast Oral Facial Institute, Newport Beach, CA; clinical professor, Restorative Dentistry, USC School of Dentistry, Los Angeles, CA, USA
‡Co-executive director, Newport Coast Oral Facial Institute Newport Beach, CA; associate professor, Restorative Dentistry, USC School of Dentistry, Los Angeles, CA, USA

JOURNAL OF ESTHETIC AND RESTORATIVE DENTISTRY

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American Academy of Cosmetic and Adhesive Dentistry,
Belgian Academy of Esthetic Dentistry, Dutch Academy of Esthetic Dentistry,
and the Scandinavian Academy of Esthetic Dentistry



1X

2X



8X



12X



16X



24X



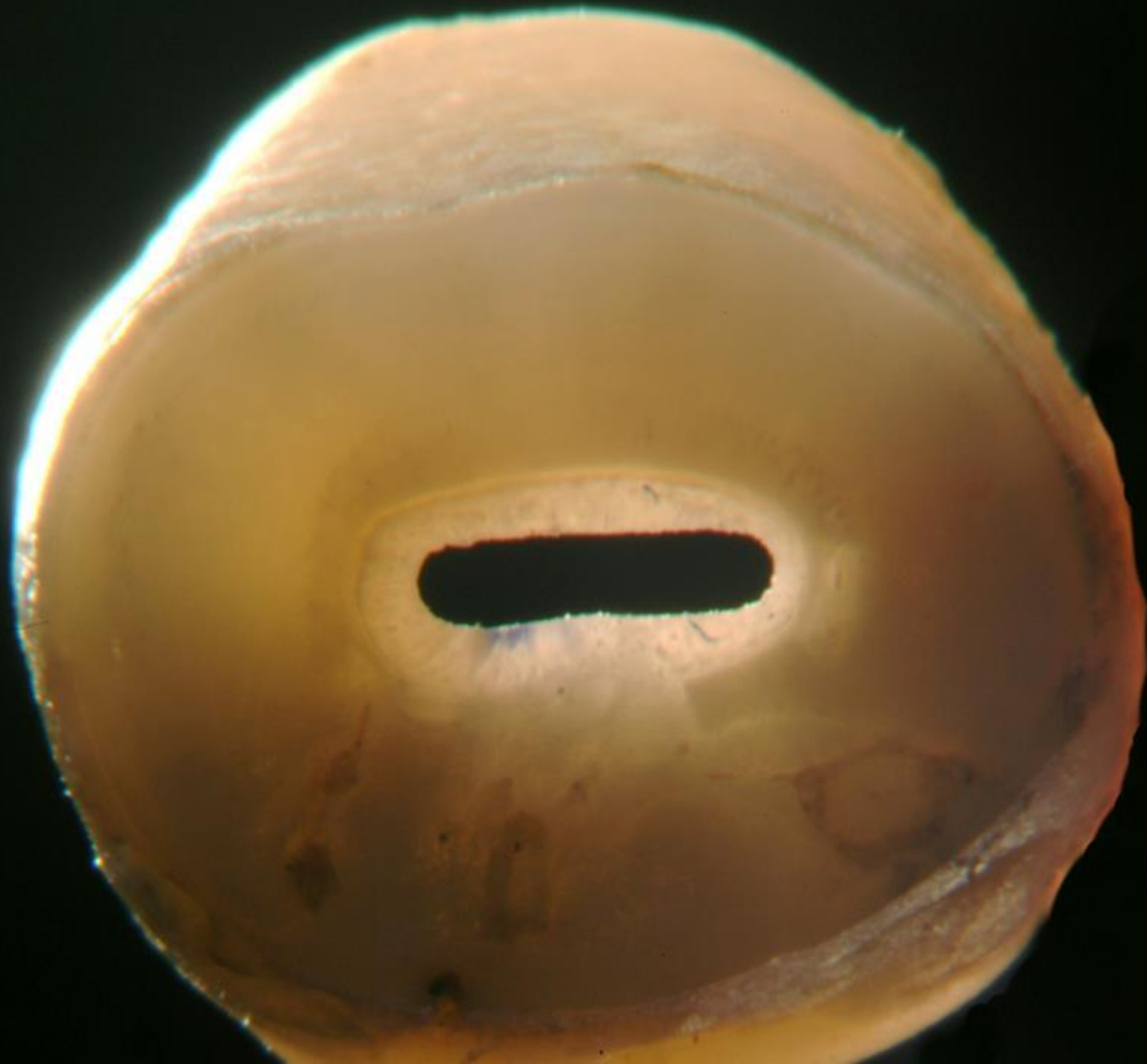


**ONE OF THE ENDURING
FIRST IMPRESSIONS OF
CLINICAL MICROSCOPE
DENTISTRY IS THE
STAGGERING ARRAY OF
CRACKS THAT ARE
SUDDENLY VISIBLE**

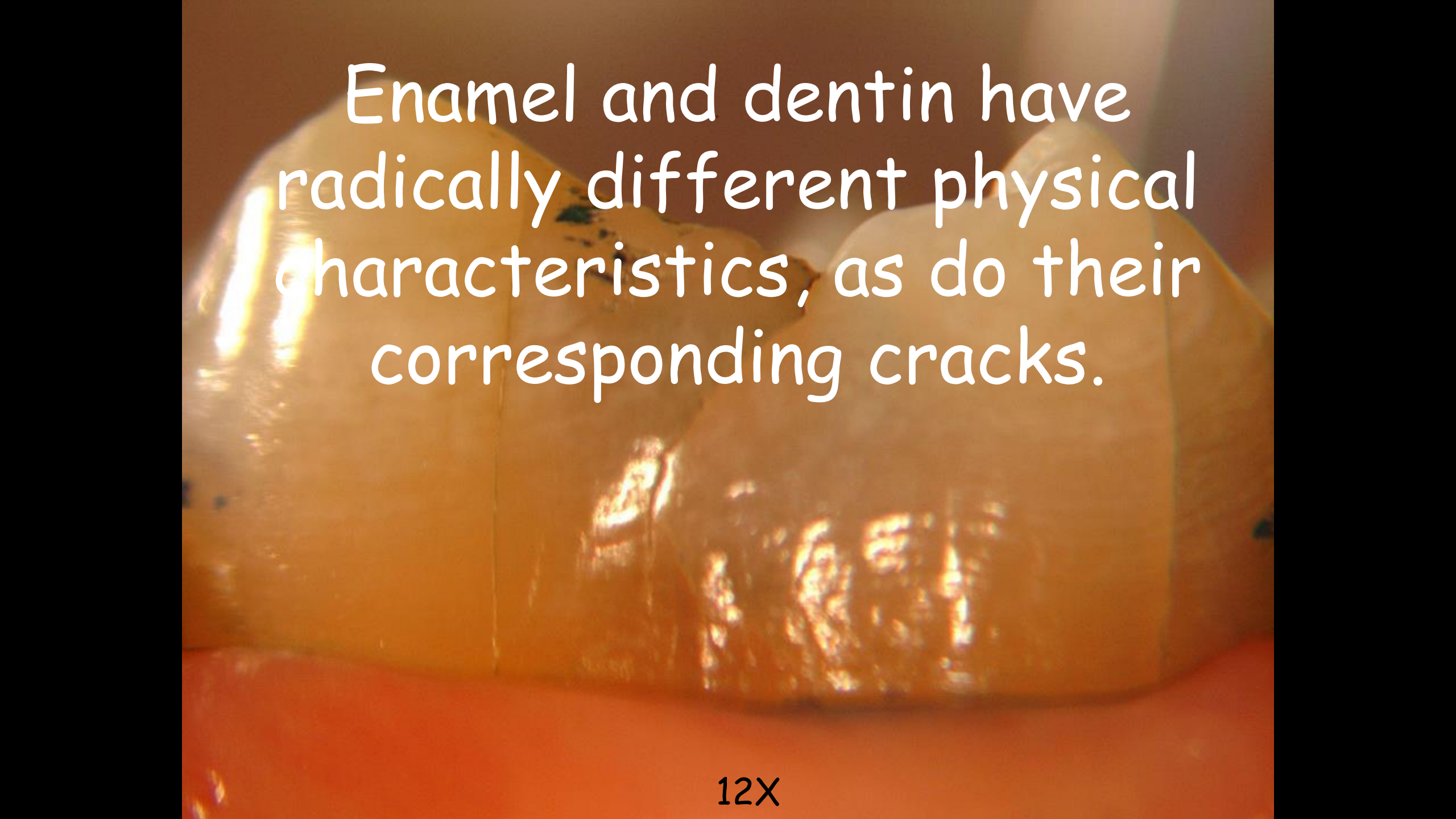
Clark, D.J., Paquette J., Sheets C., *Journal of Esthetic and Restorative
Dentistry*; Special Edition, 2004

Nature does
nothing
uselessly.

Aristotle 322 BC

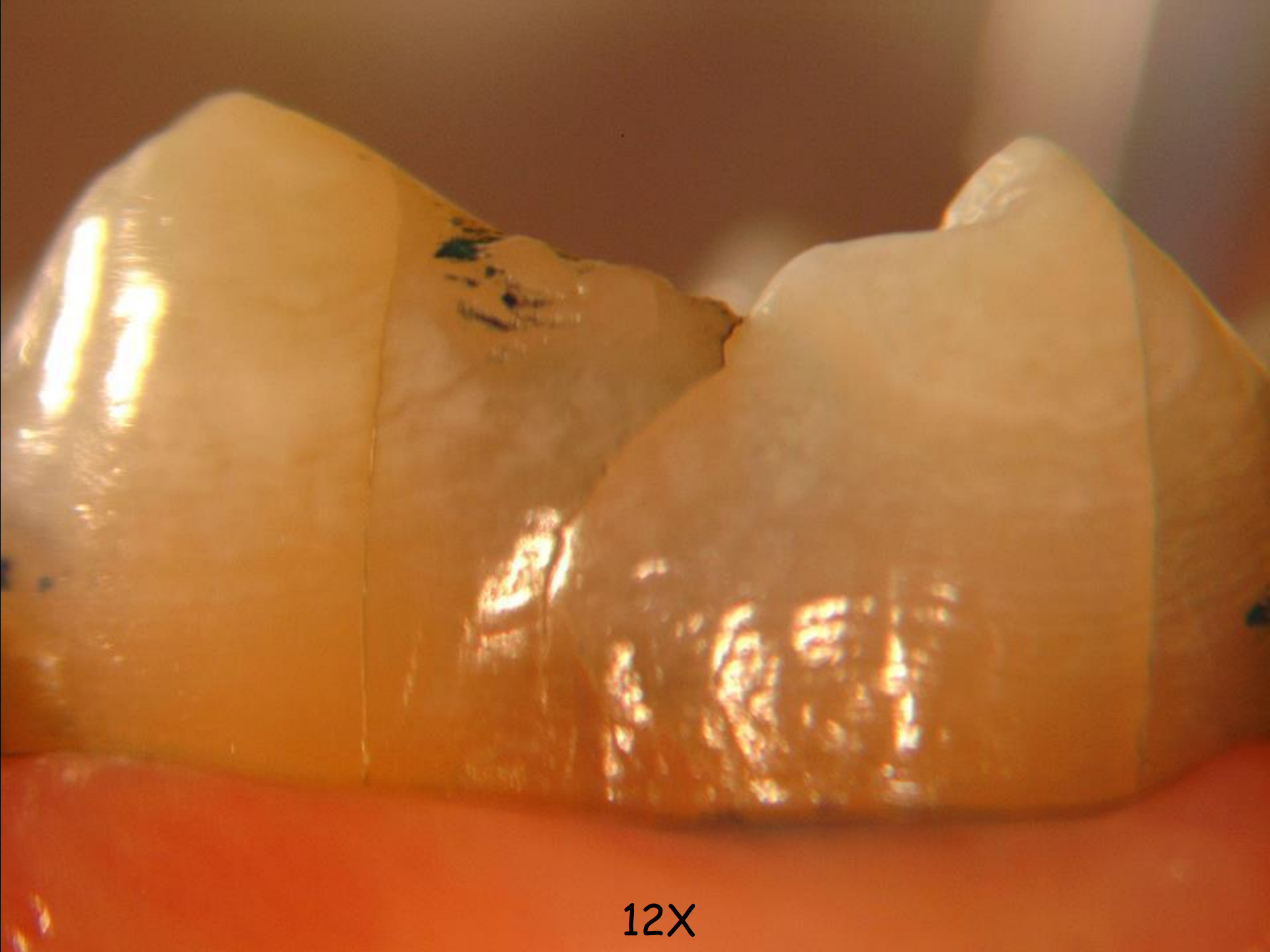


Enamel and dentin have radically different physical characteristics, as do their corresponding cracks.

A microscopic view of a tooth cross-section, showing the enamel and dentin layers. The enamel is the outer, lighter-colored layer, and the dentin is the inner, darker-colored layer. The image shows several cracks or fractures in the enamel and dentin, illustrating the text's claim that they have radically different physical characteristics. The cracks are visible as dark lines and irregular shapes within the tooth structure.

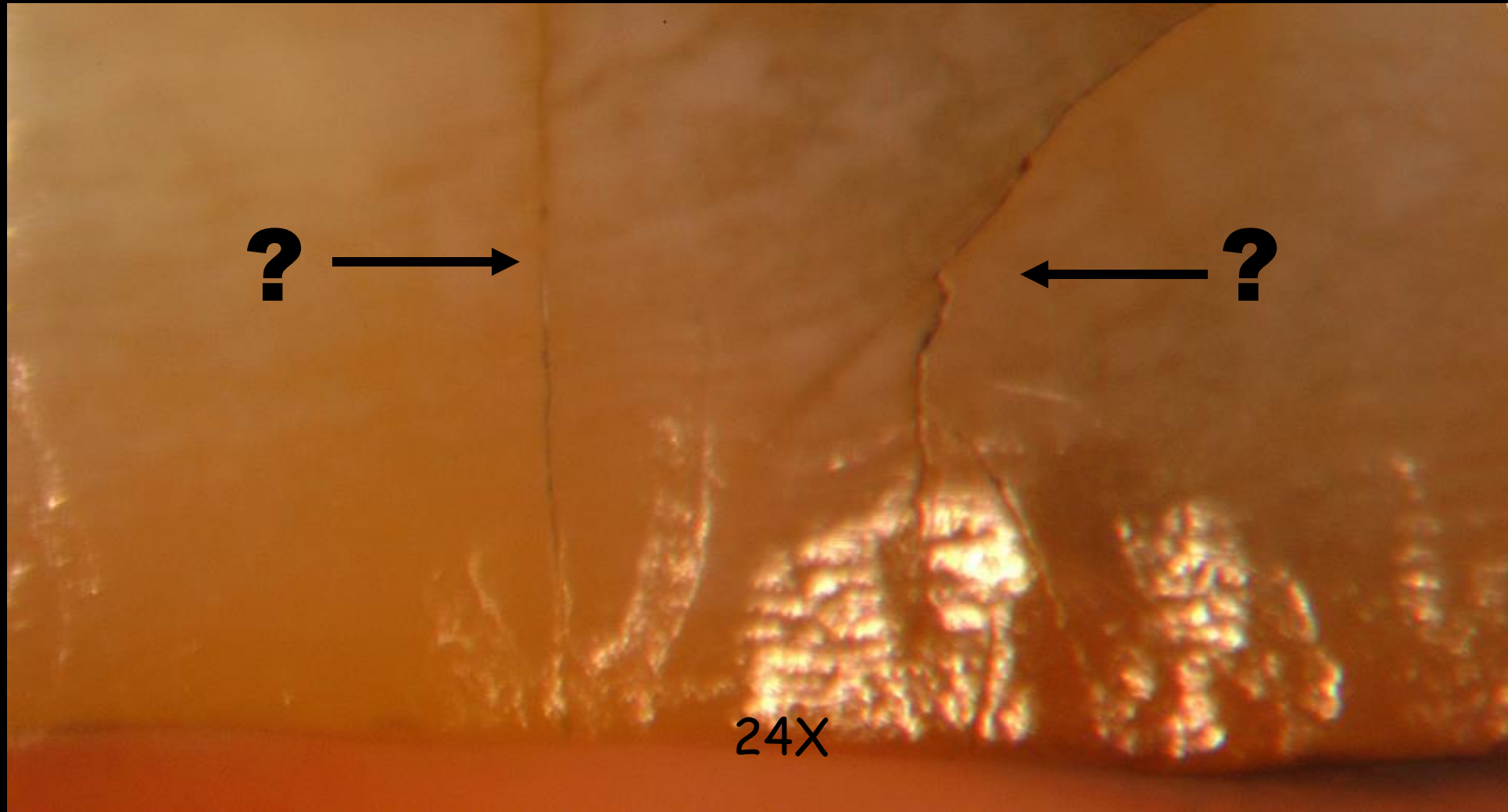
Enamel and dentin have radically different physical characteristics, as do their corresponding cracks.

12X



12X

Which enamel crack is "native", which crack is indicative of underlying pathology?



English pg. 21 Issues pg. 130 Microissues pg. 100

DENTISTRY TODAY
October 2004

BETTER RESULTS THROUGH MAGNIFICATION

Carl MacNeil, MD, PhD, FRCR, FRCR, FRCR, FRCR
pg. 34

Paul Collins, MD, FRCR, FRCR, FRCR, FRCR
pg. 35

Christopher Smith, MD, FRCR, FRCR, FRCR, FRCR
pg. 36

The Epidemic of Cracked and Fracturing Teeth



David Clark, DMD

Teeth are fracturing faster in dental numbers. Cracked and fractured teeth are now the third leading cause of tooth loss in industrialized nations.¹ Fractured teeth with conservative analgesic and antibiotic use, sealing, and long-term crown fracturing all at three levels. Fractured teeth treated with sealers, including all, and single layering (Figure 1). Additionally, endodontics are reporting that cracked teeth are now replacing crown teeth for curative strategy in a number of patients referred for endodontic treatment.

We assume that the reason of this period and growing problem are not so long known. In our areas levels are rising, and dentists and dentists are also more general, in the advent of the high-speed handpieces, speeded billions of horsepower (HP). Most every preparation that have work and powder teeth (Figure 2) and the deep endo-crown preparations in the case of powder condition, and yet aggressive "crown-down" endodontic change is definite, new endo teeth.

Dentistry has great capacity (including a poorly understood process). A dramatic change in the form of combining dental education, dental, dentistry, dentistry, and dentistry has shifted our attention more from some of the most integral aspects of the building and dentistry, and dentistry, and dentistry. We now find our profession faced with a tremendous problem that will require a significant re-evaluation and re-education of



Figure 2. In an anterior right, and viewed with a microscope (x16 magnification), the tooth is cracked. The crack is visible, and the other cracked tooth is visible in the lower right corner of the image.

dentists to address appropriately. There is no need to assess. Many, to most simply will require a new paradigm and part to work.

BRINGING DIAGNOSIS AND PREVENTION OUT OF THE ROOM

Microscopic and operator-driven diagnosis have been the accepted modalities for the diagnosis of cracked teeth. The following list

of signs of the lack of visual confirmation create therapies that education can be used in the treatment process. One looking first impression of cracks through the clearance coverage is the staggering array of cracks that come within such structures (Figure 3). Traditional visual examination (or longer) limits the clinician's ability to assess the pro-

Table 1. How Can We Eliminate Tooth Fracturing?

Phase 1:	Phase 2:	Phase 3:	Phase 4:	Phase 5:
Diagnose the tooth in depth (in front and back) using a high speed handpiece in the preparation area.	Recognize a lot of new cracks (in preparation area) and seal with a restorative material.	Recognize a lot of new cracks (in preparation area) and seal with a restorative material.	Recognize a lot of new cracks (in preparation area) and seal with a restorative material.	Recognize a lot of new cracks (in preparation area) and seal with a restorative material.

Table 2. Quick Reference Guide for Microscopic Cracks in Posterior Teeth.

1. Most teeth in aging adults display enamel cracks.
2. Cracked teeth, even traumatic cracks, do not necessarily indicate that the tooth is cracked.
3. Only enamel cracks do not penetrate significantly (70-80%).
4. Only enamel cracks that do not penetrate significantly (70-80%).
5. Three types of underlying pathology will produce enamel cracks:
 - Enamel cracks, decay, and subclinical enamel (not contributing to microleakage around a restoration).
 - Enamel cracks should be considered as structural cracks.
 - Enamel cracks that penetrate into the pulp (in enamel, generally positioned in the middle of the pulp flow, are "structural" and do not generally contribute to the pulp's ability to respond, as "structural" (Figure 4).
 - Only teeth with both types of enamel cracks (both cracks) are also cracked. (Figure 5) Restoration will be most important that early recognition and treatment. All teeth with dental cracks should be considered as structurally unsound.

Re-evaluation/Re-education: How to?

1. Microscopic cracks in restorative materials can indicate a lack of correct structural integrity.
2. Evaluation of the condition of a cast-in-place or in-place a lack of structural integrity.
3. If a cast-in-place (or in-place) restorative and both structure can indicate a lack of structural integrity.

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Belgian Academy of Esthetic Dentistry, Dutch Academy of Esthetic Dentistry,
and the Scandinavian Academy of Esthetic Dentistry

www.bndecker.com

Prognostic Diagnosis of Early Enamel and Dental Cracks Based on Microscopic Evaluation

DAVID J. CLARK, DMD,
CHRISTOPHER G. SMITH, DMD,
JACINTHE M. BAQUETTE, DMD

Cracks and fractures of cracked teeth and incomplete coronal fractures have historically been symptoms of the dental operating microscope at x16 magnification can fundamentally change a clinician's ability to diagnose such conditions.

We have been observing cracks under extreme magnification for nearly a decade. Patients come to us with cracks that are not structural and can lead to misdiagnosis and treatment. Methodically microscopic examination, an understanding of crack progression, and appreciation of the types of cracks will guide a doctor to making appropriate decisions.

Teeth can have structural cracks in various stages. To date, diagnosis and treatment are very often at an end stage of crack development.

CLINICAL SIGNIFICANCE

This article gives new guidelines for recognition, visualization, classification, and treatment of cracked teeth based on the realistic use of x16 magnification. The significance of enamel cracks as they relate to dental cracks is detailed.

(J Esthet Restor Dent 15:XXX-XXX, 2003)

Microscopic and symptom-driven diagnoses have been the accepted modalities for cracked teeth. The inherent limitations of the lack of visual confirmation mask it through the clear coverage in the treatment process. One lacking first impression of vision through a clinical microscope is the staggering array of cracks that exist within tooth structures. Traditional visualization is limited

or ocular (visual) limits the clinician's ability to assess the presence or severity of the majority of these cracks (Figure 1).

At extreme magnification levels (x14 and greater), the translucent nature of enamel yields a wealth of information. Subtle color changes within the enamel may indicate early decay, microleakage, and a lack of structural integrity of dentin and

enamel. Being able to see previously invisible cracks can lead to more appropriate treatment of compromised teeth before devastating fractures, pulp involvement, and periodontal breakdown occur. The value of early diagnosis of the structural breakdown of teeth will become even more significant with our aging population coupled with increased tooth retention in this population.

President, Academy of Microscopic Esthetic Dentistry,
Torrance, Calif.; Director, The Great Oral Facial Institute, Torrance, Calif.; clinical professor,
Restorative Dentistry, USC School of Dentistry, Los Angeles, Calif., USA
Consultant, Director, The Great Oral Facial Institute, Torrance, Calif.; associate professor,
Restorative Dentistry, USC School of Dentistry, Los Angeles, Calif., USA



The Epidemic of Cracked and Fracturing Teeth



Dr. David J. Farnsworth, D.D.S., M.S.D.

Tooth and fracture today in dental numbers. Cracked and fractured teeth are now the most leading cause of tooth loss in industrialized nations.¹ Fractured teeth with conservative analgesic and antibiotic use, sealing, and being cause. Cracked teeth, both anterior and posterior, are fracturing at all three levels. Fractured teeth treated with sealants, sequestering, and strategic ligation (Figure 1). Additionally, endodontics are reporting that cracked teeth are now replacing crown teeth for sensitive etiologies in a number of patients referred for endodontic treatment.

We assume that the reason of the prevalence and growing problem is not too far from longer life span, stress levels are rising, and chewing and tension are also more general. It is the advent of the high-speed handpieces, powered billions of horsepower (HP), that every preparation that have work and powder teeth (Figure 2) and the deep cast crown preparations in the case of porcelain conductive, and yet aggressive "cross-link" substrate change in denture, new metal resin.

Dentistry has great options (including a poorly understood process). A dramatic change in the form of combining dental materials, bonding, dentistry, blending, and ligature has shifted our attention more from some of the most integral aspects of the building and of dentistry, oral cavity, top that but. It is now that our profession face with a tremendous problem that will require a significant commitment and reevaluation of



Figure 1. A, In the anterior region, seal ligation with a composite. B, In the posterior, seal ligation with a composite. C, In the posterior, seal ligation with a composite. D, In the posterior, seal ligation with a composite.

measures to address appropriately. There is no need to assess. Many, to start simply will require a new paradigm and part to work.

BRINGING DIAGNOSIS AND PREVENTION OFF OF THE SCENE

Microscopic and optical-drive diagnosis have been the accepted standards for the diagnosis of cracked teeth. The following list

of items of the lack of visual endodontics results therapies that education can be used in the treatment process. They listing first appearance of cracks through the clinical appearance in the staggering array of cracks that can occur within tooth structure (Figure 3). Traditional visual exam (visual or ligation) limits the dentist's ability to assess the presence of cracked teeth. The following list:

Table 1. How Can We Eliminate Teeth Fracturing?

Phase 1:	Phase 2:	Phase 3:	Phase 4:	Phase 5:
Diagnose the level of degree of fracture or degree of fracture.	Recovery of the tooth.	Corrective treatment.	Preventive treatment.	Recovery of the tooth.
Diagnose the level of degree of fracture or degree of fracture.	Recovery of the tooth.	Corrective treatment.	Preventive treatment.	Recovery of the tooth.
Diagnose the level of degree of fracture or degree of fracture.	Recovery of the tooth.	Corrective treatment.	Preventive treatment.	Recovery of the tooth.
Diagnose the level of degree of fracture or degree of fracture.	Recovery of the tooth.	Corrective treatment.	Preventive treatment.	Recovery of the tooth.
Diagnose the level of degree of fracture or degree of fracture.	Recovery of the tooth.	Corrective treatment.	Preventive treatment.	Recovery of the tooth.

Table 2. Quick Reference Guide for Microscopic Cracks in Posterior Teeth.

1. Most teeth in aging adults display enamel cracks.
2. Cracked cracks, even traumatic cracks, do not necessarily indicate that the tooth is cracked.
3. Only enamel cracks do not penetrate significantly (70-80%).
4. Only enamel cracks that display features, many with oral multiple cracks.
5. Three types of crack-type pathology are possible enamel cracks:
 - Enamel cracks, decay, and subclinical enamel (not contributing to microleakage enamel is indicated).
 - Enamel cracks should be considered as enamel cracks.
 - Enamel cracks that penetrate into dentin, generally positioned in the middle of the pulpal floor, are "enamel cracks" and "dentin cracks" (classified as the "enamel cracks" preparation, see "Enamel Cracks" Figure 4).
 - Enamel cracks that penetrate into dentin, generally positioned in the middle of the pulpal floor, are "enamel cracks" and "dentin cracks" (classified as the "enamel cracks" preparation, see "Enamel Cracks" Figure 4).

Microscopic (Microscopic) Pathology:

1. Microscopic cracks in denture, enamel, or dentin indicate a lack of control structural integrity.
2. Microscopic cracks in denture, enamel, or dentin indicate a lack of control structural integrity.
3. Microscopic cracks in denture, enamel, or dentin indicate a lack of control structural integrity.

“Dentistry’s last great mystery, that of fracturing, is a poorly understood process.”

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and the Scandinavian Academy of Esthetic Dentistry

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Definitive Diagnosis of Early Enamel and Dentinal Cracks Based on Microscopic Evaluation

DAVID J. CLARK, DDS,
DORLAND G. SMITH, DDS,
JACQUELINE B. QUINN, DDS

ABSTRACT

The diagnosis of cracked tooth and incomplete coronal fracture have historically been symptomatic. The dental operating microscope at 40x magnification can fundamentally change a clinician's ability to diagnose such conditions.

Clinicians have been observing cracks under extreme magnification to be merely cosmetic. Patients are becoming clear that an early or appropriate treatment option is symptomatic or detection in tooth structure occurs. Generally, many cracks are not structural and can locate in the grooves and overhangs of. Methods of microscopic examination, an understanding of crack progression, and an appreciation of the types of cracks will guide a clinician in making appropriate decisions.

Teeth can have structural cracks in various stages. To date, diagnosis and treatment are very often a trial and error of crack development.

CLINICAL SIGNIFICANCE

This article gives new guidelines for recognition, classification, and treatment of cracked teeth based on the routine use of 40x magnification. The significance of enamel cracks as they relate to coronal cracks is detailed.

J Esthet Restor Dent 16:XXX-XXX, 2004

Microscopic and symptomatic diagnoses have been the accepted modalities for cracked teeth. The inherent limitations of the lack of visual confirmation result in therapies that often come out late in the treatment process. One limiting factor, irrespective of vision through a clinical microscope is the enlarging array of cracks that color visible tooth structures. Traditional visualization (unaided

or ocular) cannot reliably distinguish the presence or severity of the majority of these cracks (Figure 1A).

At extreme magnification levels (40x and greater), the translucent nature of enamel yields a wealth of information, such as color changes within the enamel may indicate early decay, microleakage, and a lack of structural integrity of dentin and

enamel. Being able to see previously invisible decay can aid restorative decisions to more appropriate early treatment of compromised teeth. Before discussing trauma, pulp involvement, and periodontal involvement occur. The value of early diagnosis of the structural breakdown of teeth will become even more significant with our aging population coupled with increasing tooth retention in this population.

¹President, Academy of Microscopic Oral and Esthetic Dentistry
²Consultant, American Academy of Esthetic Dentistry, Silver Spring, Md.; Clinical Professor of Restorative Dentistry, DTC School of Dentistry, Los Angeles, CA, USA
³Consultant, American Academy of Esthetic Dentistry, Silver Spring, Md.; Associate Professor, Restorative Dentistry, DTC School of Dentistry, Los Angeles, CA, USA

In 20 Minutes

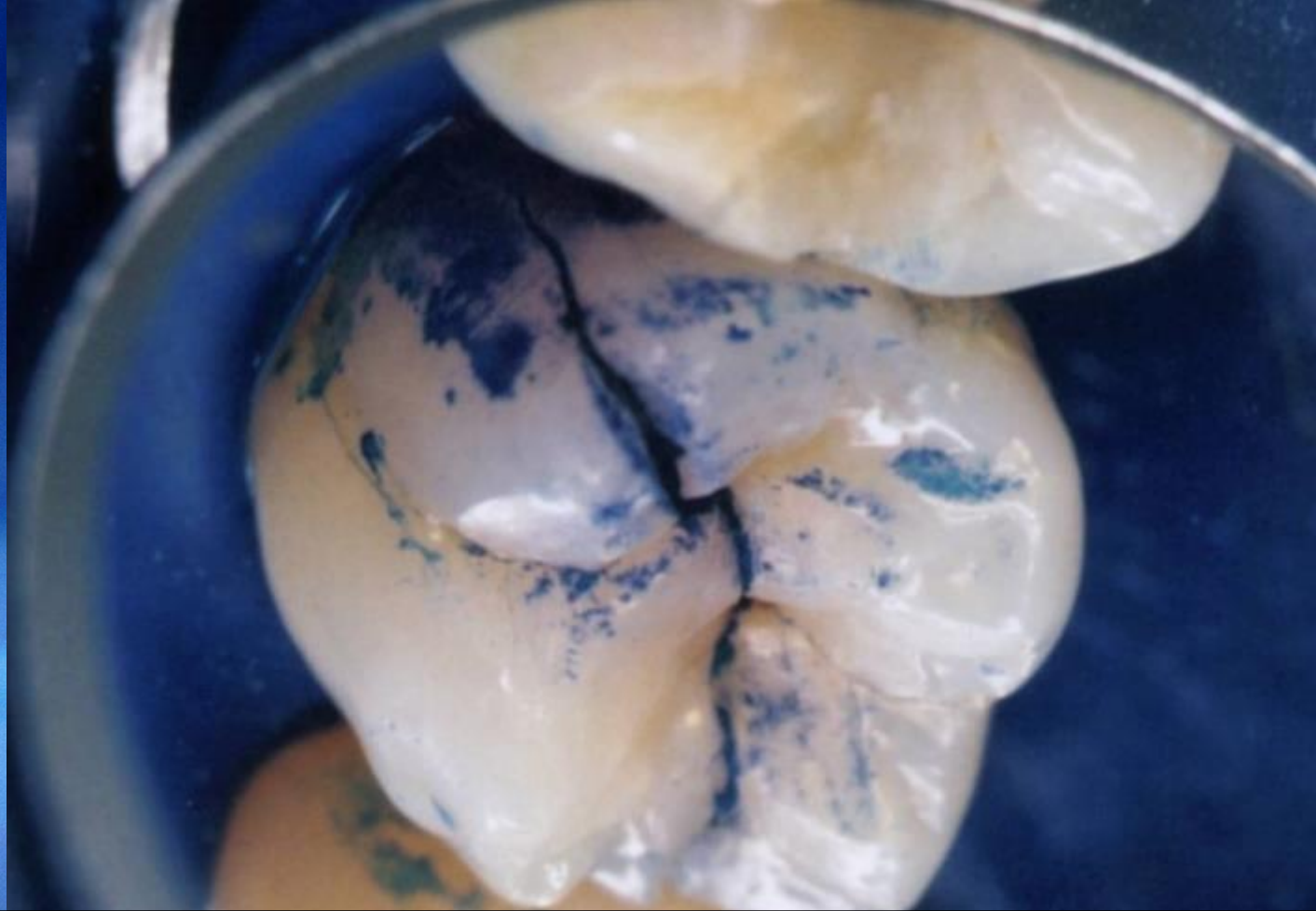
- Gross fracture patterns
- End Stage
- 2 year microscope centered study –dentinal fracture trends
- First ever system for identifying, classifying and treating microscopic **enamel** cracks in asymptomatic teeth

Pulpal Implications of Incomplete Fractures (Regardless of symptoms)

• ICF of 1 cusp	Mild risk of future necrosis
• ICF of MB cusp	Moderate risk of future necrosis
• ICF of 2 cusps	Moderate risk of future necrosis
• IVF crosses only a portion of pulpal floor	Mild risk of future necrosis
• IVF crosses pulpal floor completely from buccal to lingual or mesial to distal	Moderate to high risk of future necrosis
• IVF completely crosses pulpal floor <i>and</i> houses debris	High risk of present and future necrosis

Implications of Cracks in Furcal Floors and Lateral Walls of Endodontically Accessed Teeth

Crack in one lateral wall	Reasonable to save tooth if attachment probes normally
Crack in two lateral walls or furcal floor	Extract...unless...
Micro-movement of halves can be elicited by wedging an explorer	Extract



Vertical Crack End Stage:
Complete Tooth Fracture
(split tooth)

Endstage Oblique Fracture Cuspal Fracture



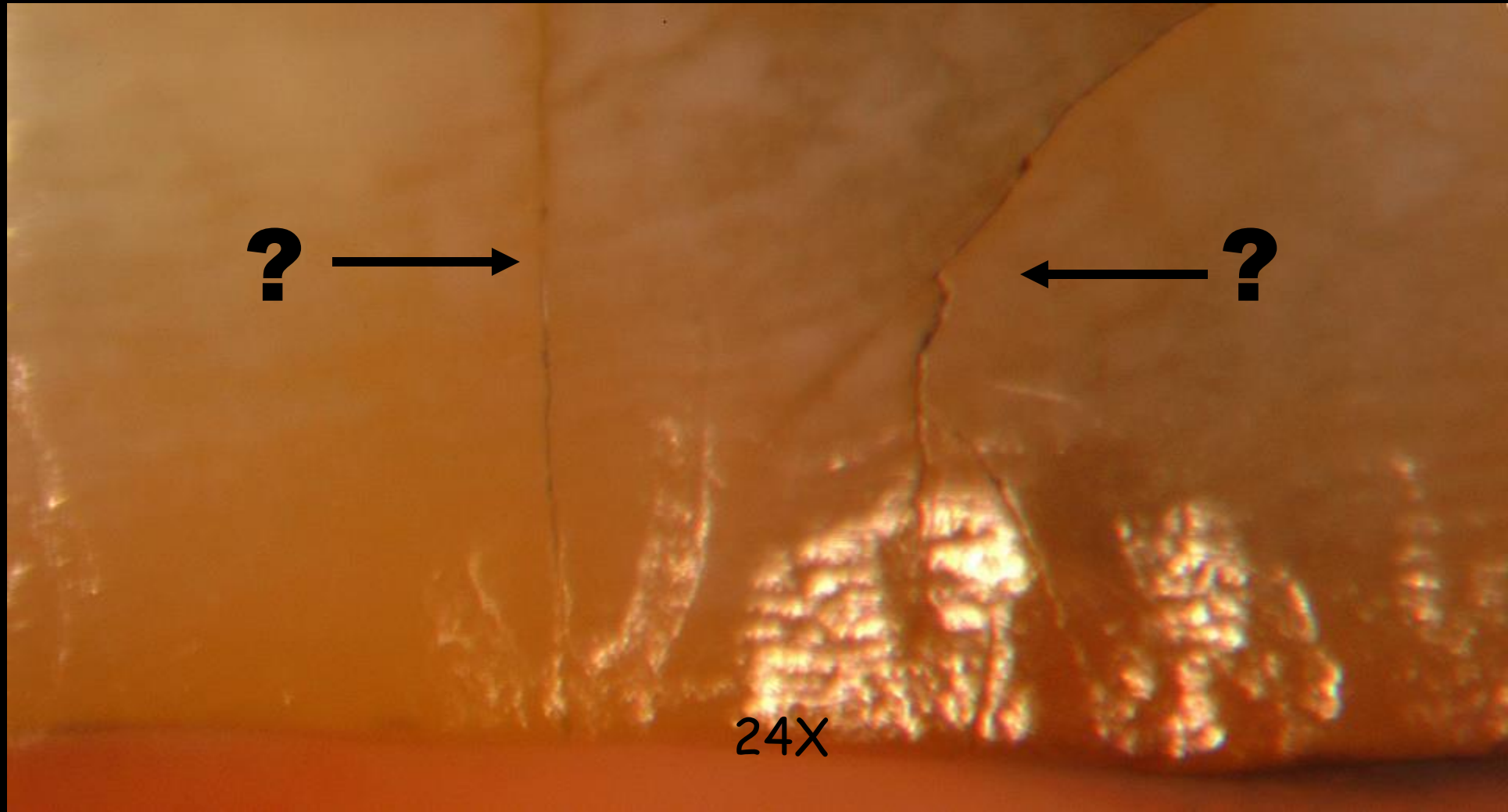
The new patient protocol

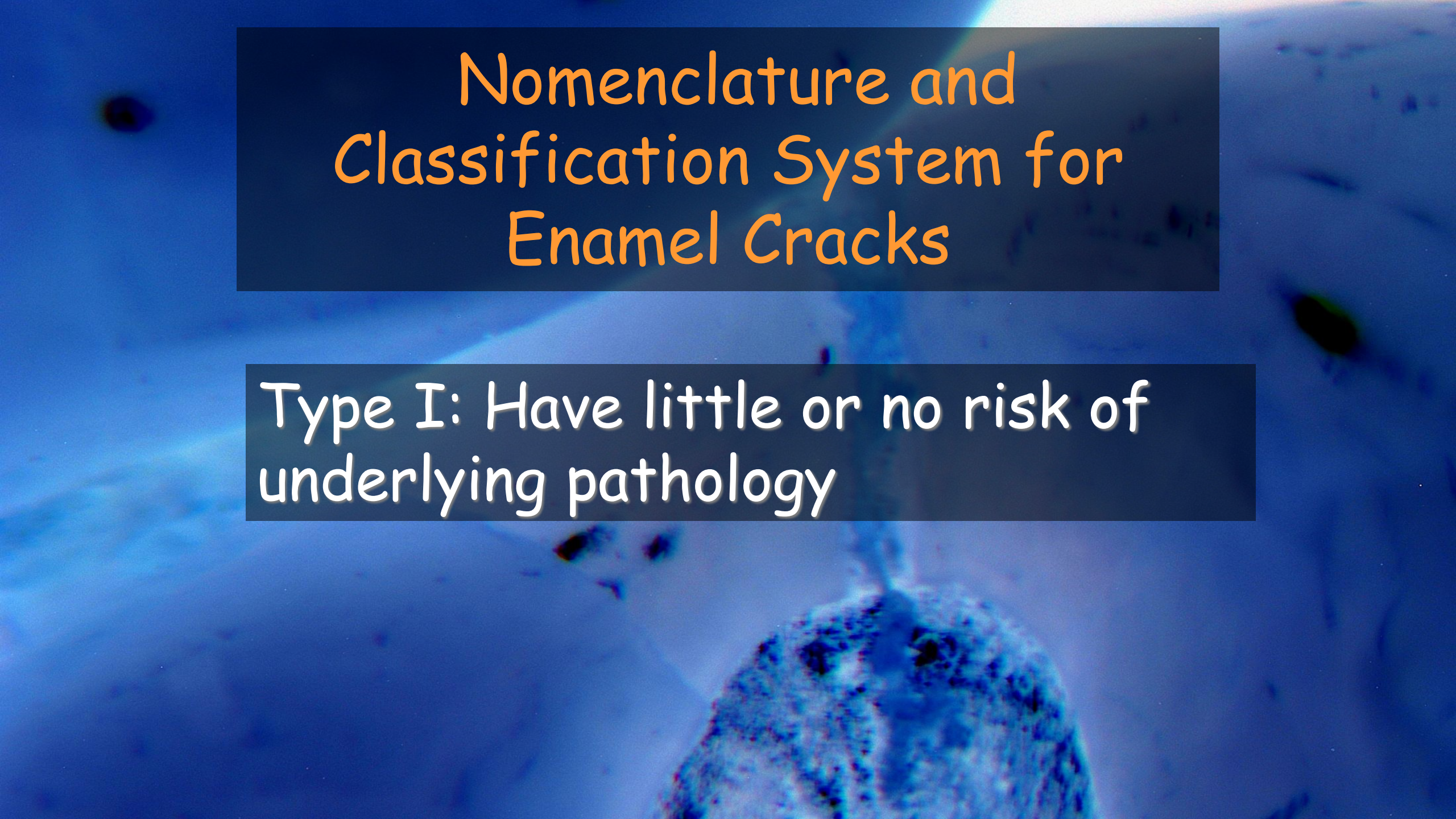


Enamel and dentin have radically different physical characteristics, as do their corresponding cracks.

12X

Which enamel crack is "native", which crack is indicative of underlying pathology?



A microscopic image of an enamel crack, showing a dark, irregularly shaped crack running through the enamel structure. The background is a light, textured surface. The crack is the central focus of the image.

Nomenclature and Classification System for Enamel Cracks

Type I: Have little or no risk of
underlying pathology

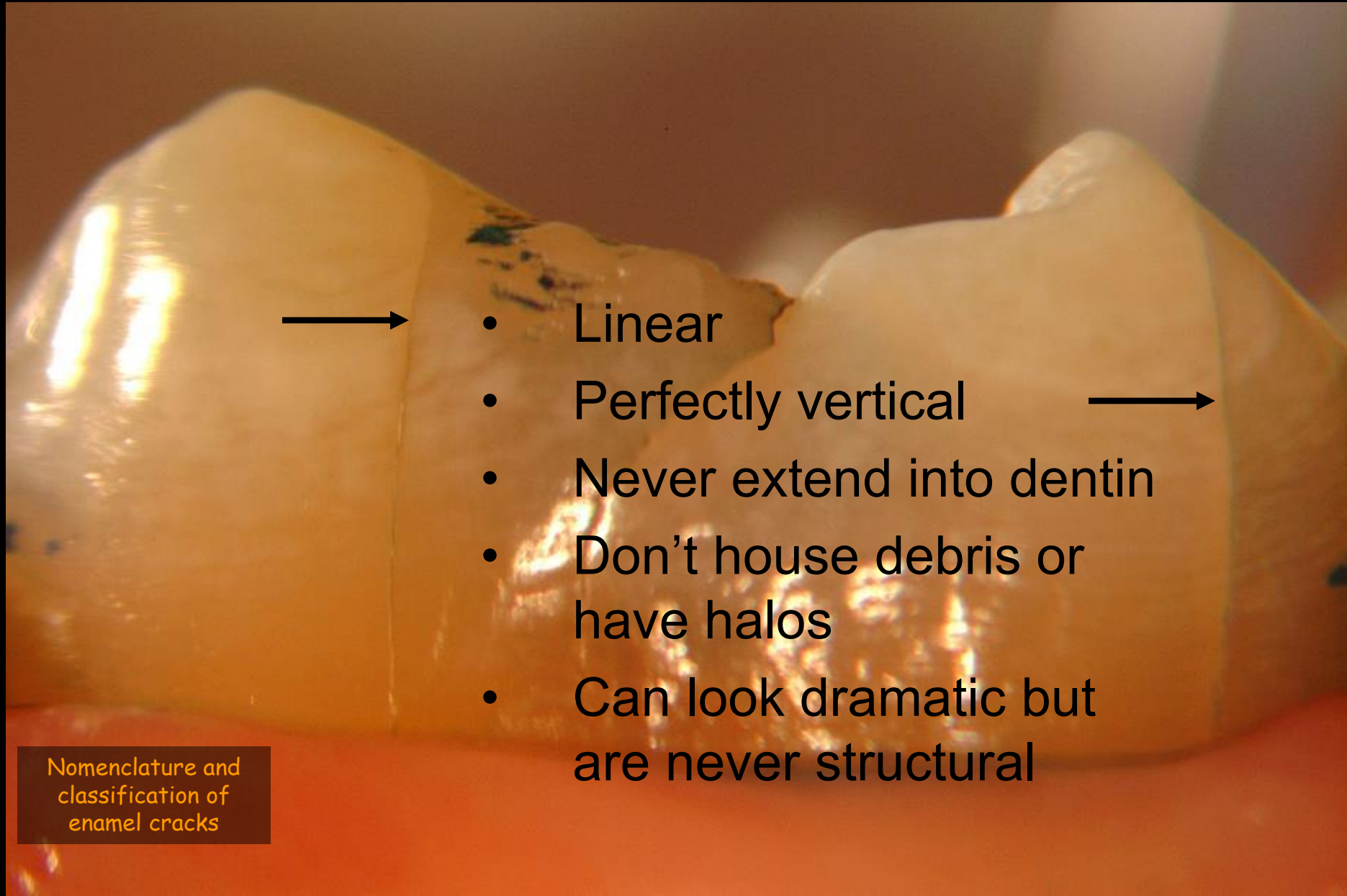
Type I: Have little or no risk of underlying pathology

- A) Craze lines
- B) Small vertical cracks
- C) Cracks that follow natural anatomic grooves
- D) Cracks with superficial stain penetration

Type I: Have little or no risk of underlying pathology

- F) Cracks Resulting from Polymerization Shrinkage of Composite
- G) Enamel Crackling in Aging, Thin, Cervical Enamel

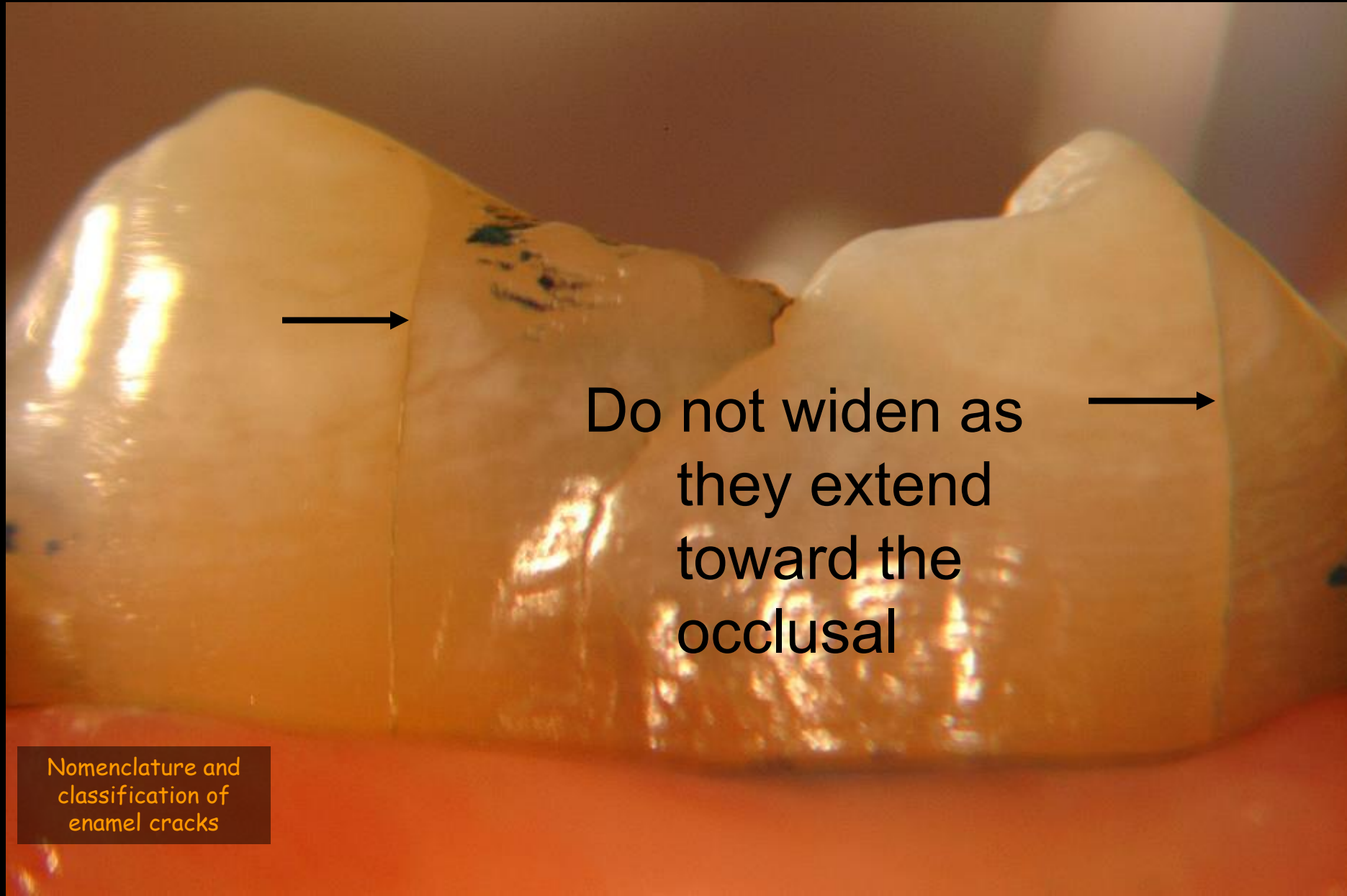
Craze Lines



- Linear
- Perfectly vertical
- Never extend into dentin
- Don't house debris or have halos
- Can look dramatic but are never structural

Nomenclature and
classification of
enamel cracks

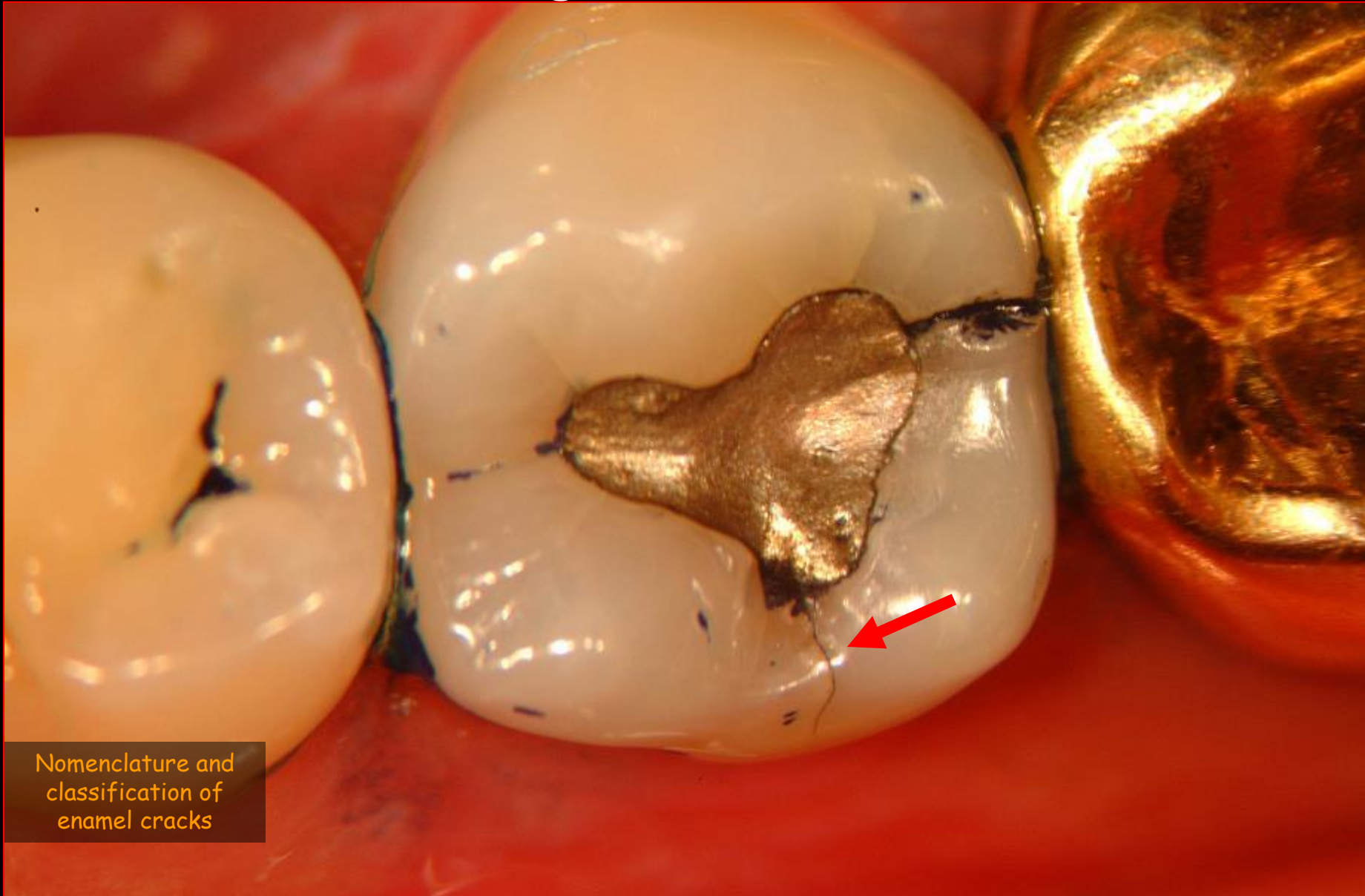
Craze Lines



Do not widen as
they extend
toward the
occlusal

Nomenclature and
classification of
enamel cracks

C. Cracks that follow anatomic grooves

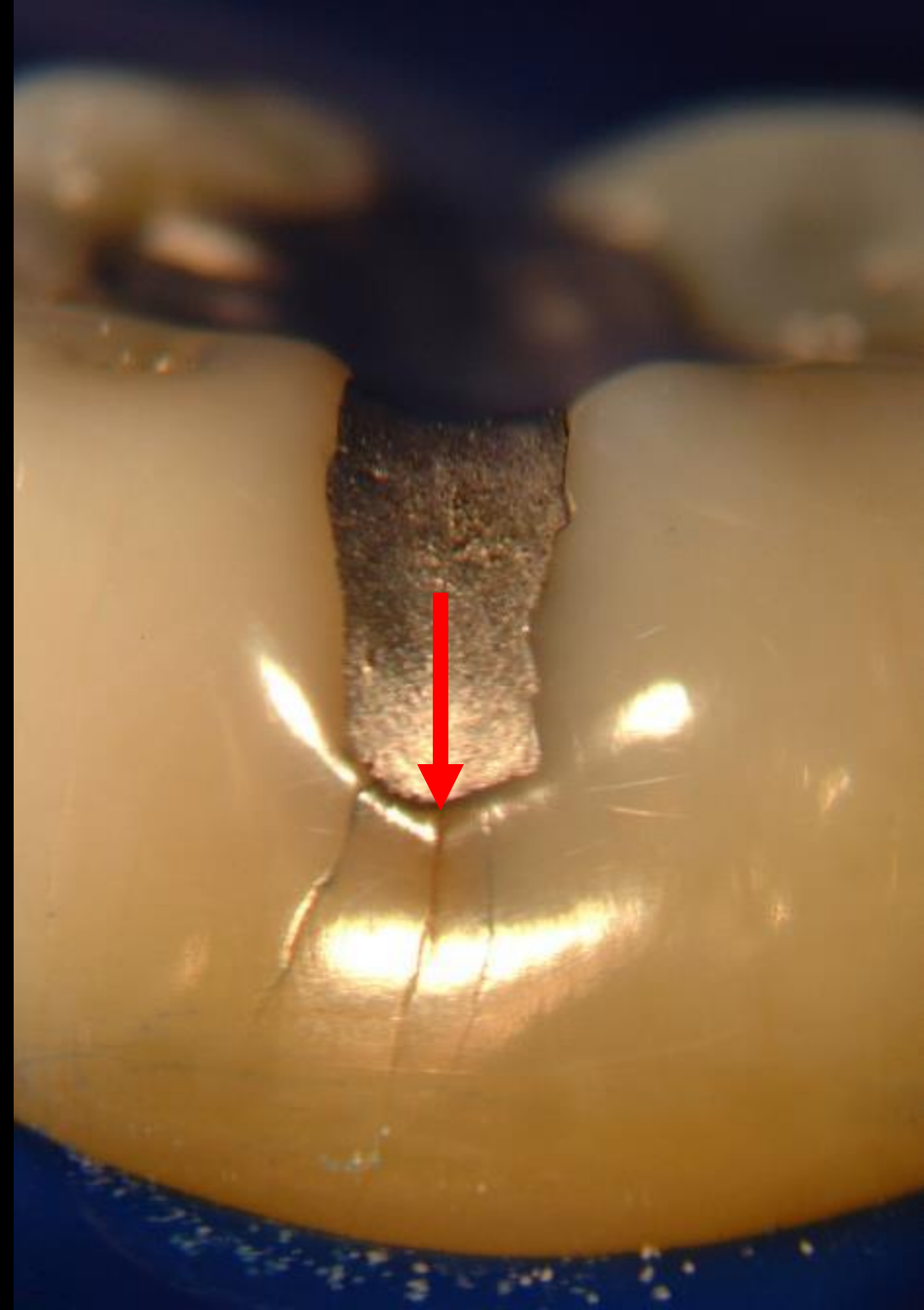


Nomenclature and
classification of
enamel cracks

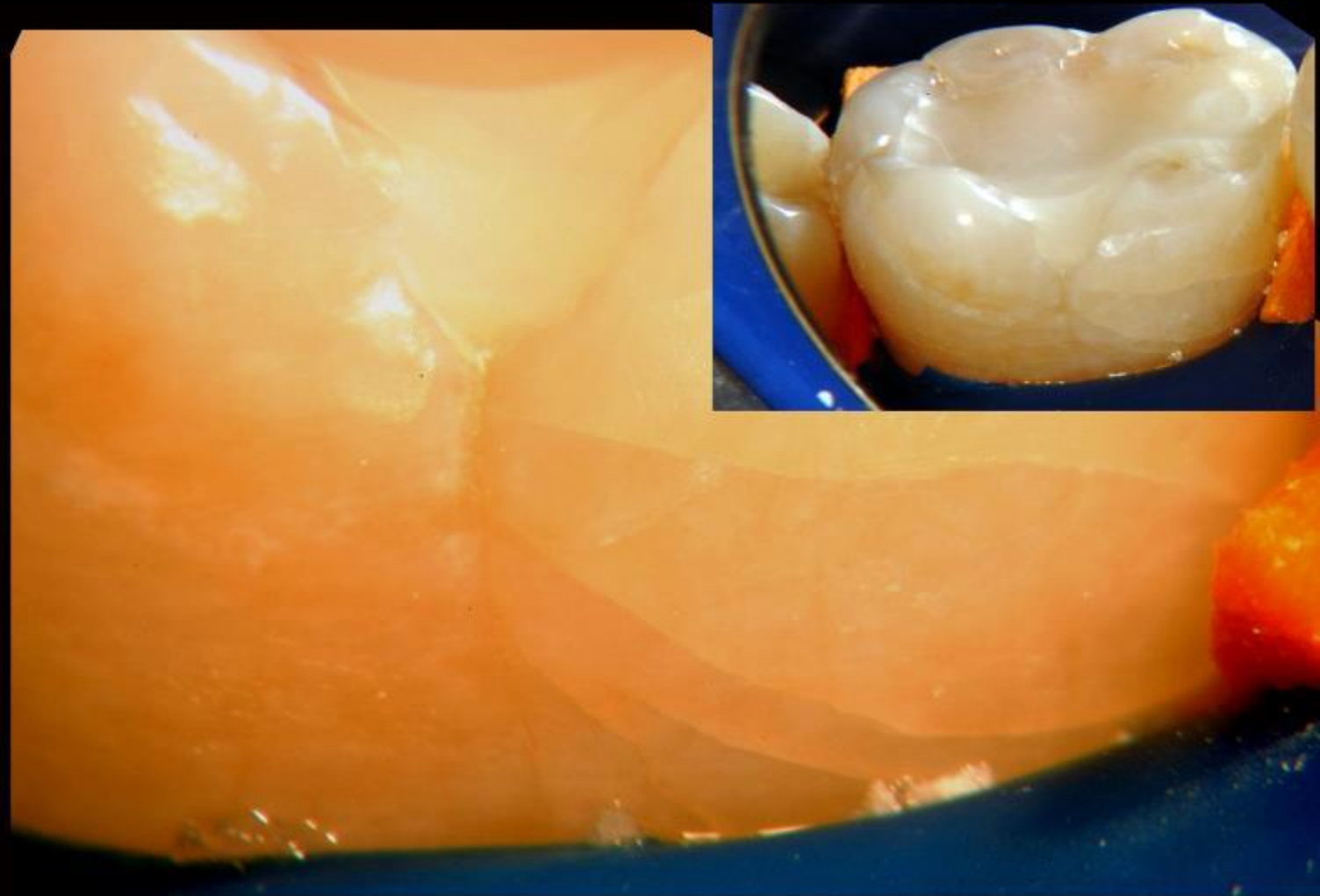
C. Cracks that follow natural anatomic grooves

D Superficially Stained Cracks

Nomenclature and
classification of
enamel cracks



E. Cracks that result from polymerization shrinkage of composites



Nomenclature and classification of enamel cracks

F. Enamel Crackling in Aging, Thin, Cervical Enamel

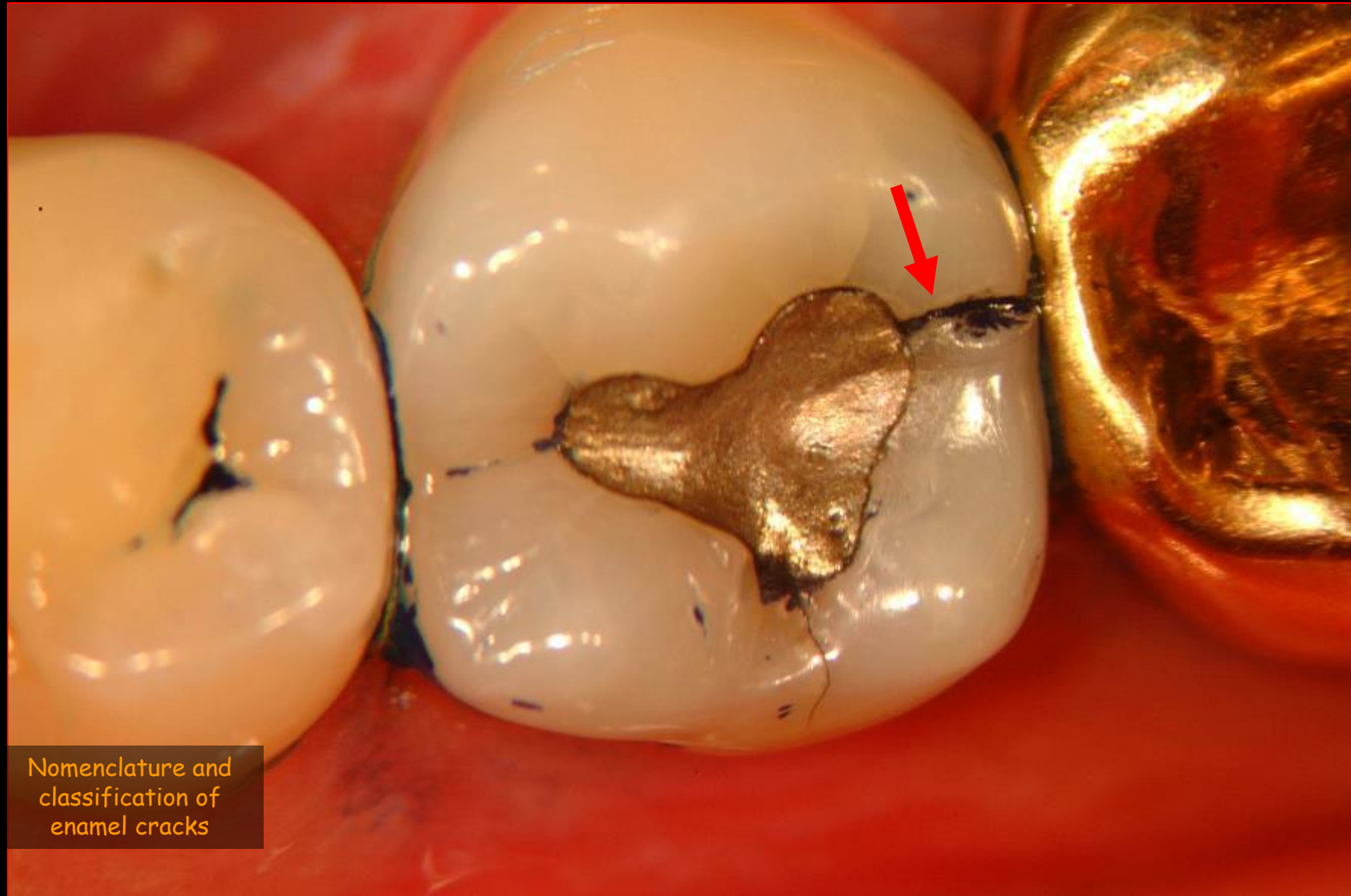


Nomenclature and classification of enamel cracks

Type II: Have moderate risk of underlying pathology

- A) V-shaped enamel ditching with no adjoining restoration often associated with a wear facet centered over an otherwise benign crack
- B) V-shaped enamel ditching with a prior restoration often associated with a wear facet centered over an otherwise benign crack
- C) Cracks that detour from or do not follow natural anatomic grooves

B. V shaped ditching



Nomenclature and
classification of
enamel cracks

C. Non linear cracks that detour from or do not follow natural anatomic grooves



Type II: Have moderate risk of underlying pathology

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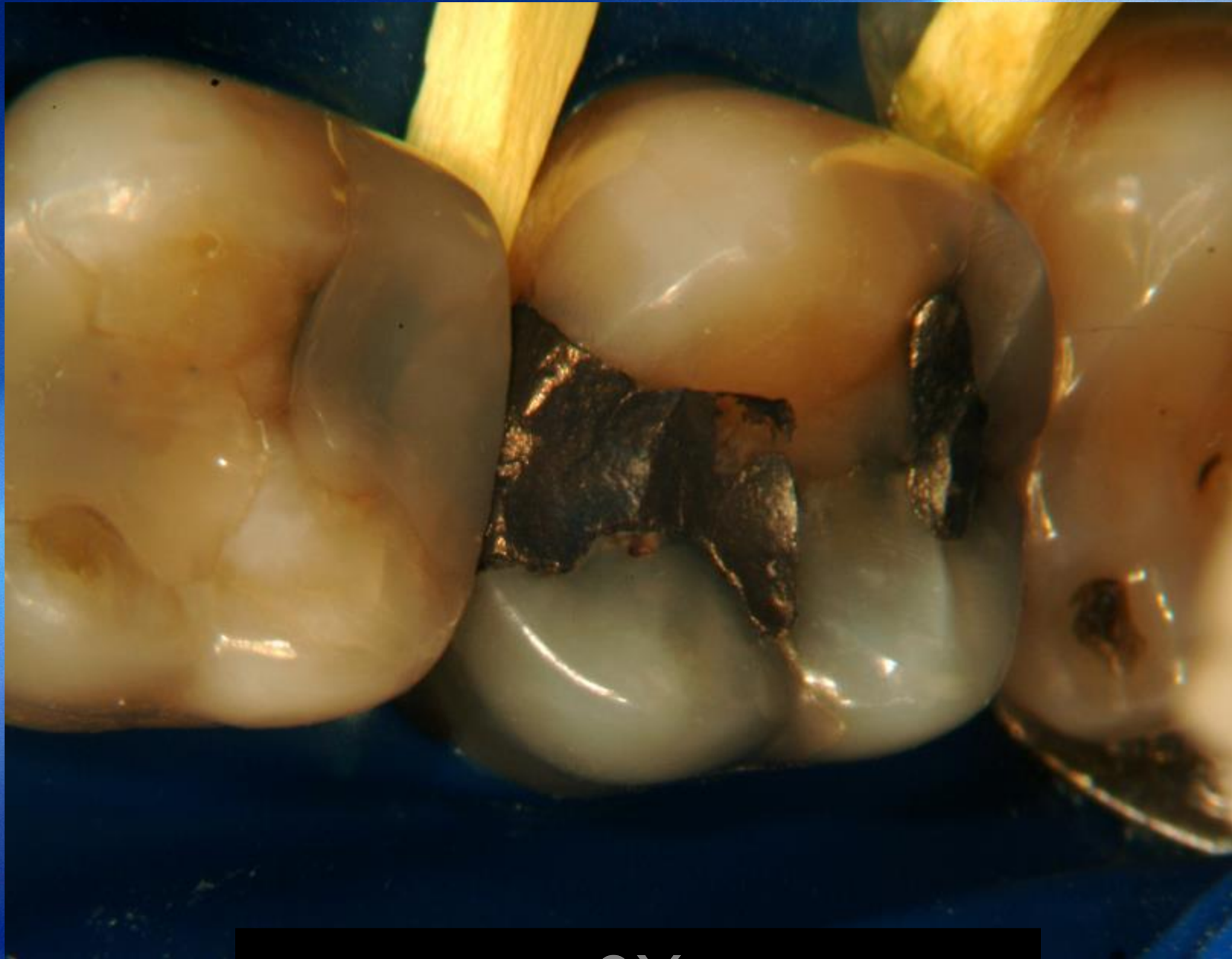
1X



2X



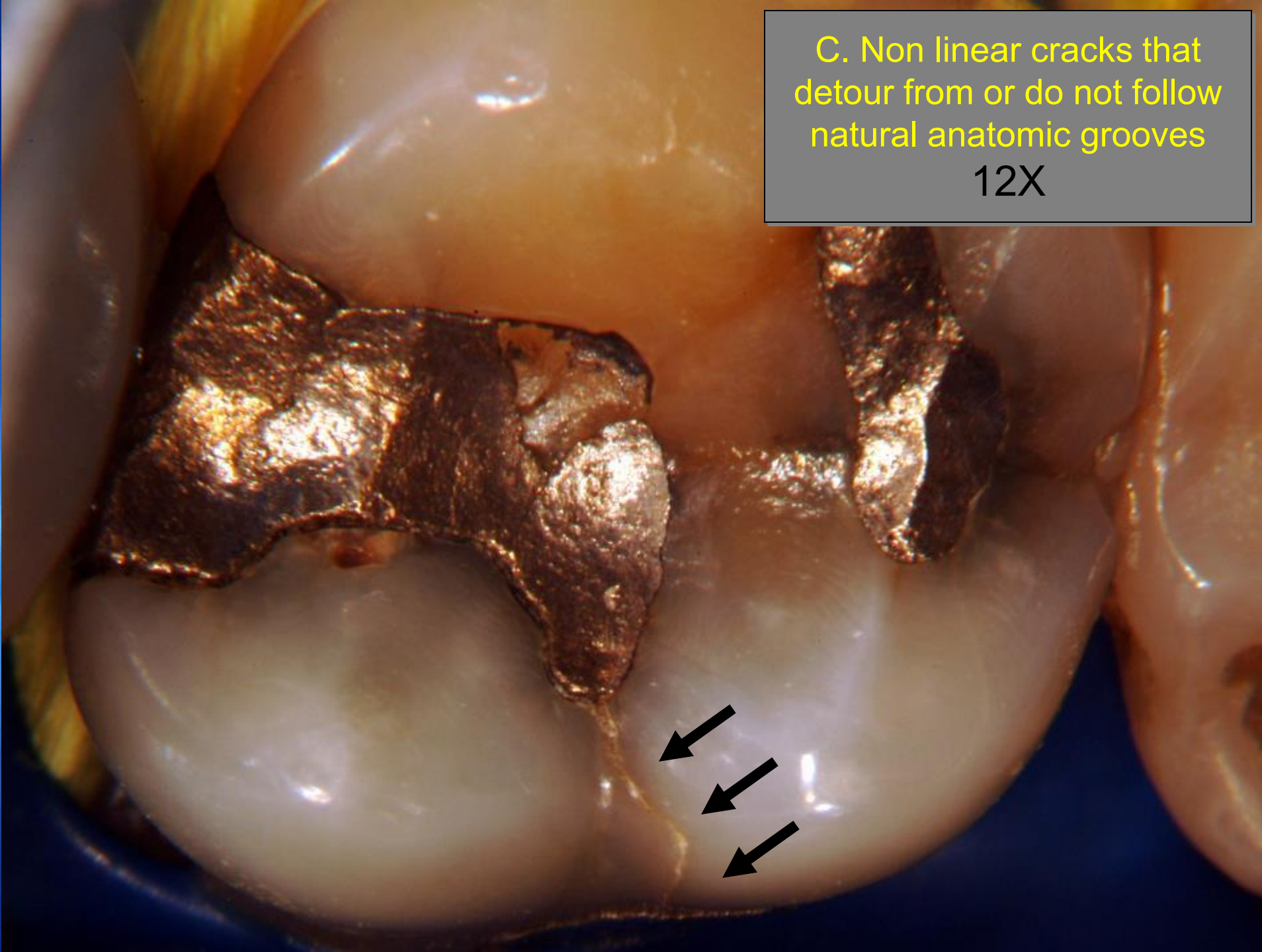
4X



8X

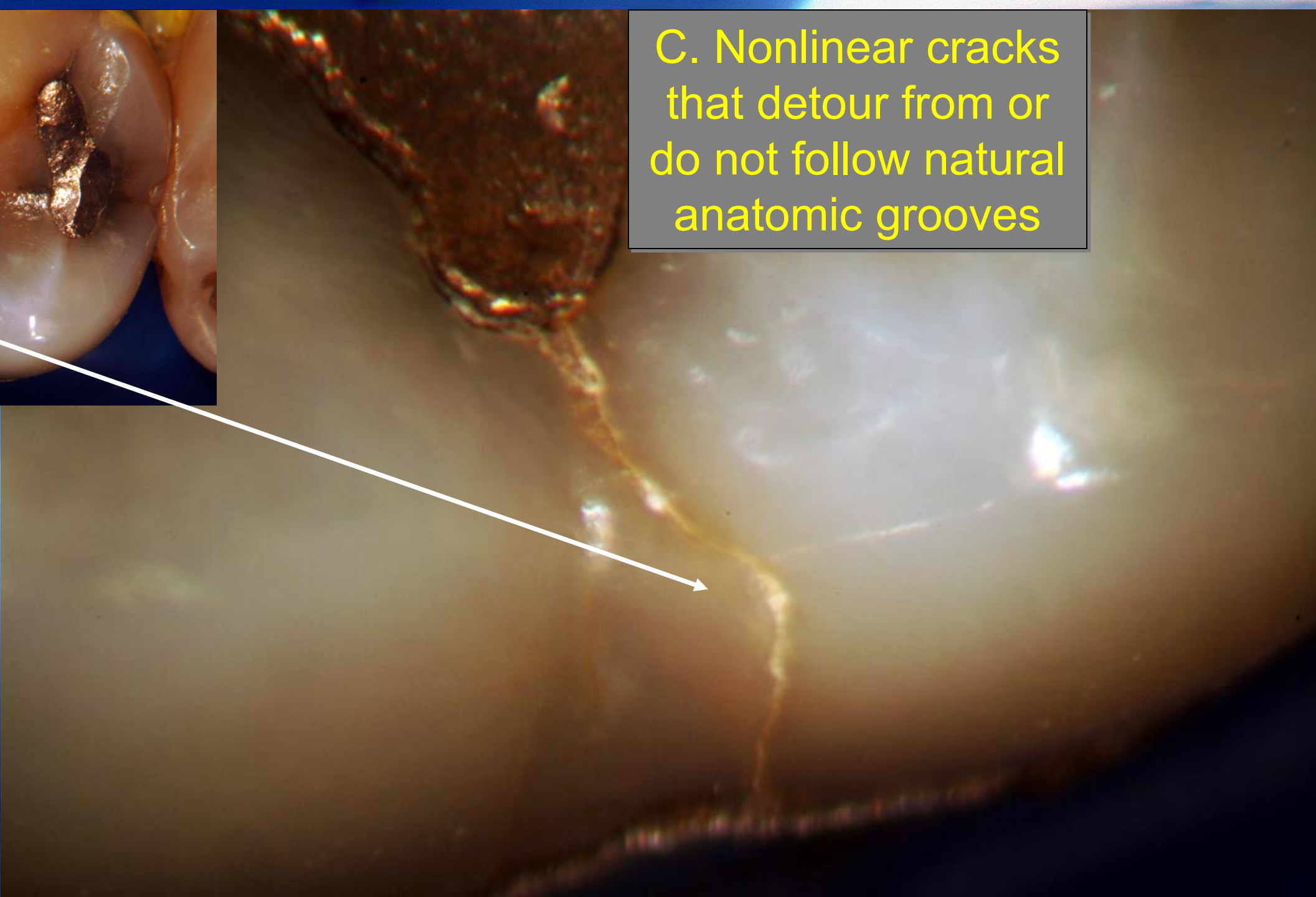
C. Non linear cracks that
detour from or do not follow
natural anatomic grooves

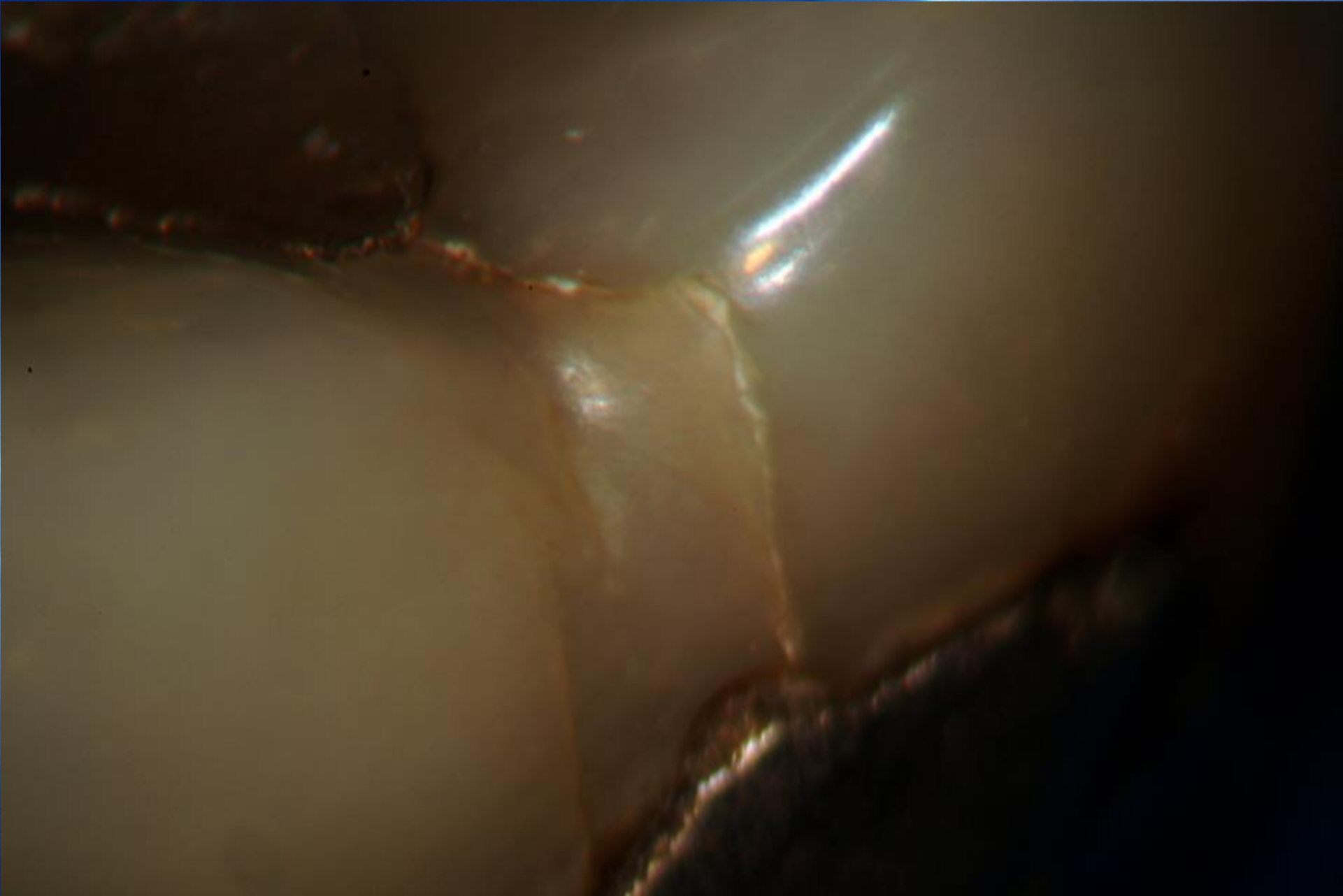
12X



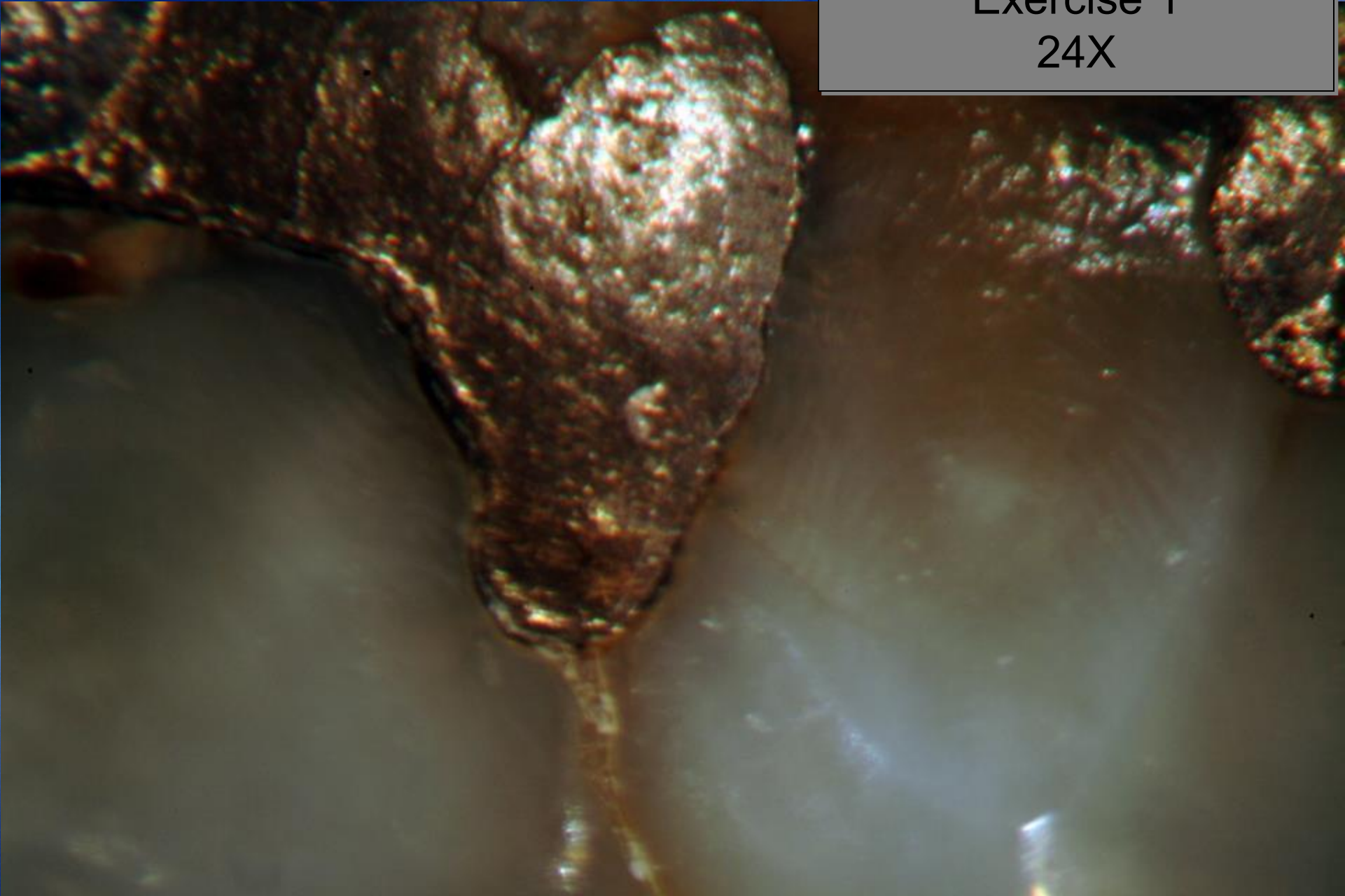


C. Nonlinear cracks that detour from or do not follow natural anatomic grooves

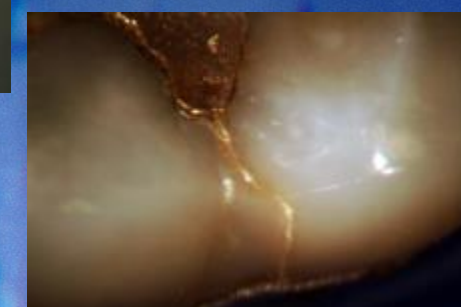
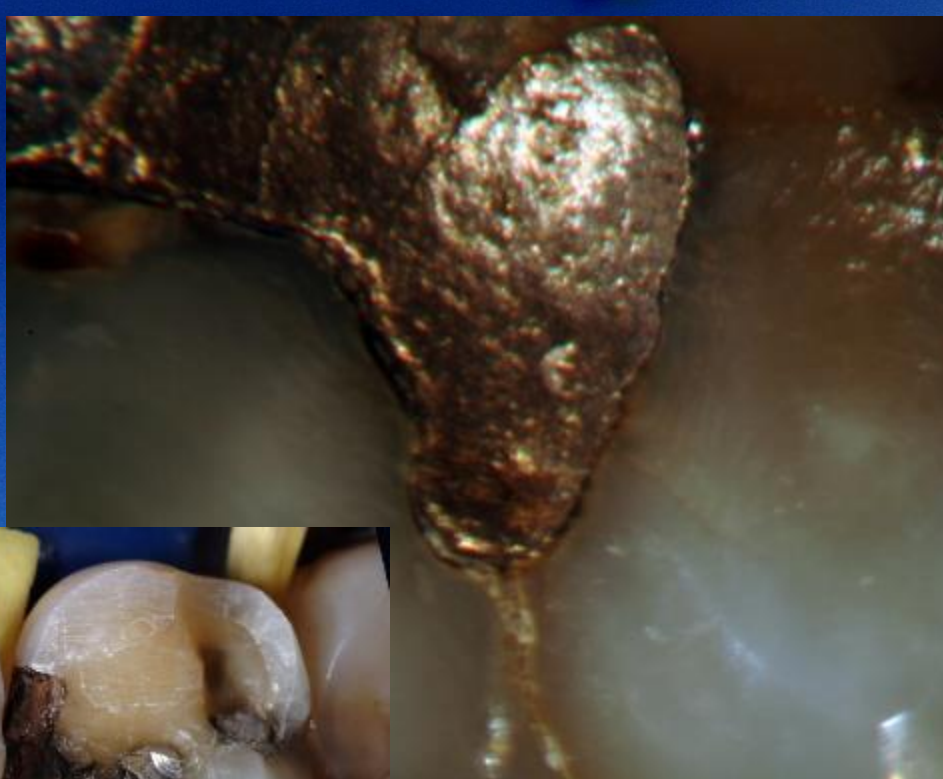




Exercise 1
24X



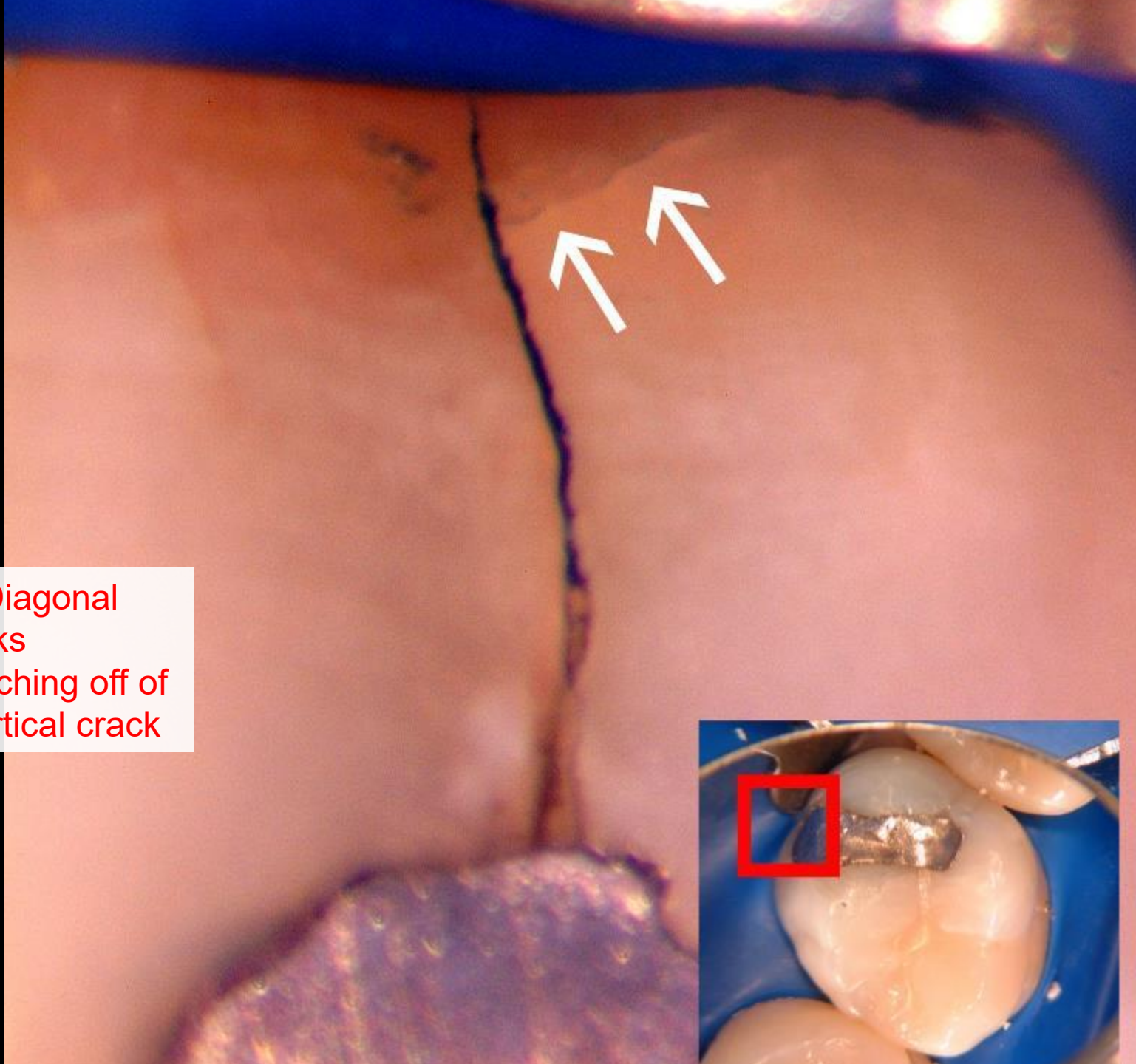


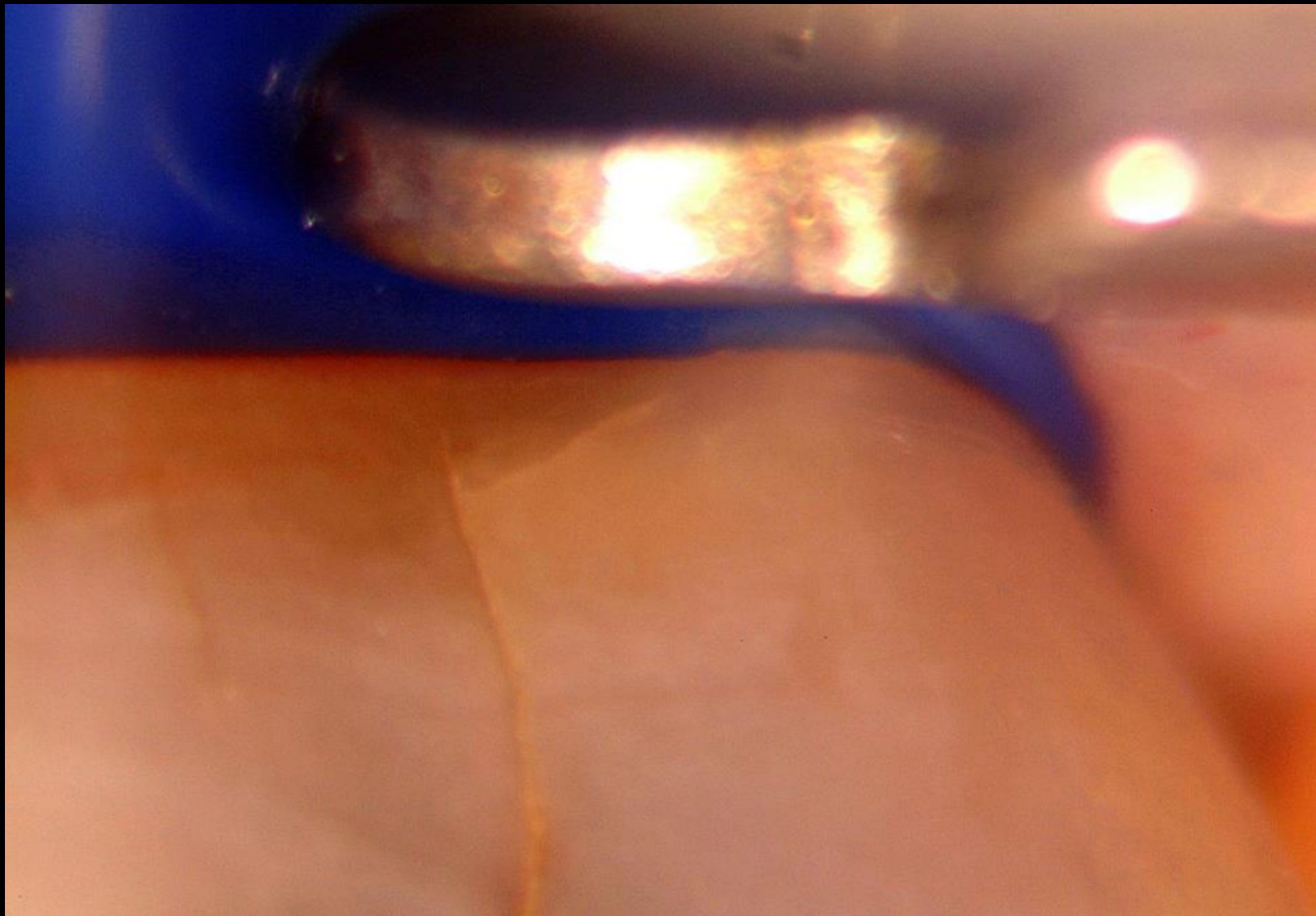


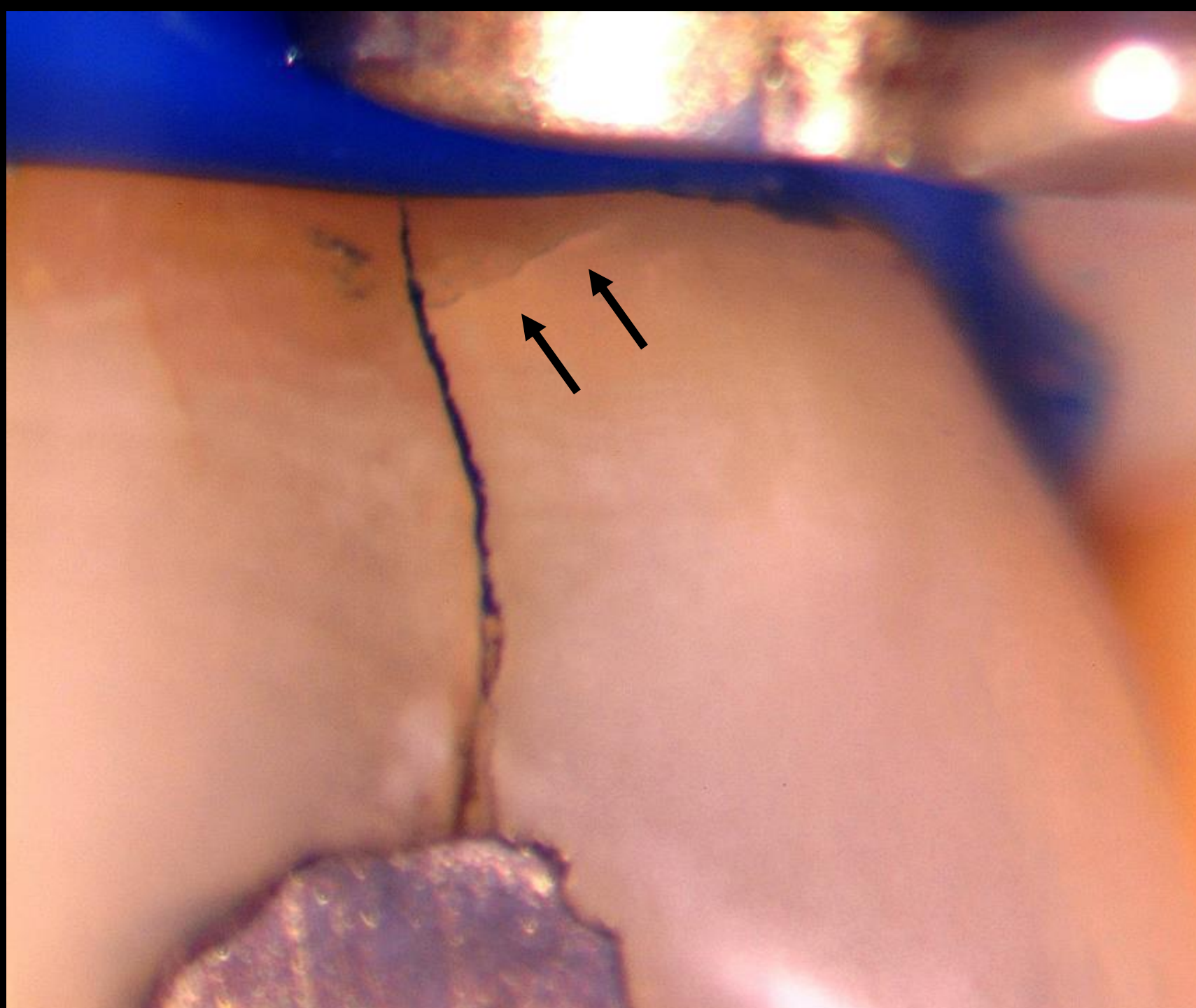
Type III: Have high risk of underlying pathology

- A) Diagonal cracks branching off a vertical crack
- B) Horizontal or diagonal cracks that emanate from the corner of a restoration
- C) Cracks that house debris

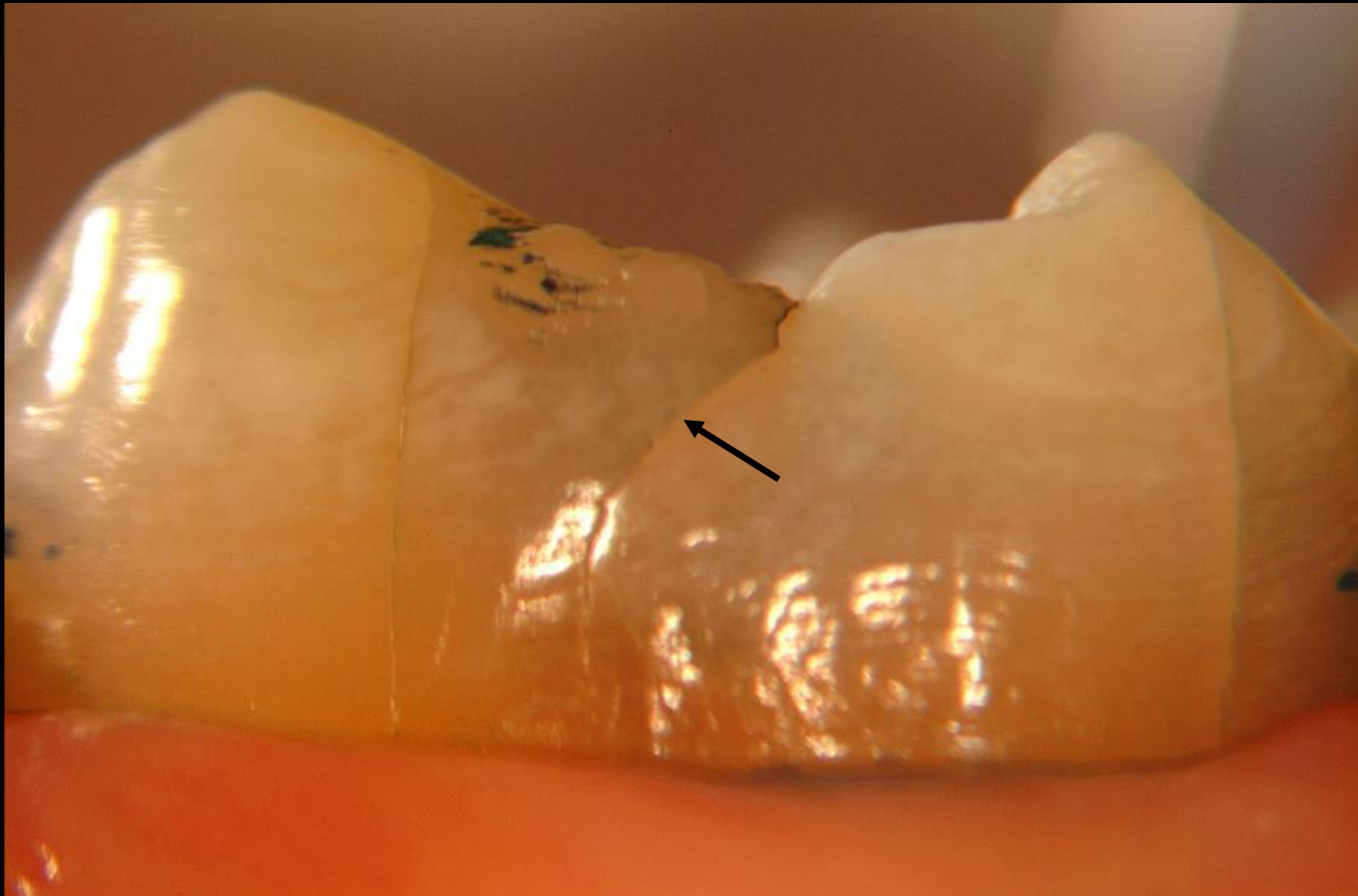
A) Diagonal cracks branching off of a vertical crack



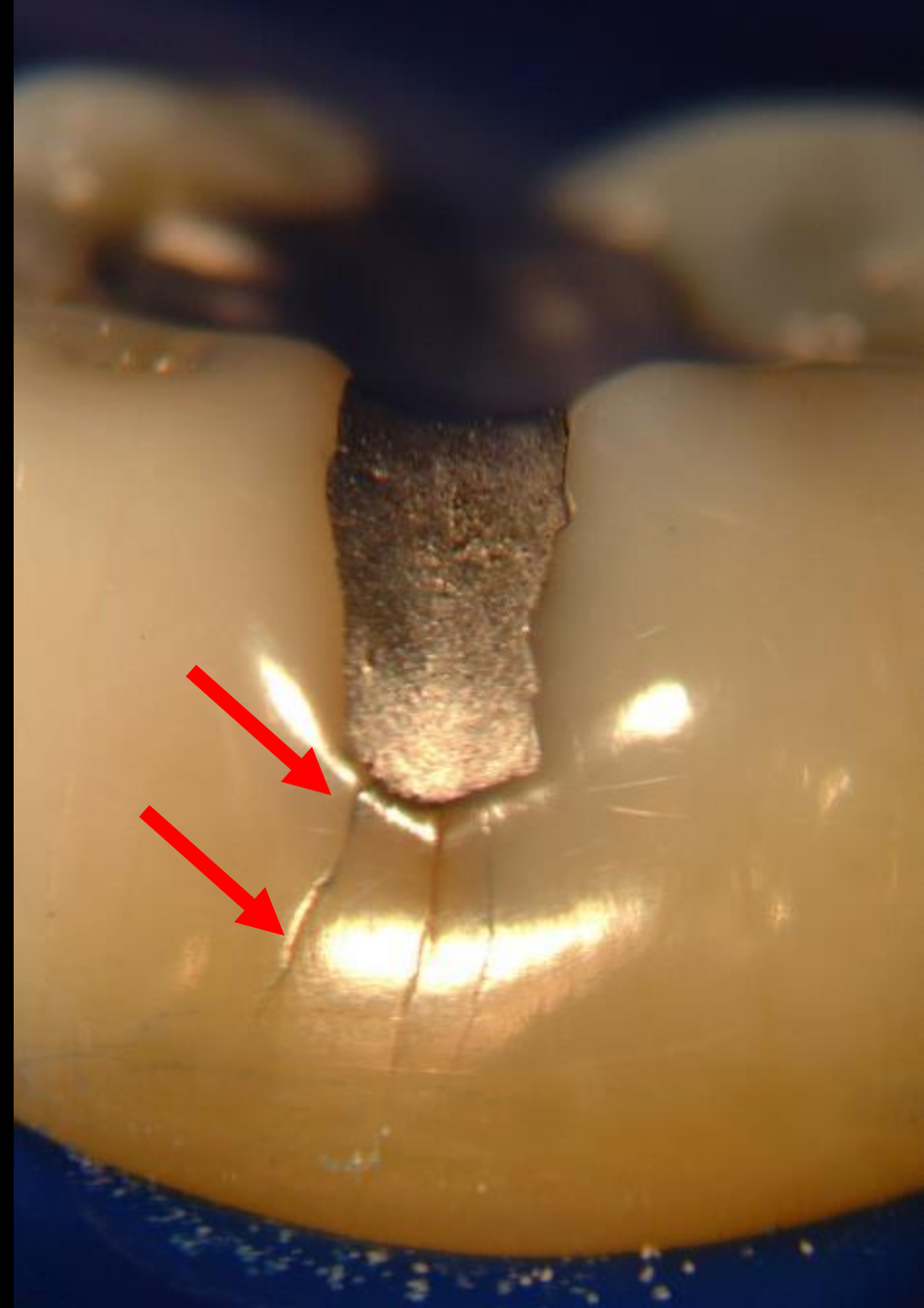




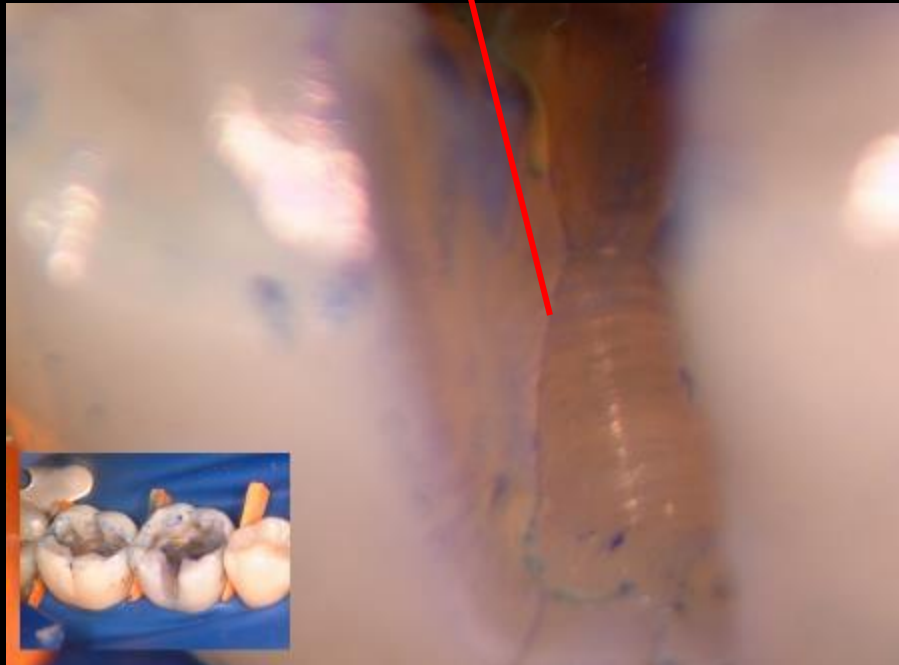
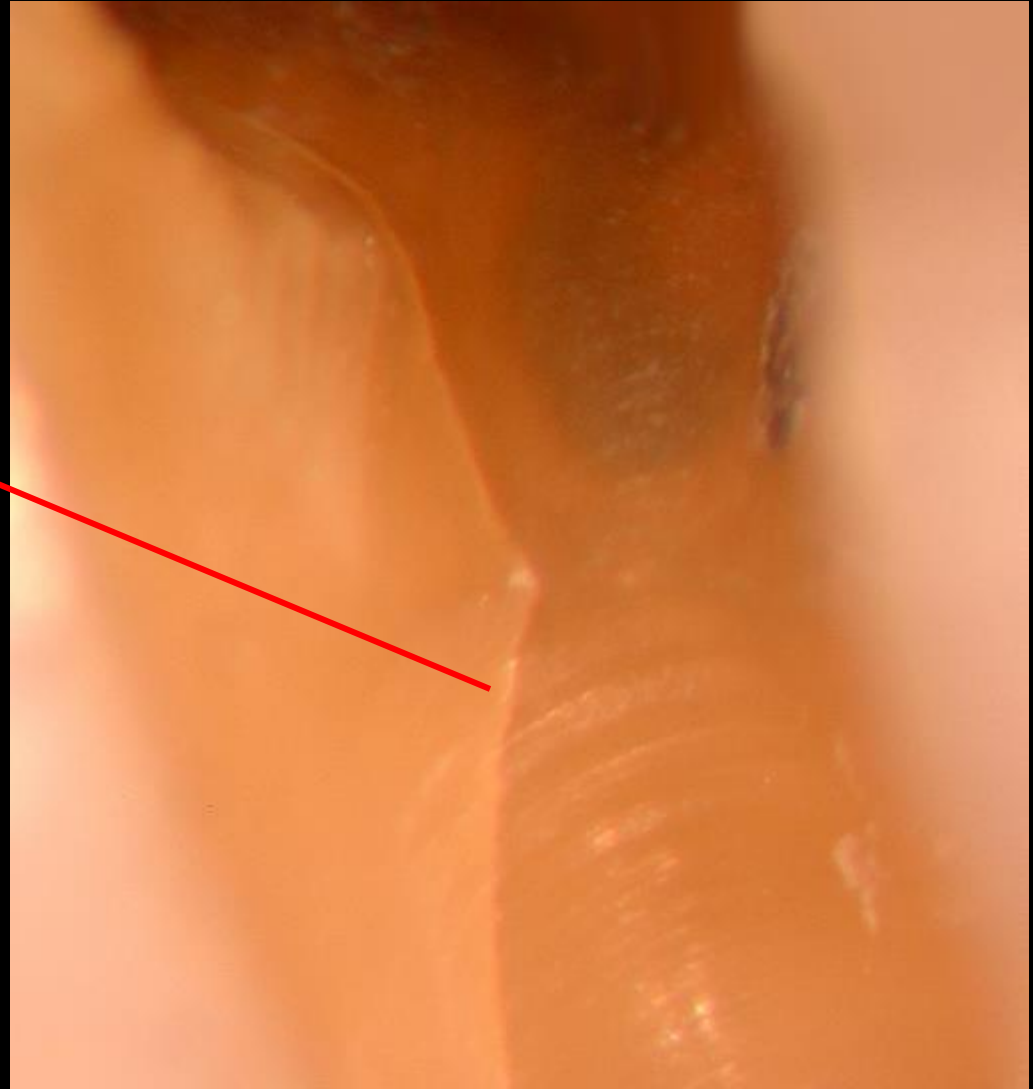
A. Diagonal cracks



B. Diagonal cracks that emanate from the corner of a restoration

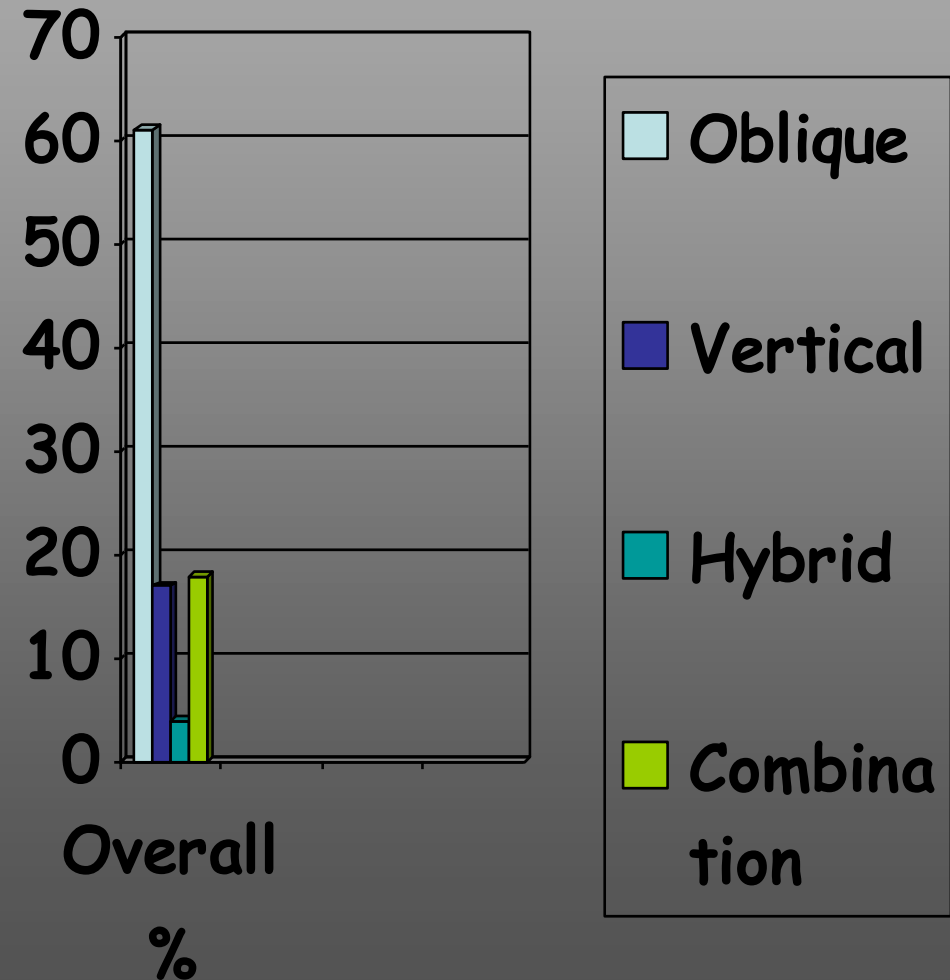


Nomenclature and
classification of
enamel cracks



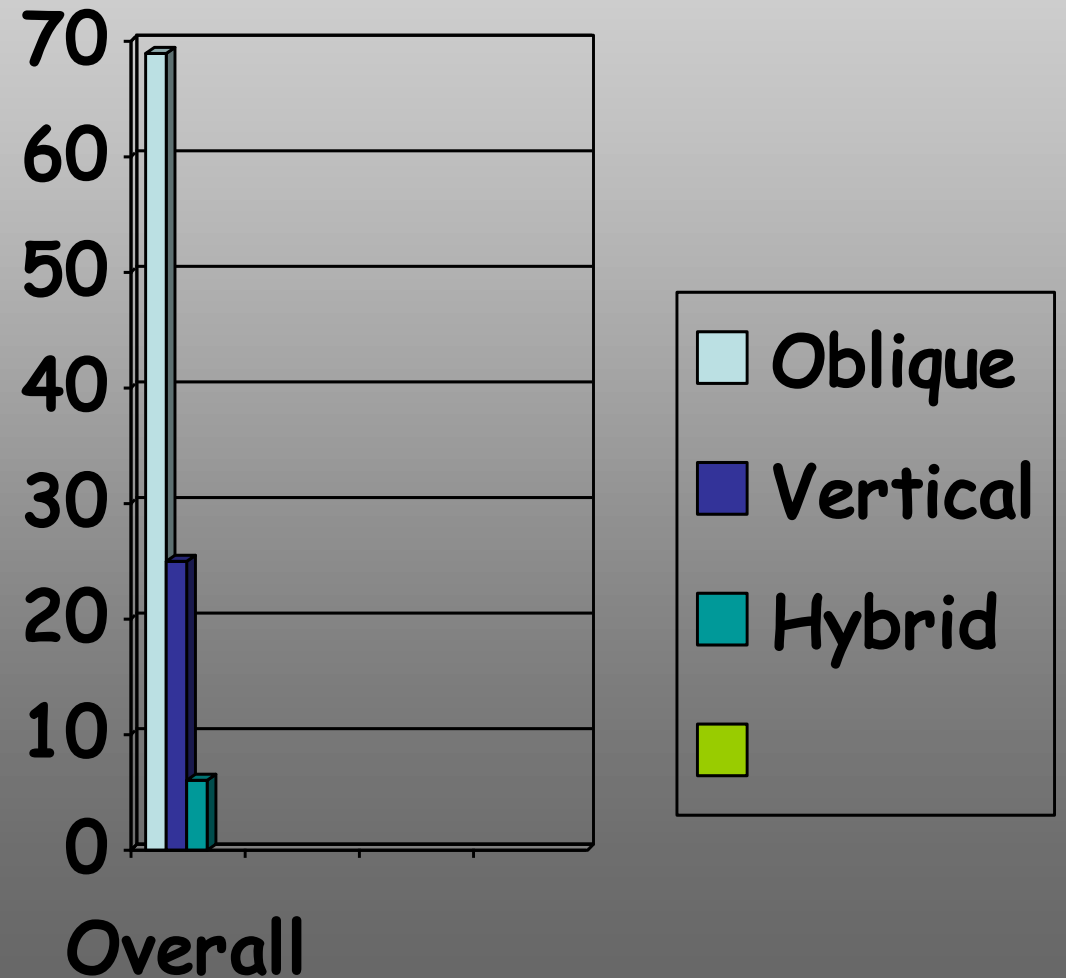
A Two Year Study 2001-2003

- 120 Teeth
- 24 months
- Every tooth treated restoratively examined at 16x after restorative material removed

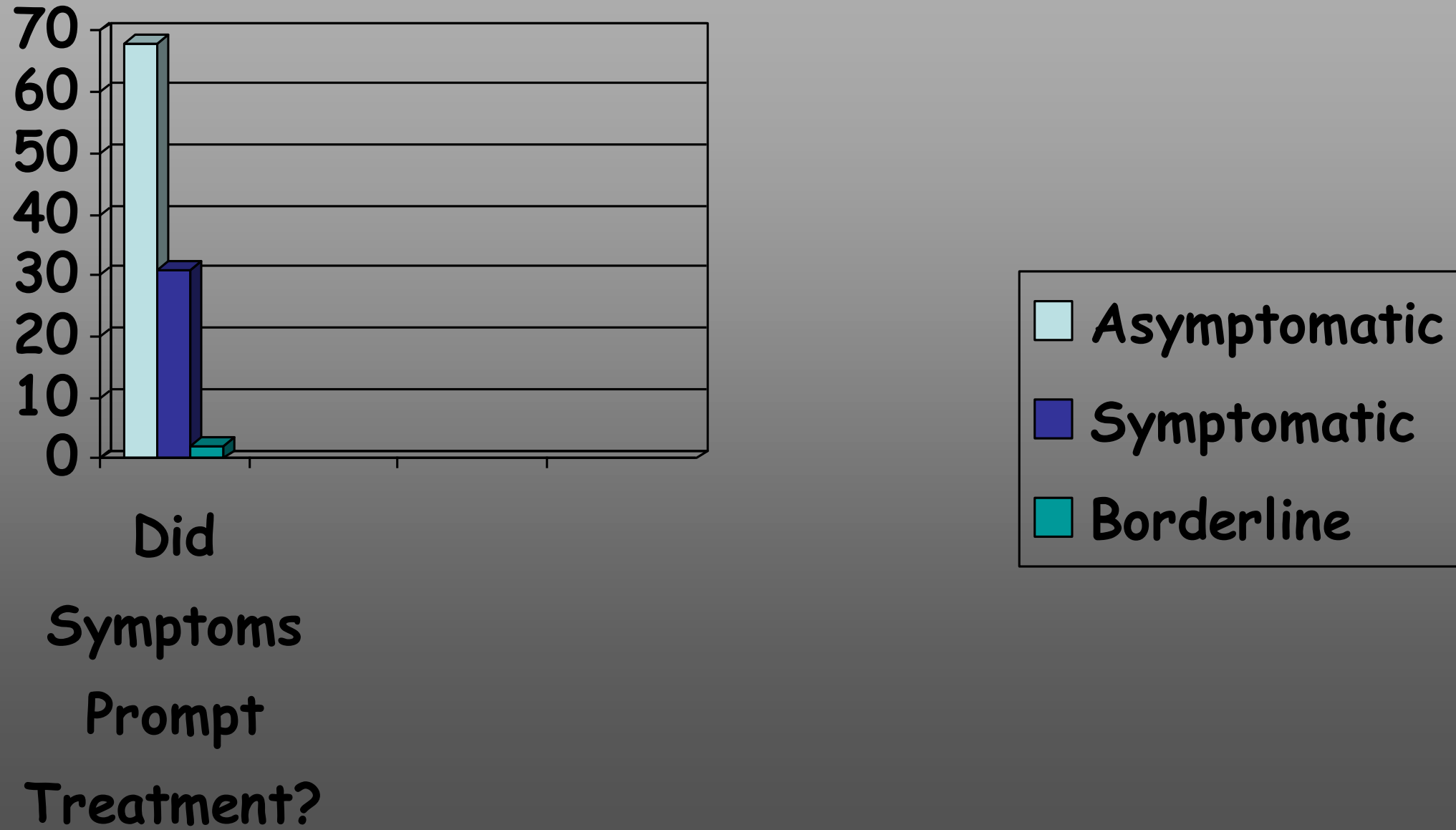


A Two Year Study

- 120 Teeth
- 188 Dentin Cracks
(Incomplete Fractures)



A Two Year Study



- The third leading cause of tooth loss today is from splits/fractures. (Lynch CD McCinell RJ. The cracked tooth Syndrome. J Dent Assoc Sept 2002; 68(8):470-475)
- Crack initiation and progression should not be labeled a “syndrome”
- Diagnosis and treatment should be similar to approaches we utilize to address other pathologies (i.e. caries, periodontal disease)

B. Diagonal cracks that emanate from the corner of a restoration



2X

Nomenclature and
classification of
enamel cracks

B. Diagonal cracks that emanate from the corner of a restoration



4X

B. Diagonal cracks that emanate from the corner of a restoration



8X

B. Diagonal cracks that emanate from the corner of a restoration



B. Diagonal cracks that emanate from the corner of a restoration



12X

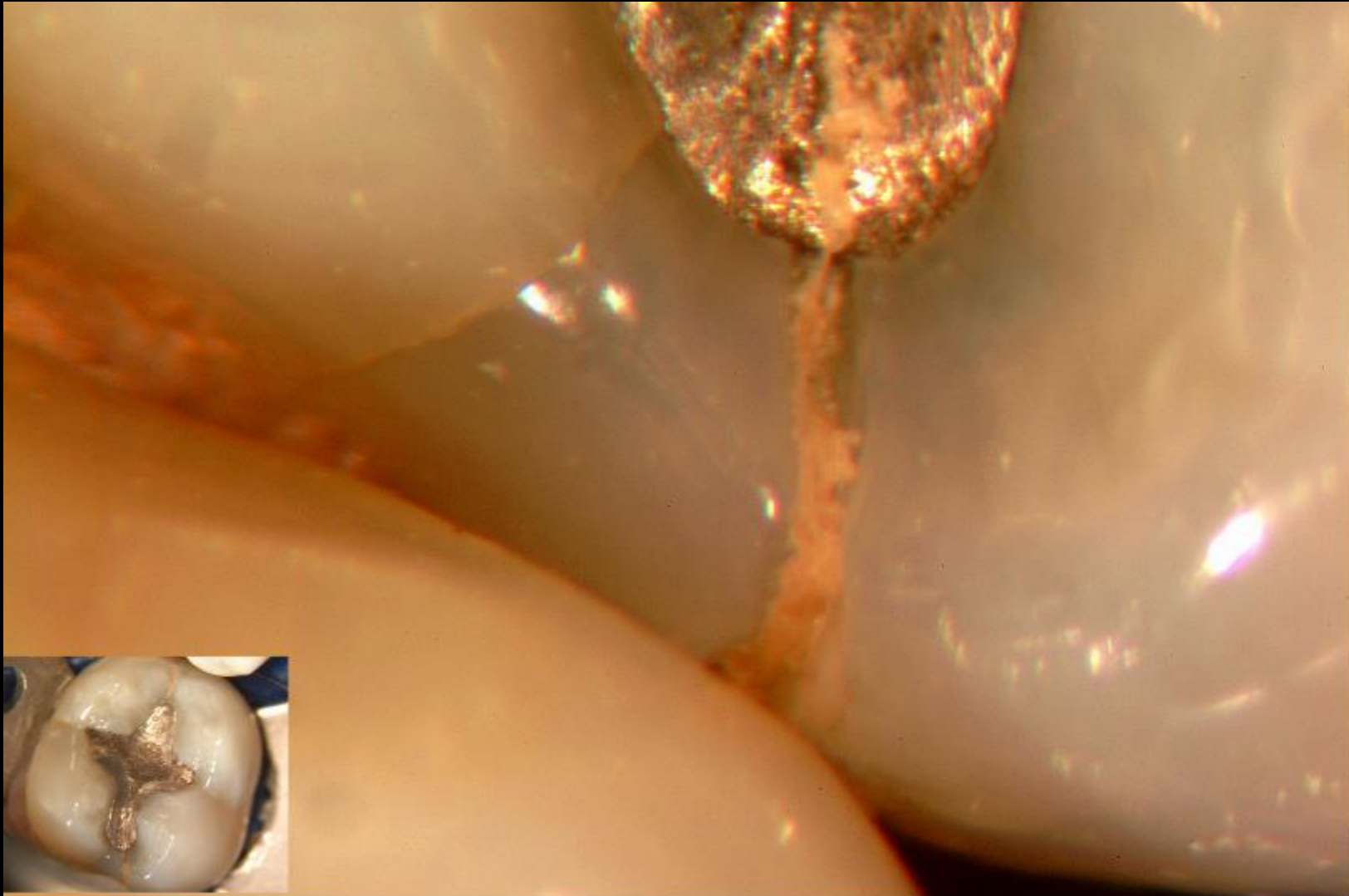


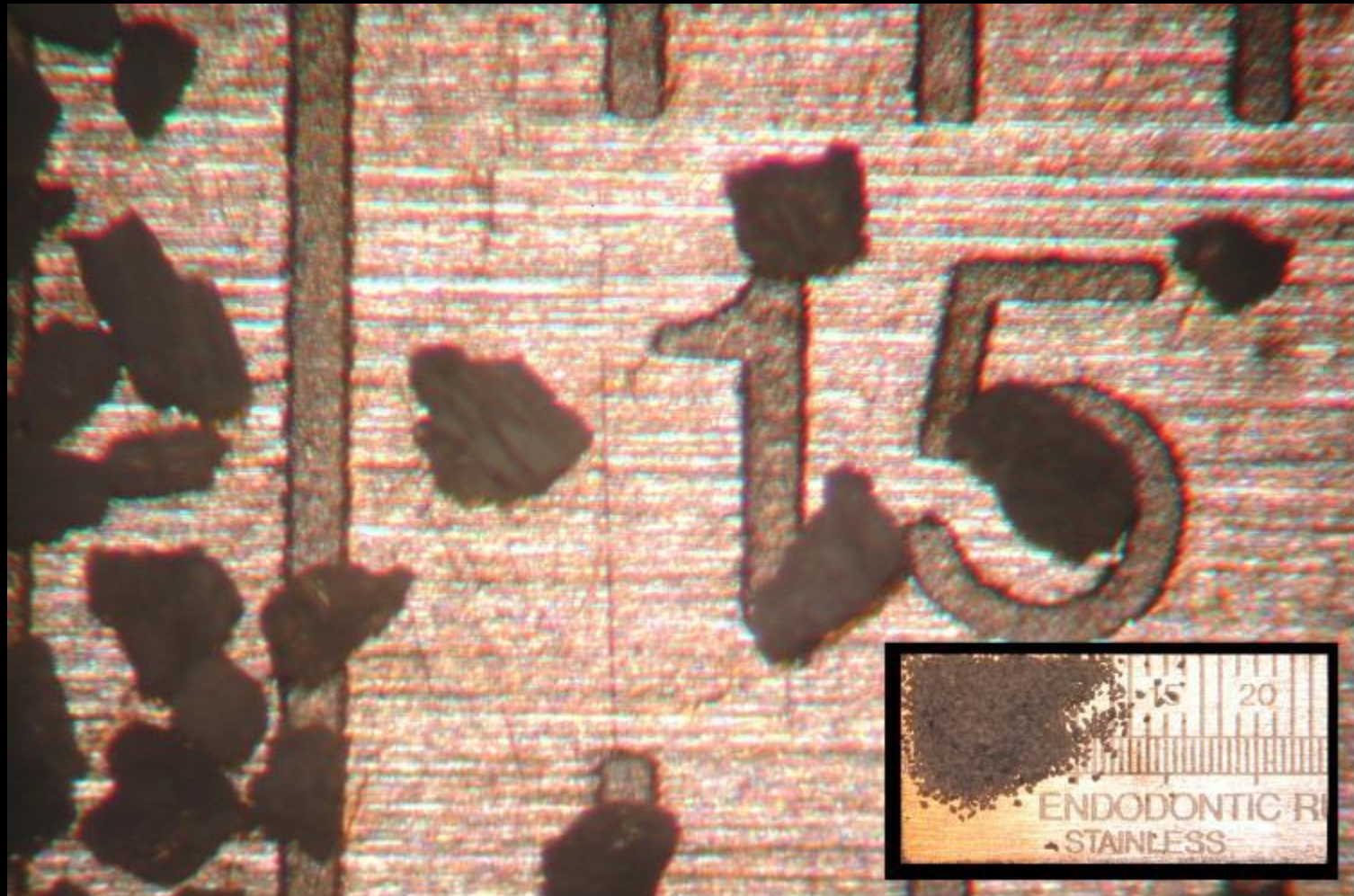
16X

B. Horizontal cracks



C. Crack that houses debris





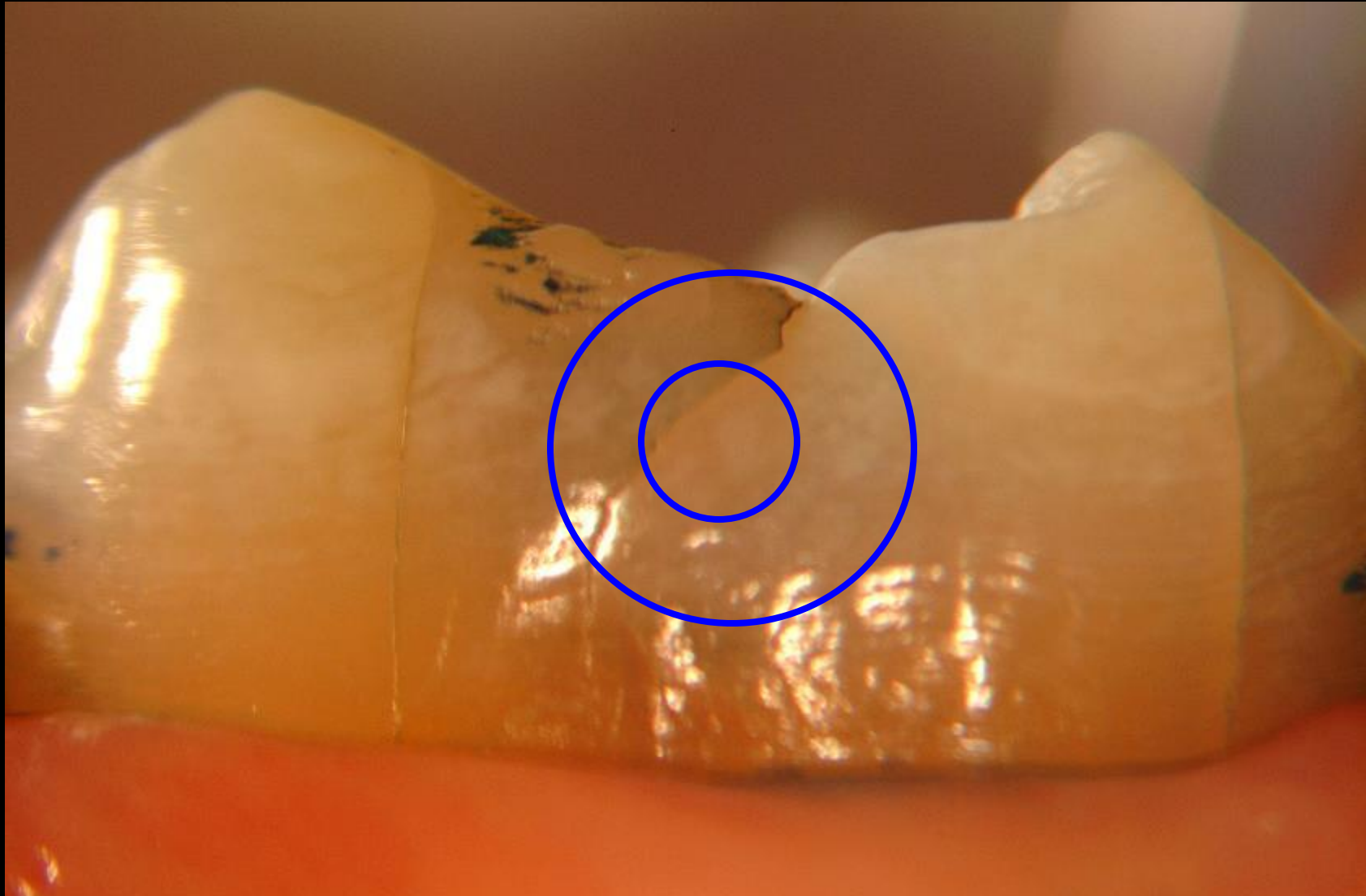
Type III: Have high risk of underlying pathology

- D. Pair of cracks that outline an area (cusp or marginal ridge) of discolored enamel
- E. Crack with corresponding halo of brown, grey or white centered on crack

D. Pair of cracks that outline an area (cusp or marginal ridge) of discolored enamel



E. Crack with corresponding halo of brown, grey or white centered on crack



E. Crack with corresponding halo of brown, grey or white centered on crack



Other Microscopic Findings That Can Indicate a Lack of Coronal Structural Integrity

- Unusual or asymmetric gapping of filling material
- Crack in Filling material
- Gray discoloration of a cusp or cusps



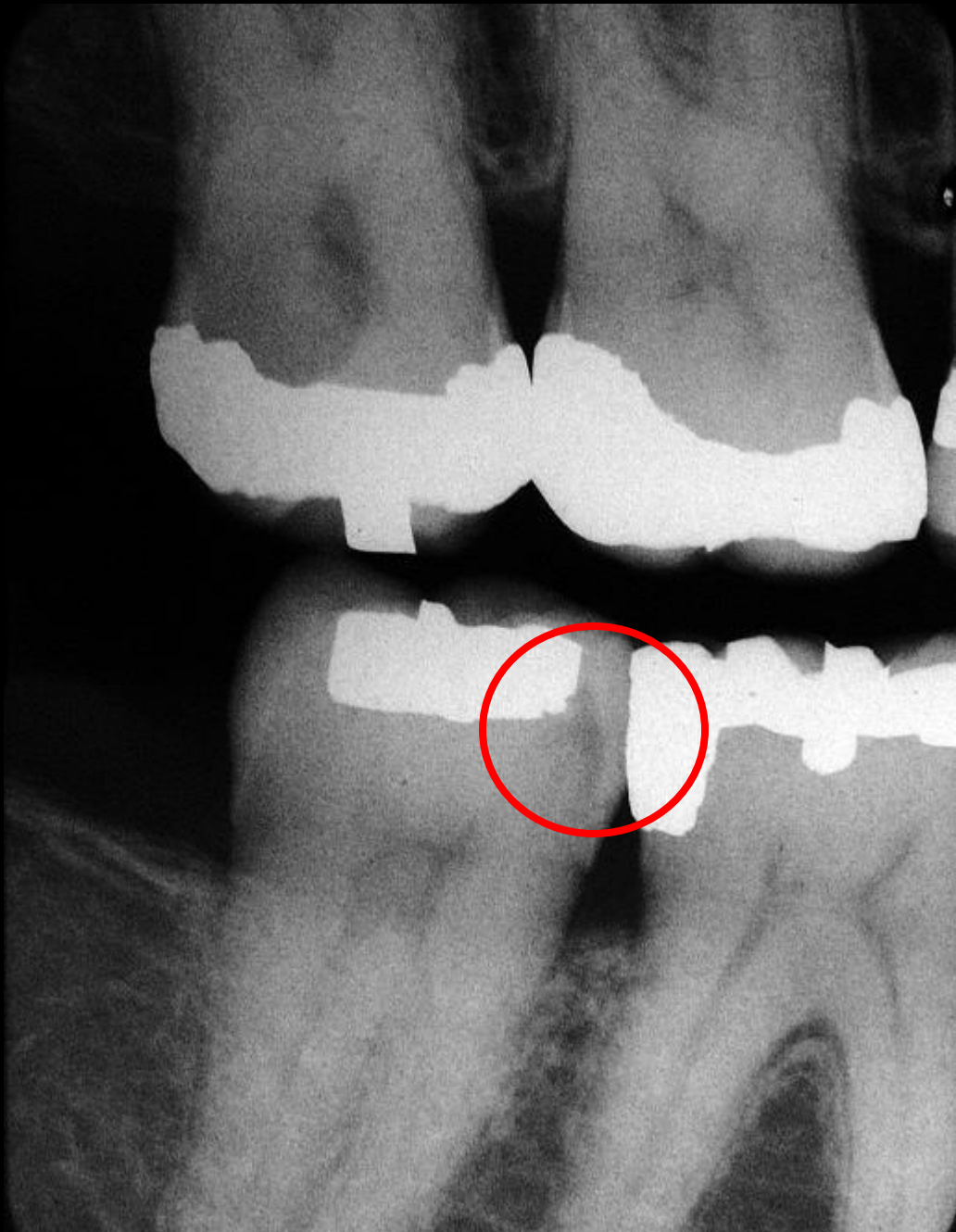


A Tale of Three Marginal Ridges



A Tale of Three Marginal Ridges



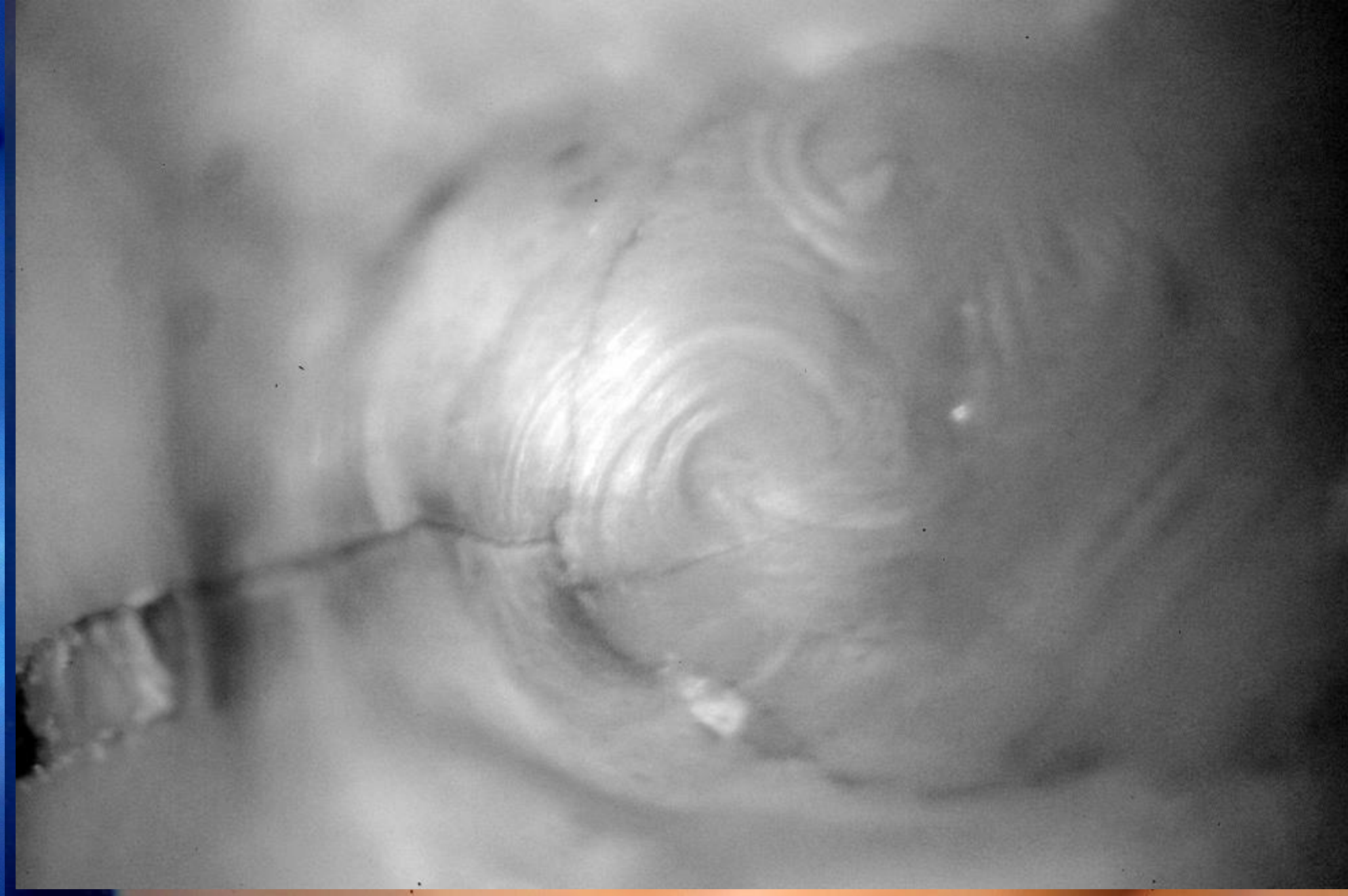


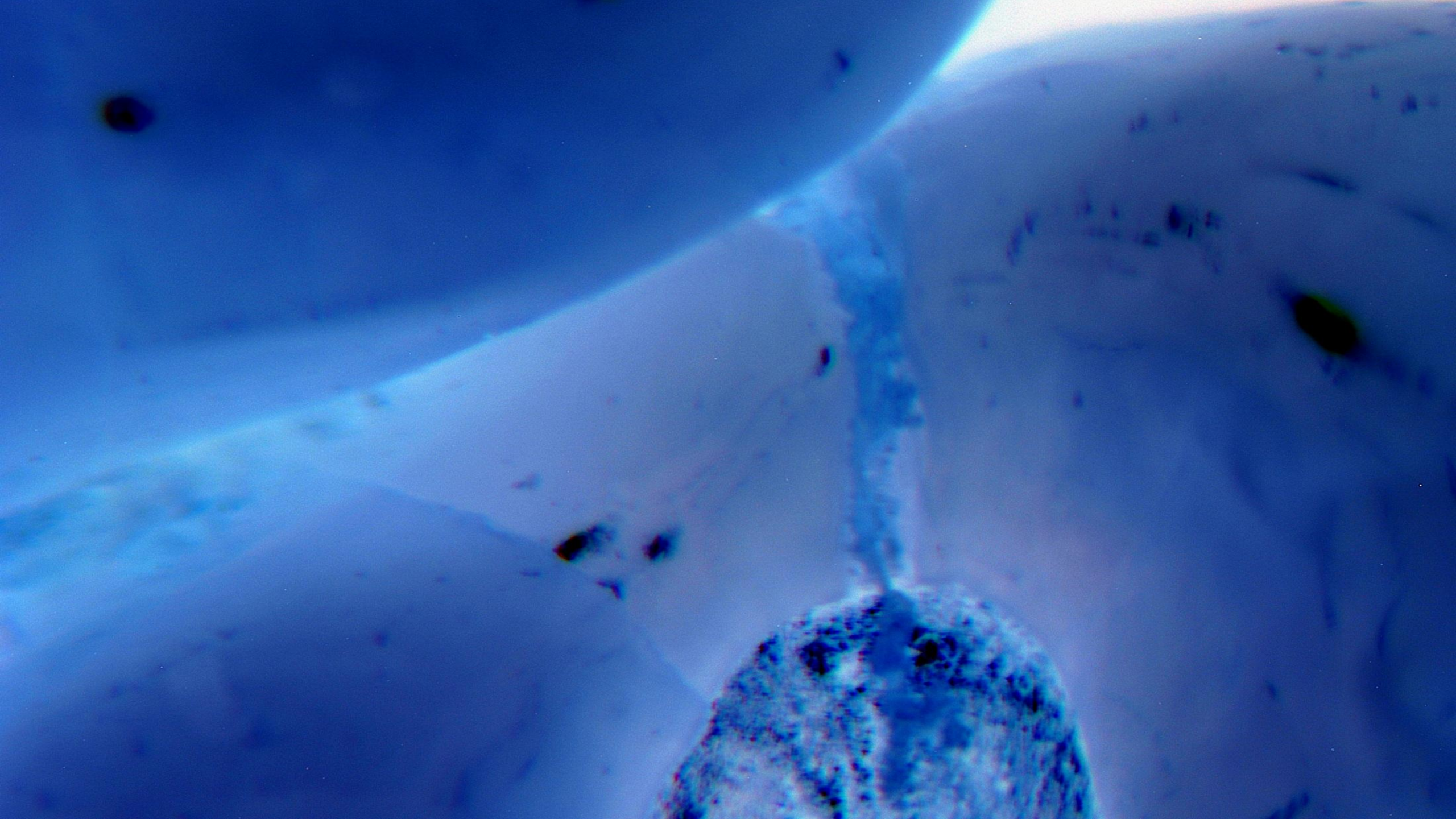


A Tale of Three Marginal Ridges



A Tale of Three Marginal Ridges





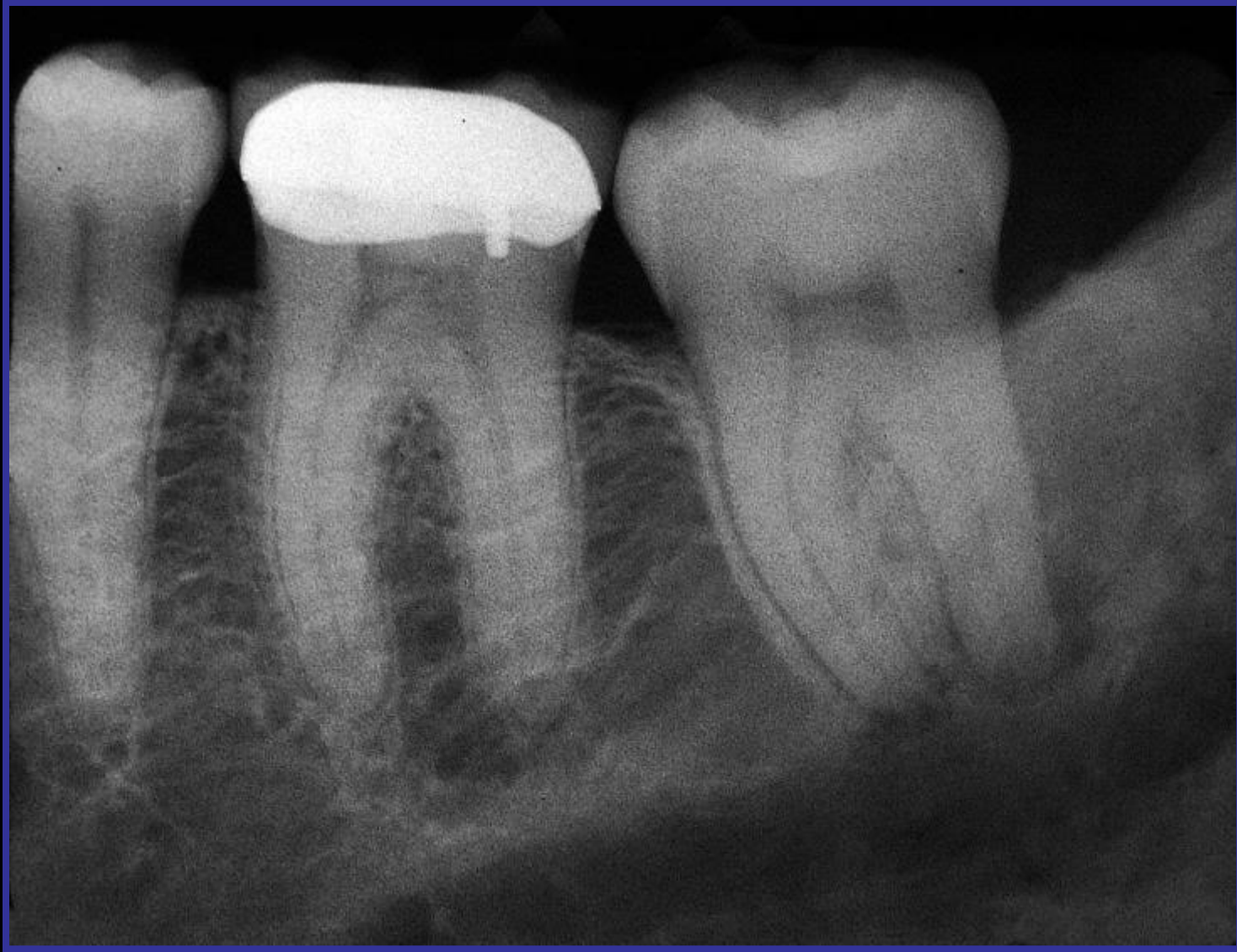


A Tale of Three Marginal Ridges

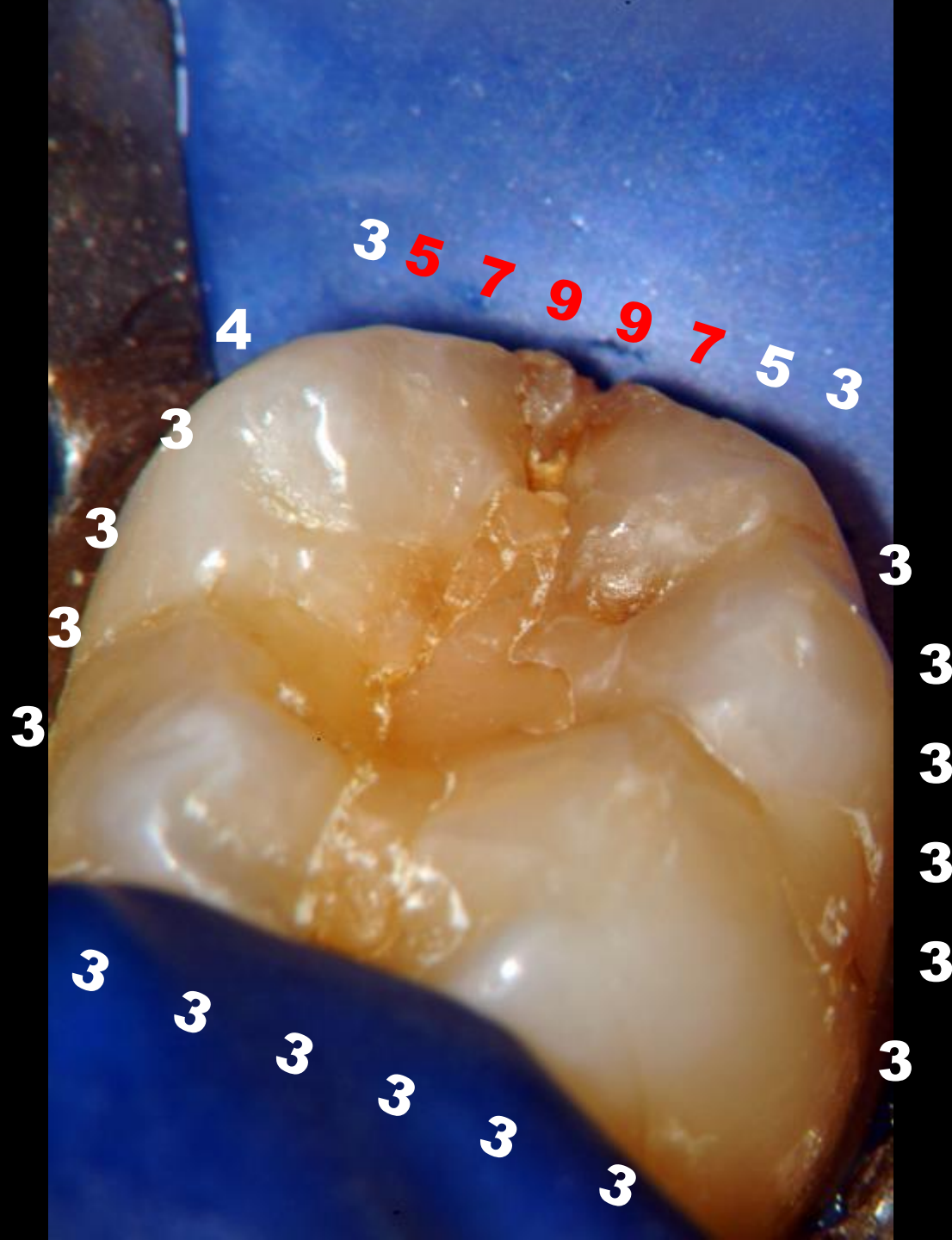


A Tale of Three Marginal Ridges

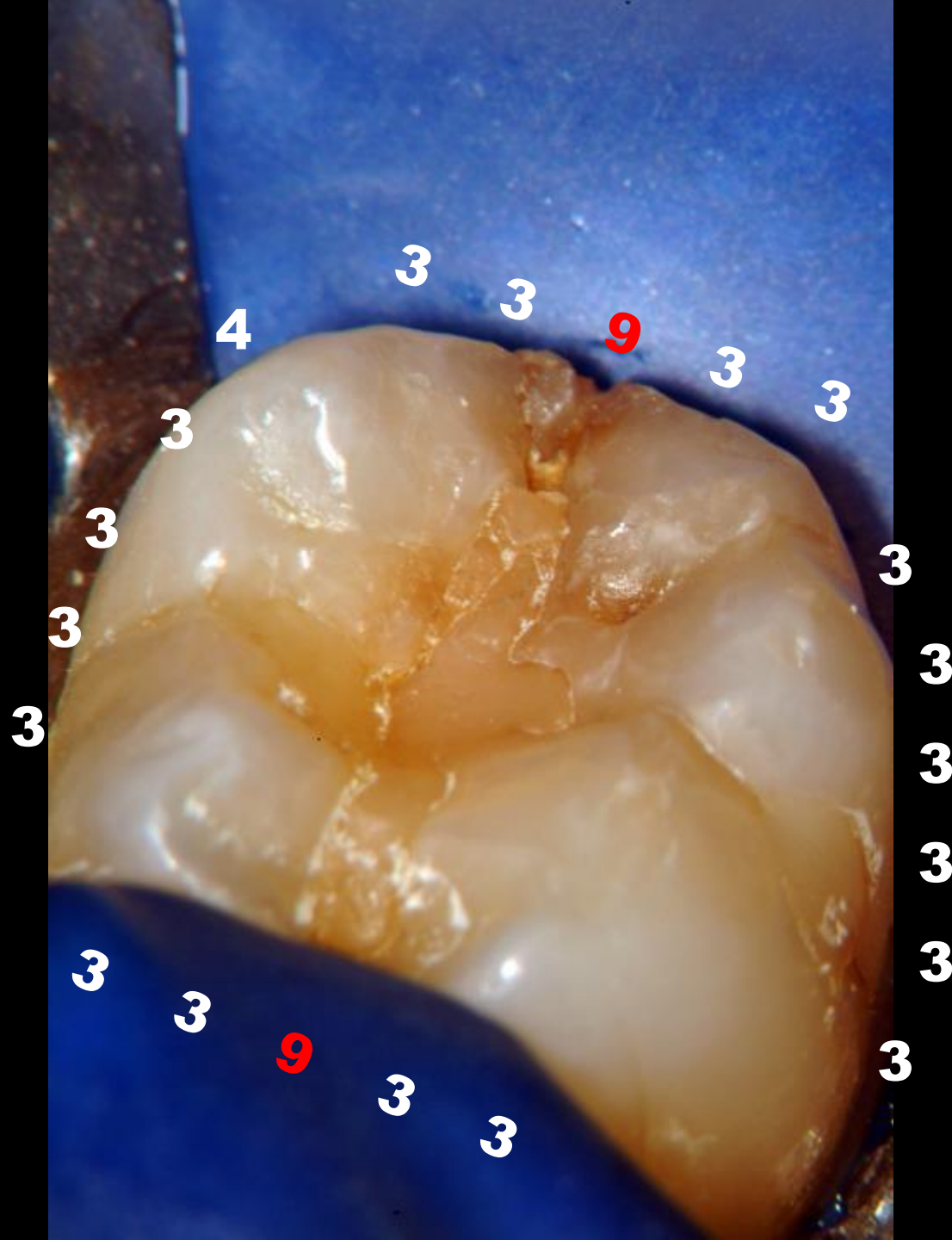




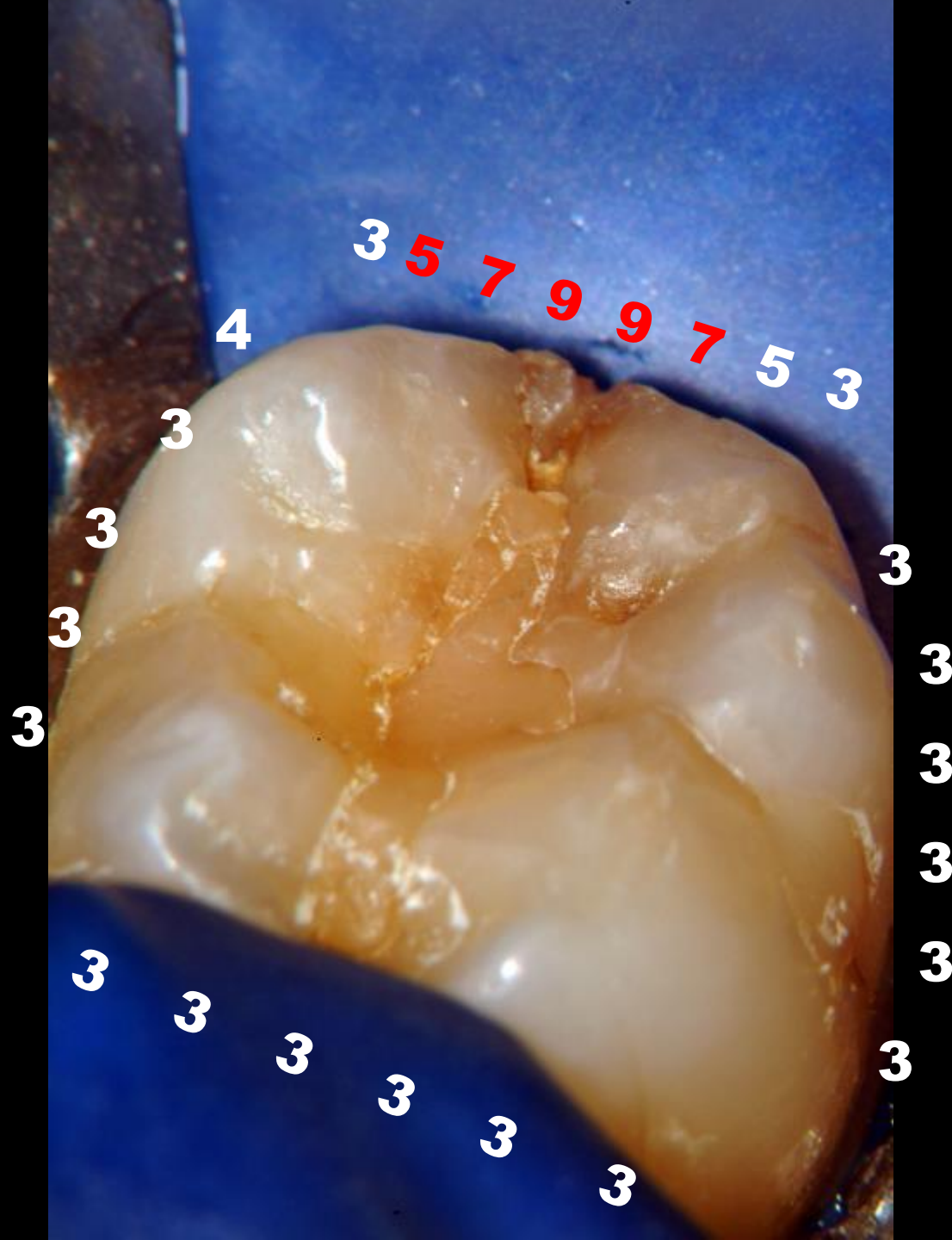
What
we
probed

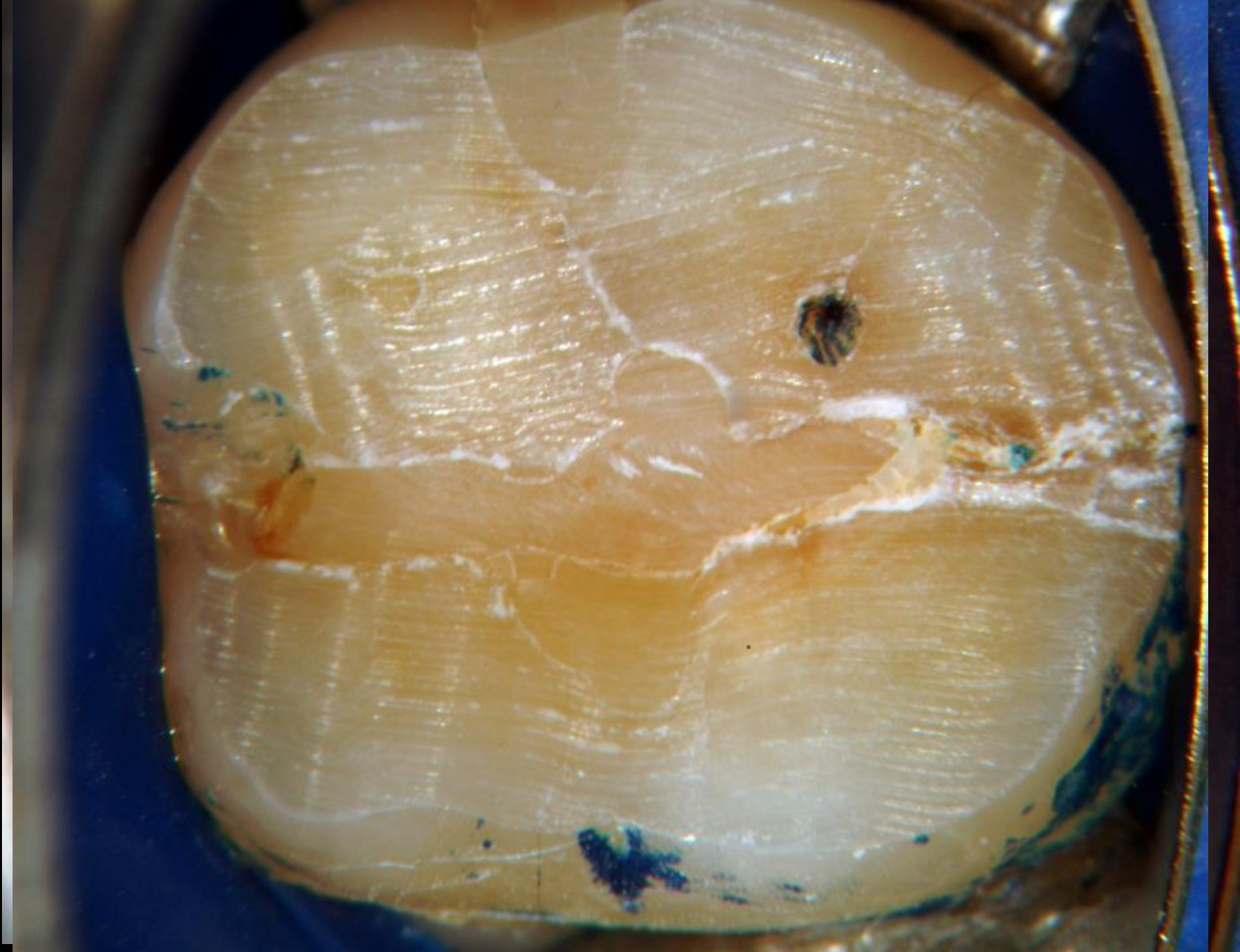


*What
we
expected*

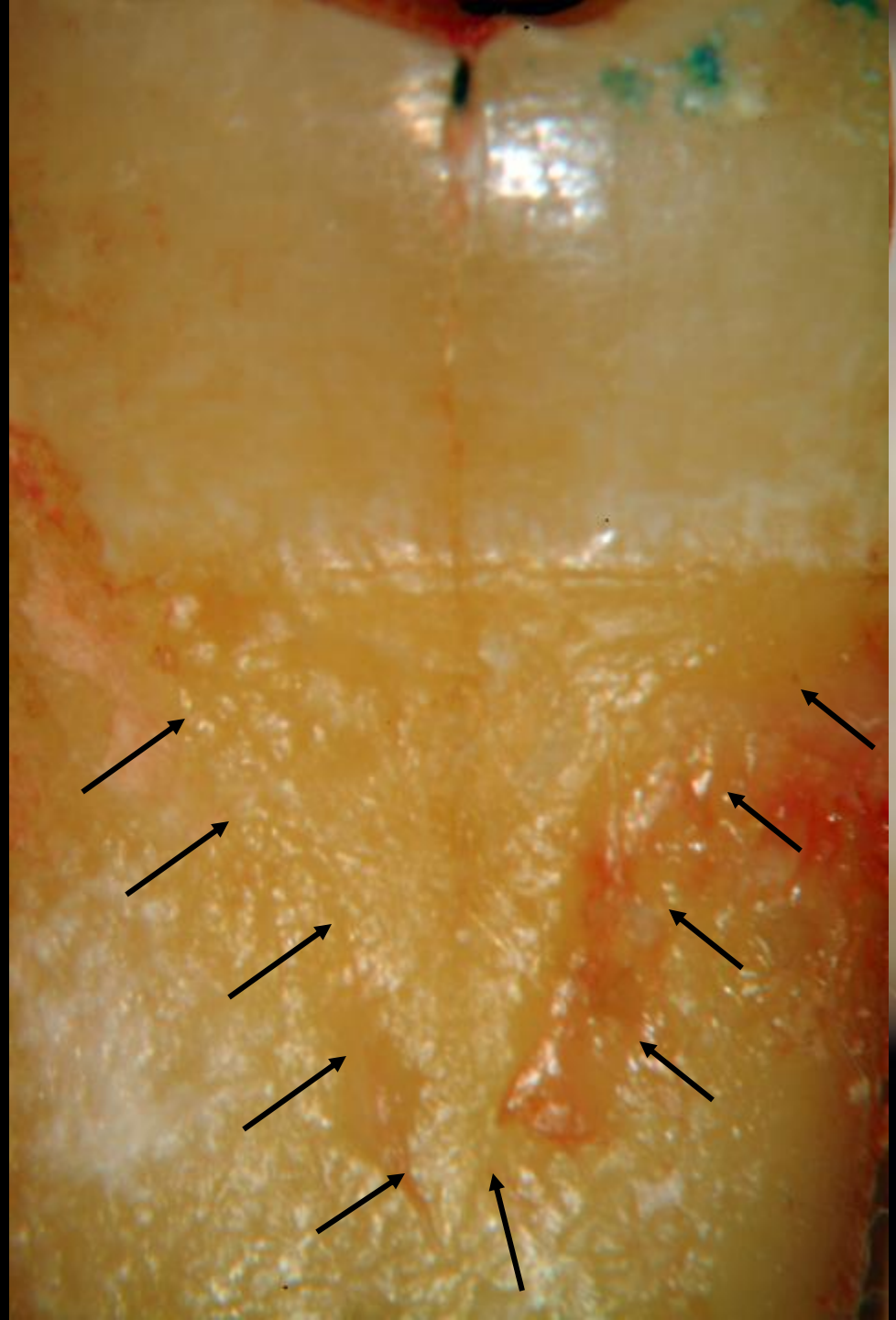


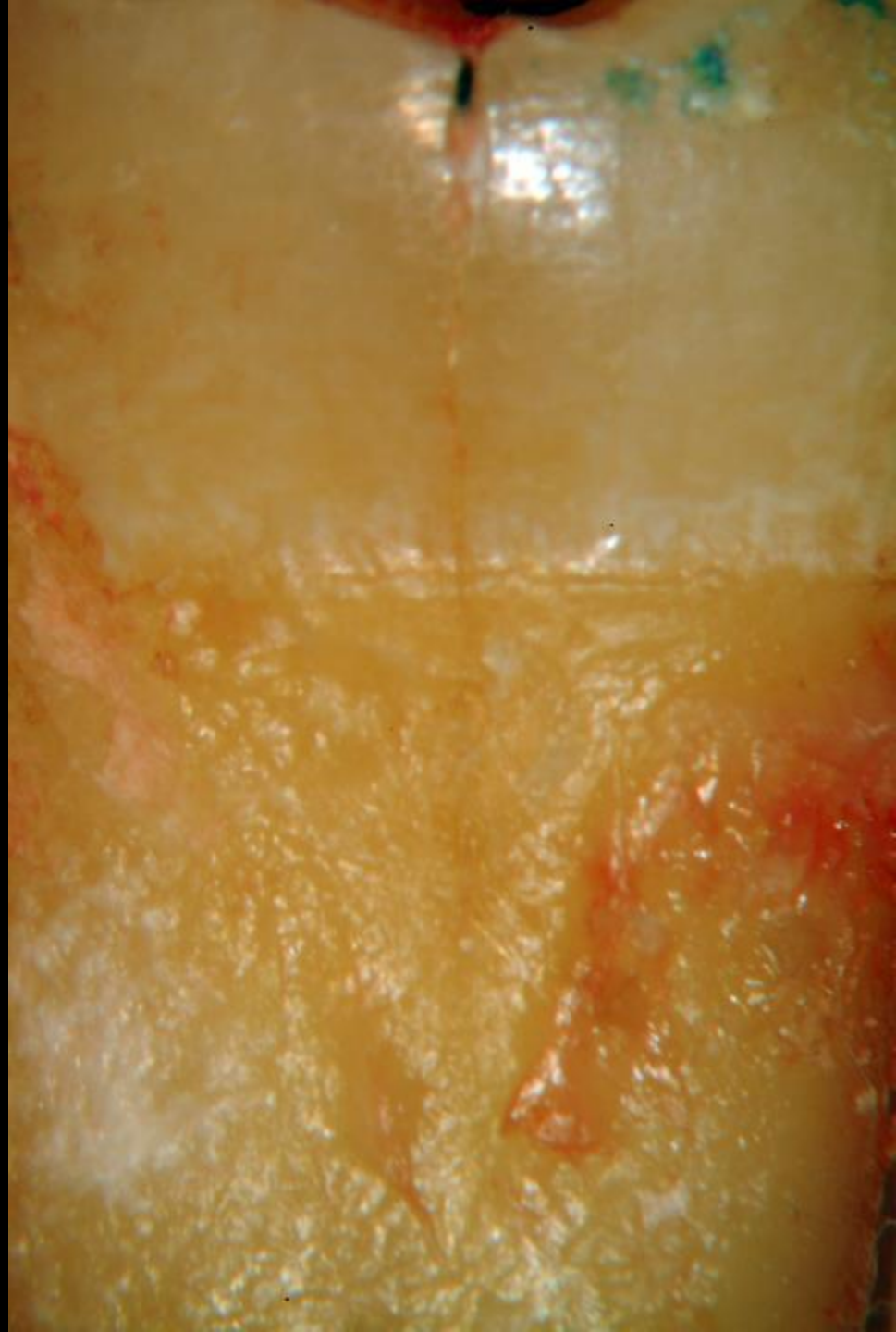
*What
we
probed*



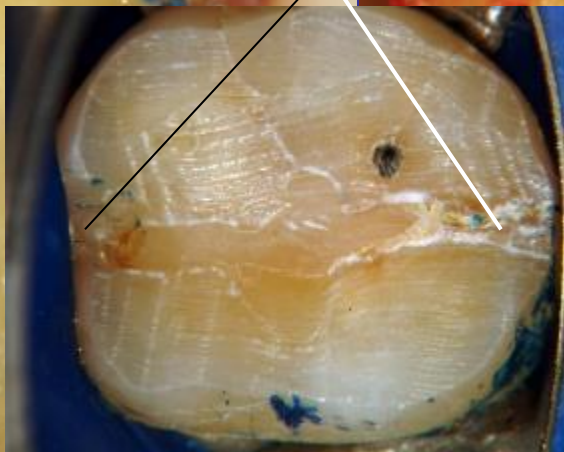
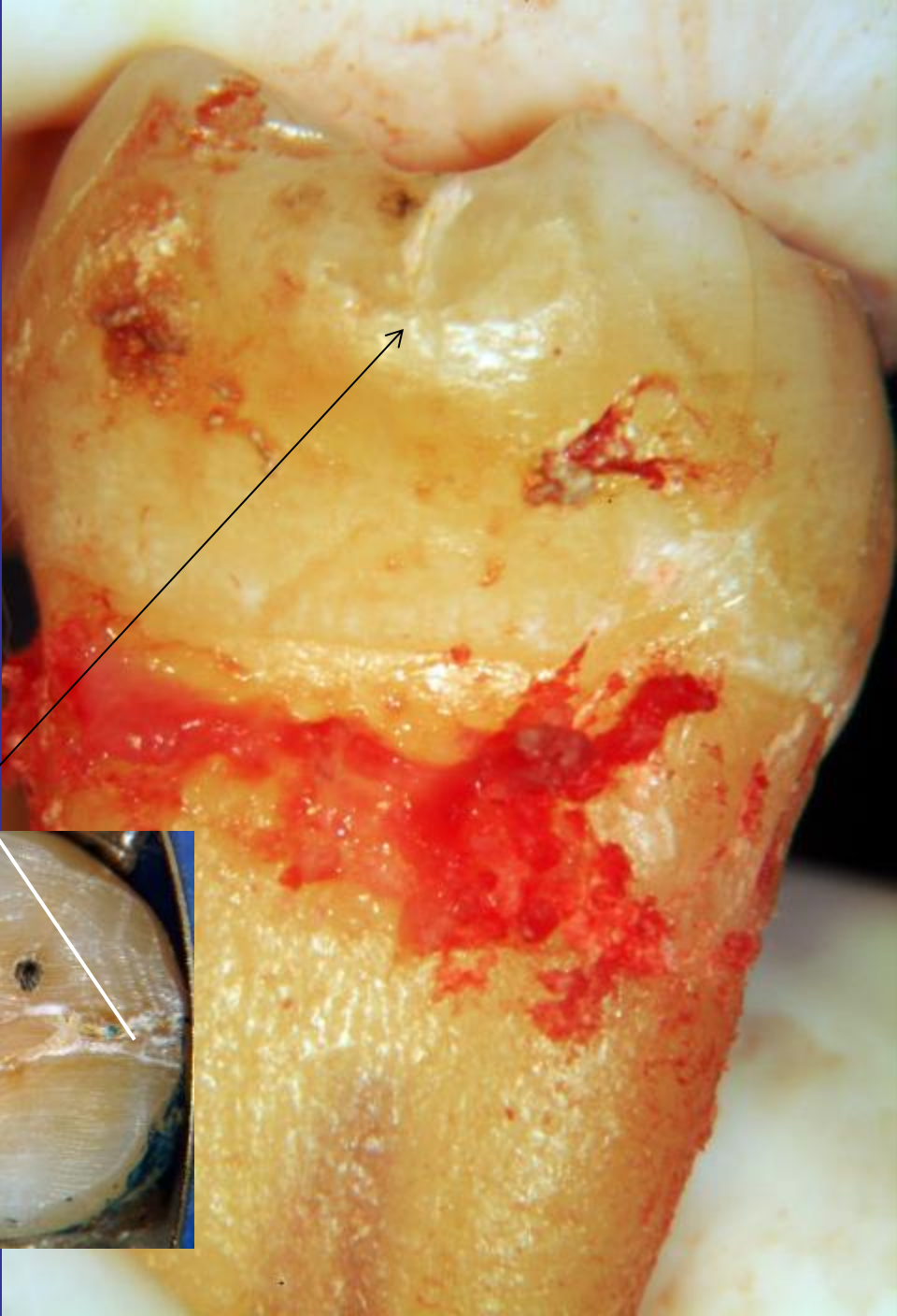
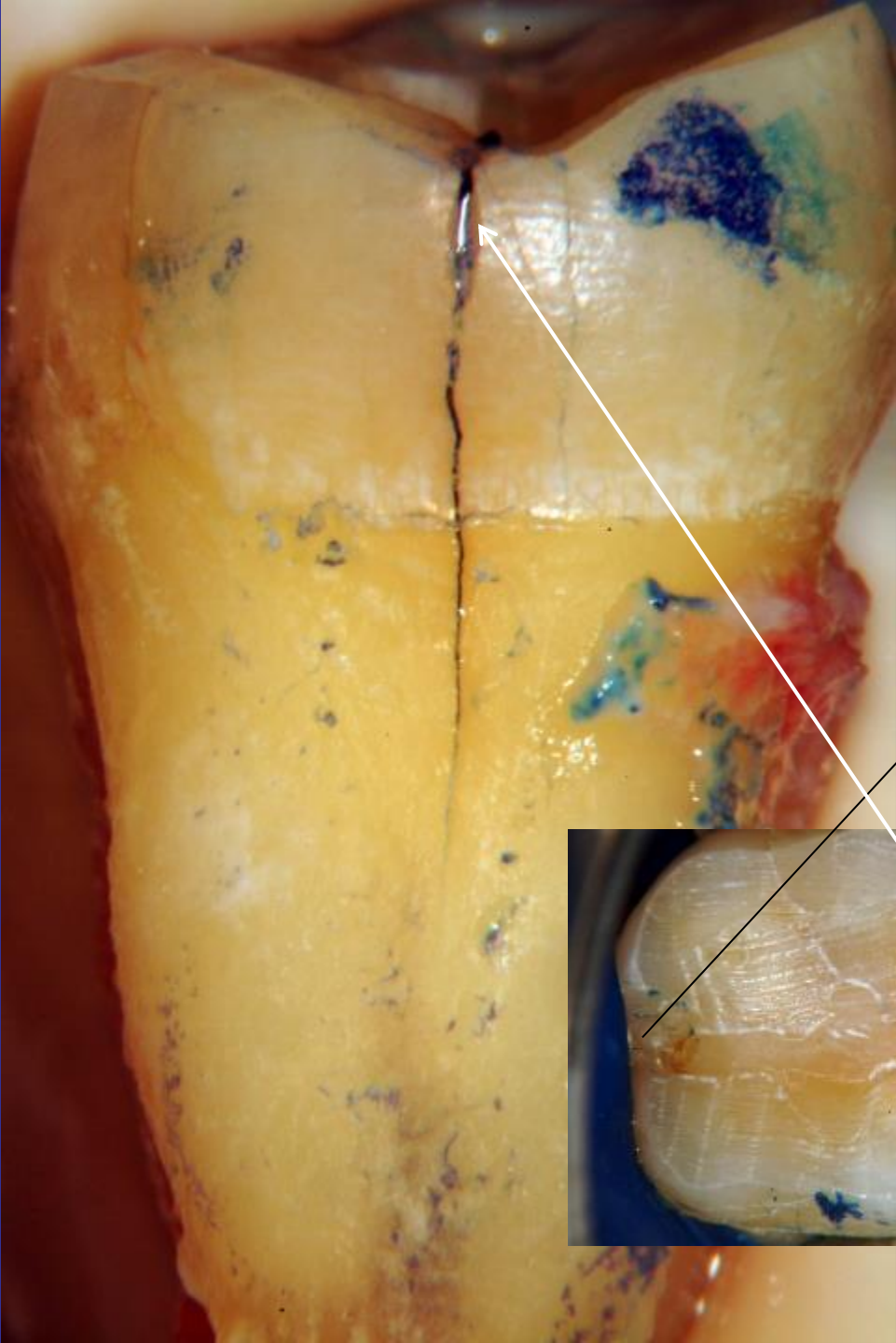




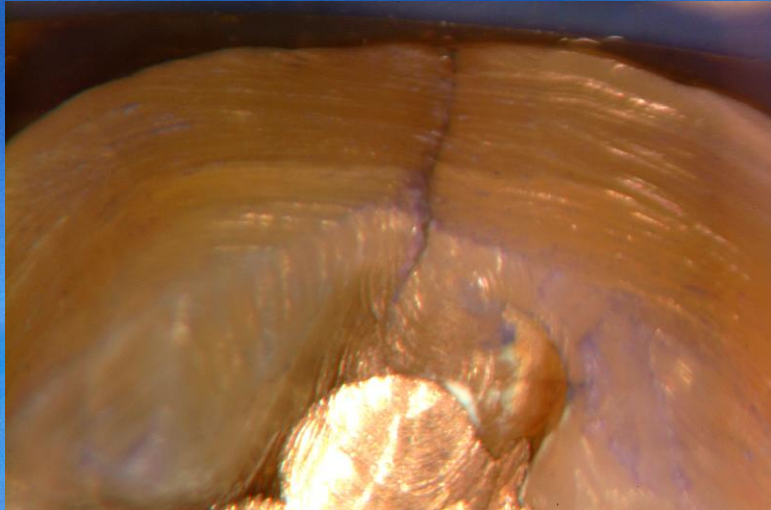






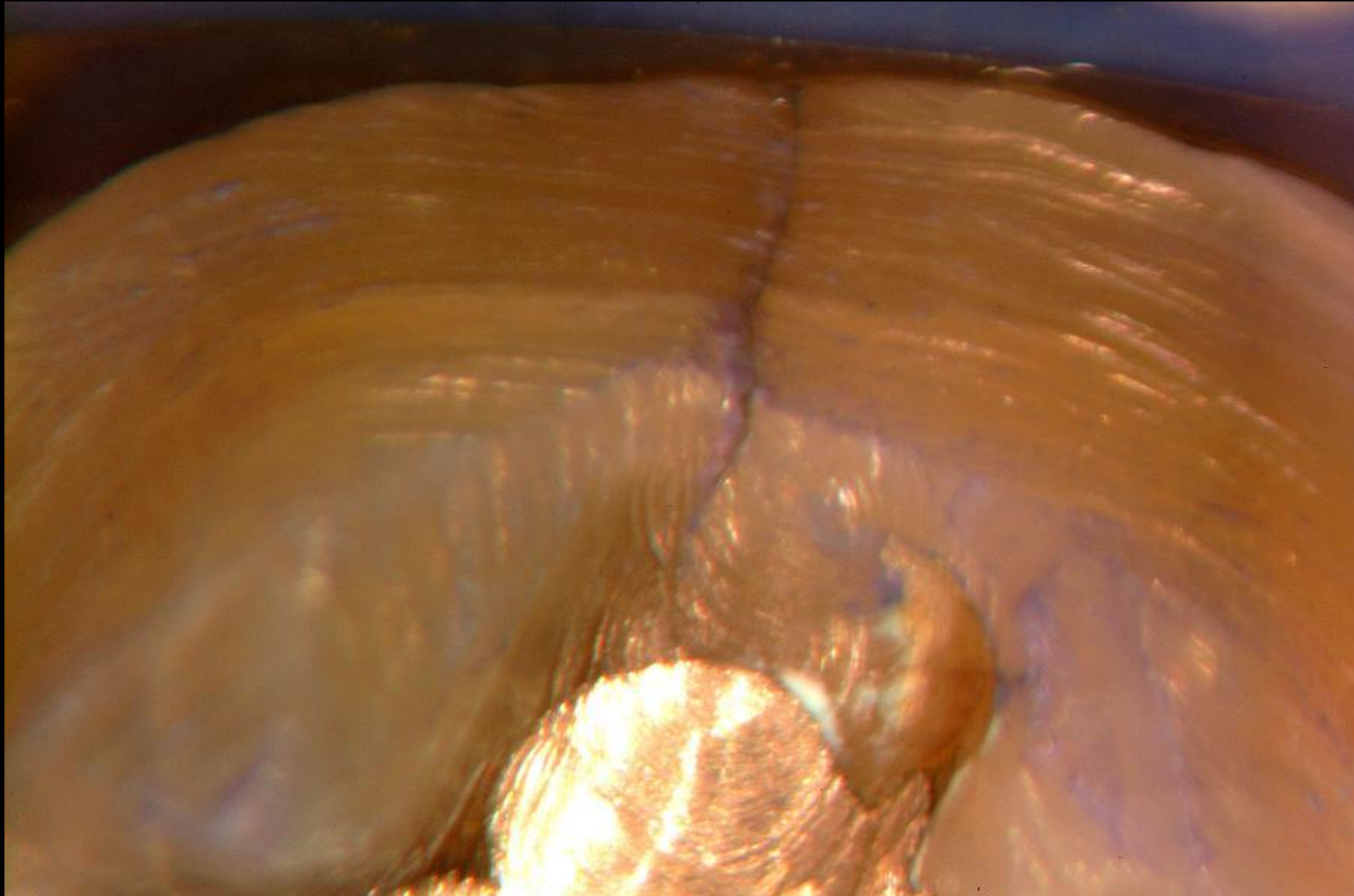


Incomplete and Complete Fractures



Case Study

Occlusal view of distal





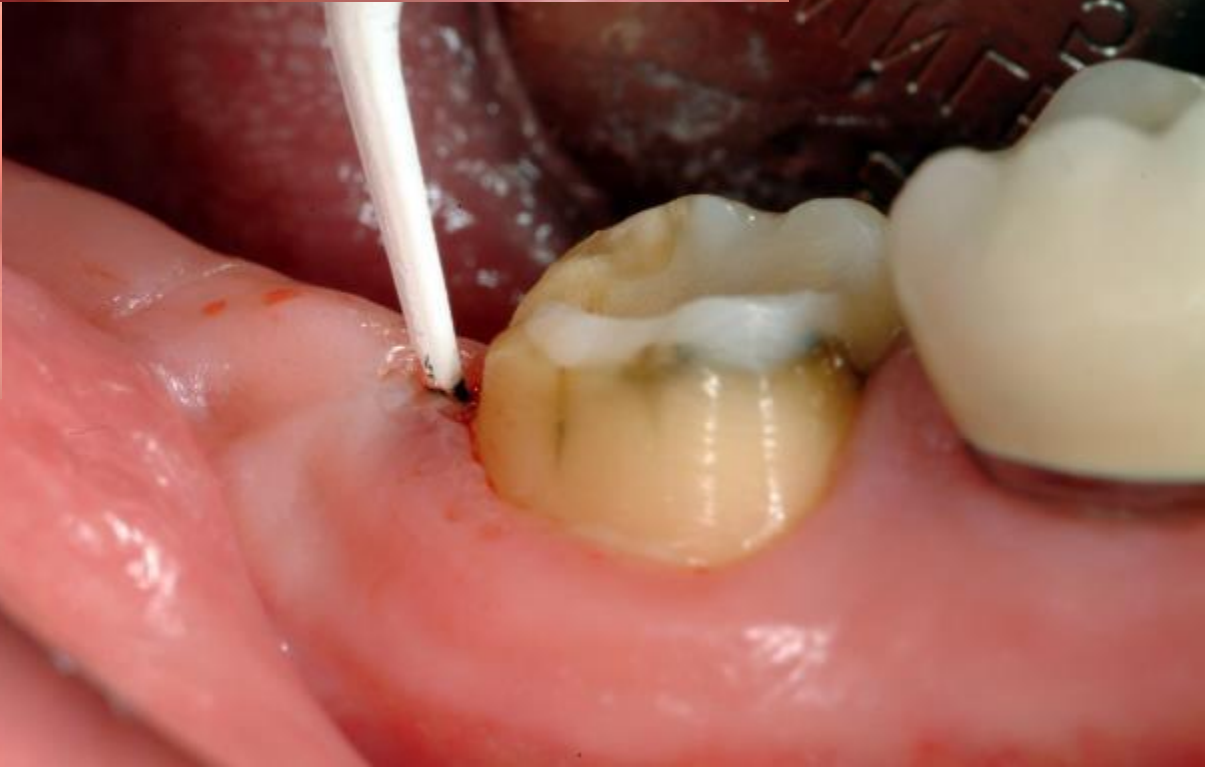
Initial
appointment



3-6 month
wait with
temp crown



4 month
wait





The Old Cracked Tooth Classification System...

Was Based on Symptoms
and Conjecture

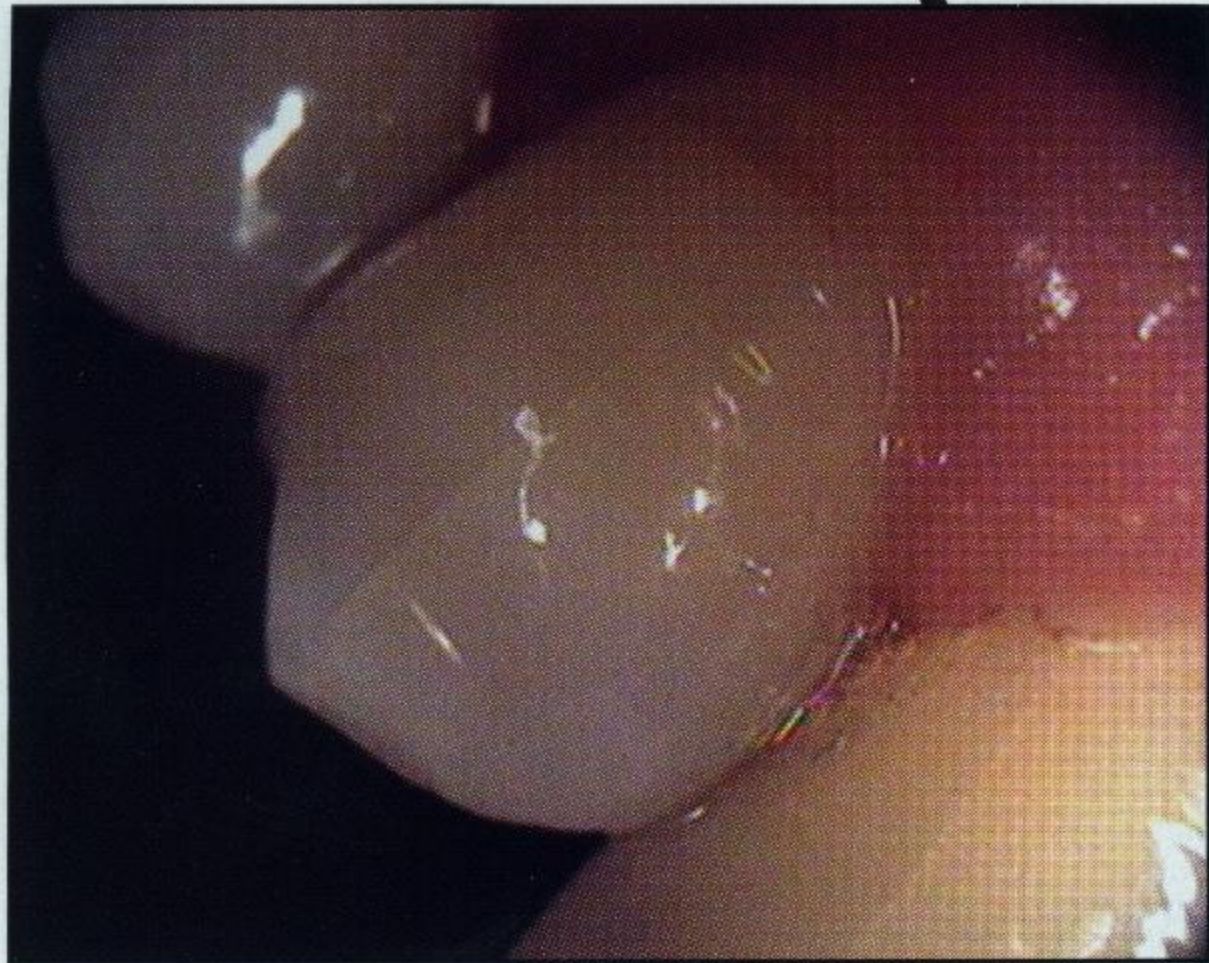
Epidemiologic
third most com
countries. This
syndrome is of

Cracked tooth syndrome

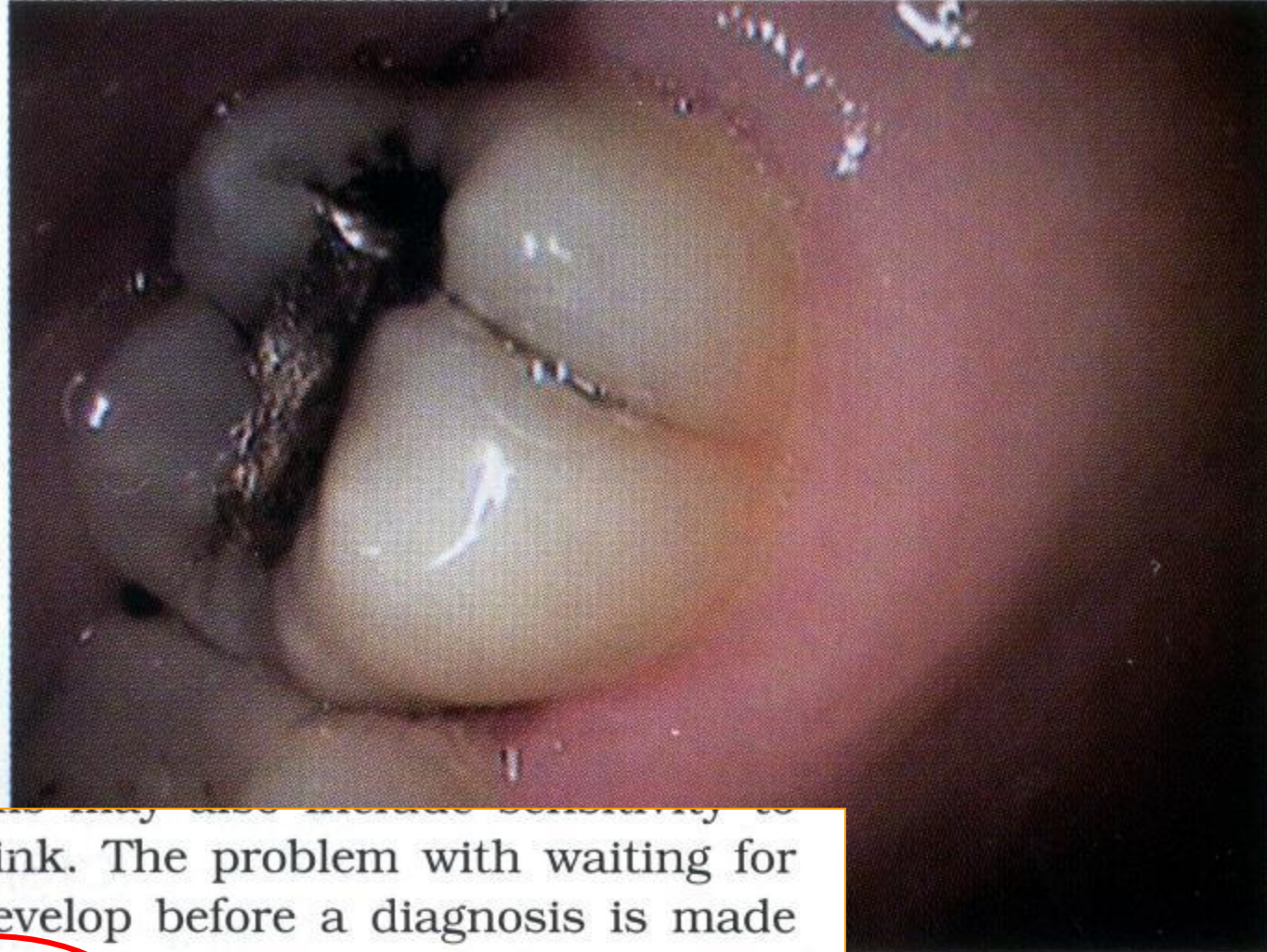
Figure 1



Figure 1



- Sad
main



cold food or drink. The problem with waiting for symptoms to develop before a diagnosis is made is that at this point the crack is usually at what is referred to by Clark⁵ as end-stage crack progression, requiring more aggressive treatment.

The emergence of the dental microscope has been a tremendous aid in the diagnosis and treatment of cracked teeth. The routine, methodical

“Build a bridge
from buccal to
lingual, and the
crack(s)
becomes
dormant.”

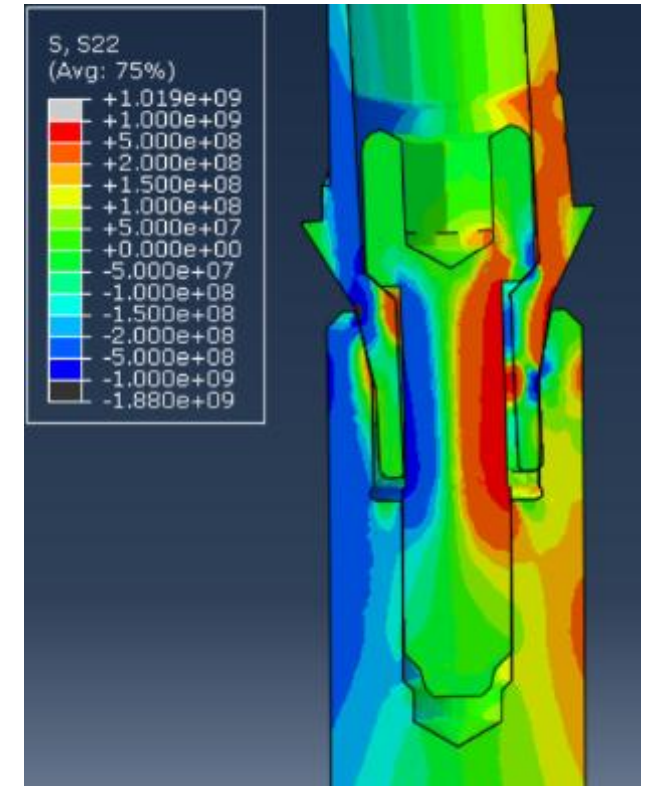
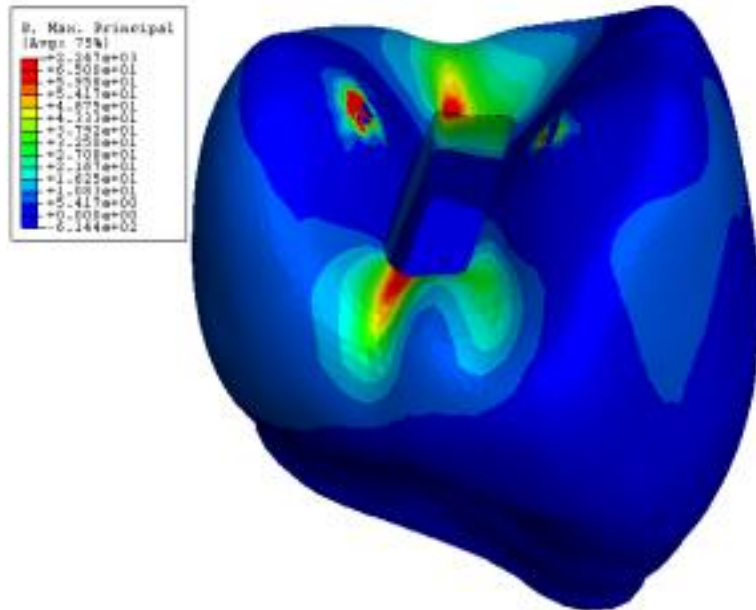


DR. ALEX FOK

Let's Review: Stress/strain concentration

occurs at

- Abrupt changes in geometry
- Mismatches in mechanical properties
- Concentrated loads





∞ BIOCLEAR LEARNING CENTER

The Bioclear Learning Center aims to improve restorative outcomes and raise patient expectations of modern composite dental care by providing dentists with continuing education and certification in the practice of the Bioclear Method.

- The Learning Center is equipped with exclusive, patented Bioclear tools, equipment, and your own operator setup
- Small class sizes with hands-on, interactive curriculum modules
- Online class options available at the convenience of your practice
- Operate a Tell, Show, Do education model
- Learn and understand the Five Pillars of the Bioclear Method

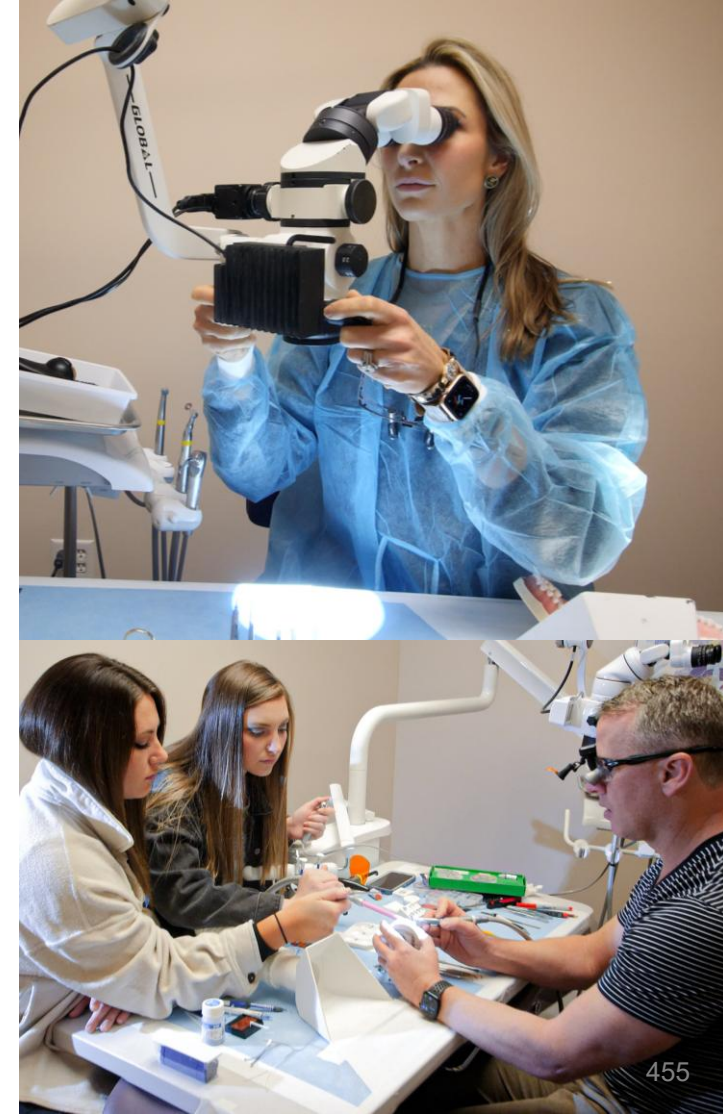
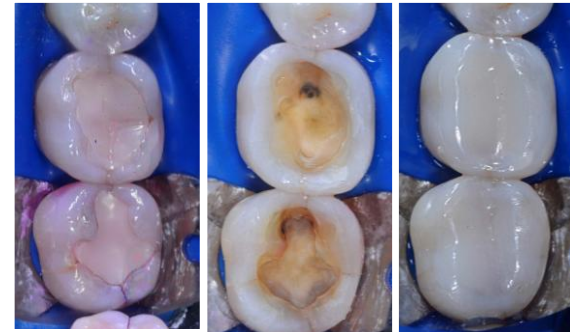
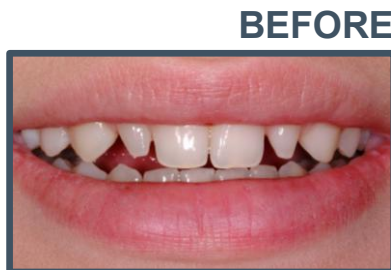
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36 CE CREDITS

This course builds a strong foundation in the Bioclear Method and an understanding of Bioclear products. The focus of the course is indirect methods on adult dentitions as an alternative procedure to porcelain crowns and veneers.

Students will learn the foundation of posterior and anterior restorations and are introduced to the engineering principles involved in the design of the new non-retentive compression-based preps. Students collaboratively practice all applications of the Bioclear Method during intensive, hands-on exercises that simulate posterior and anterior restorations.

LEARN MORE



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Learning Center info or the essential
Bioclear Library, email us at:

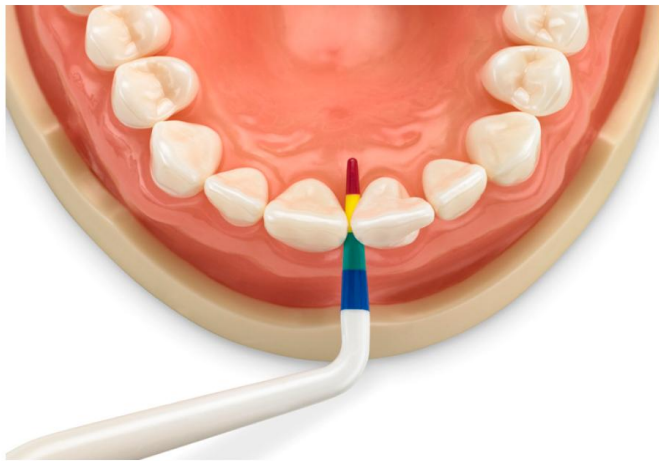
lectures@bioclearmatrix.com

BLACK TRIANGLE

CERTIFICATION COURSE

18 CE CREDITS

This three-part live hands-on certification course will teach you how to treat black triangles, gingival recession, root abrasions, and perform confident restorations. In becoming a certified Bioclear black triangle doctor, you'll increase your overall skill and knowledge of Bioclear and learn to market your new skills to patients.



Toronto
February 27th 2026

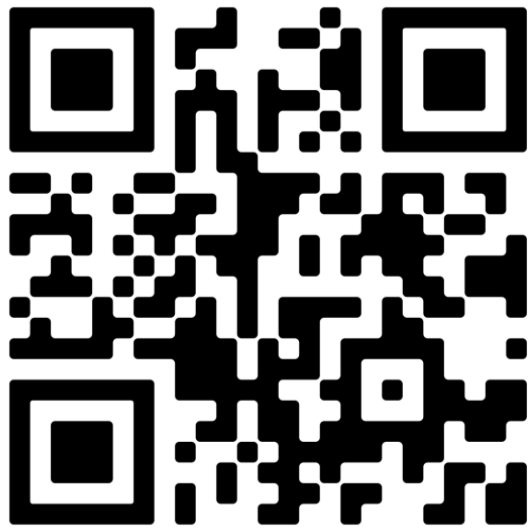
Washington DC
May 8th 2026

Orange Beach
April 24th 2026

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BEFORE



AFTER



BEFORE



AFTER

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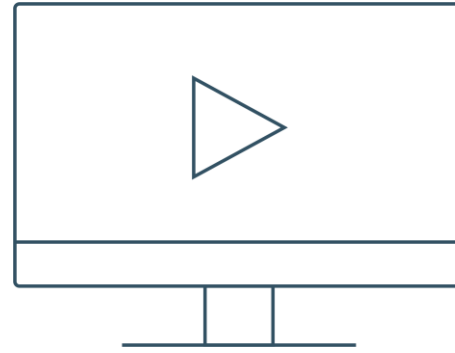
Stop by convention

booth #1916

to...

- ✓ Hear more about Bioclear courses
- ✓ Meet our team of Bioclear nuts
- ✓ Order products
- ✓ Register for courses
- ✓ Learn why Bioclear is a BIG DEAL!





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Step by Step Guide for
Injection Molded Class II

∞ BIOCLEAR

The Adjustable Push-Pull Instrument
for Ideal Contacts



EVOLVE MATRIX SYSTEM

∞ BIOCLEAR
Powered by 3M Oral Care

of Class II
Restorations

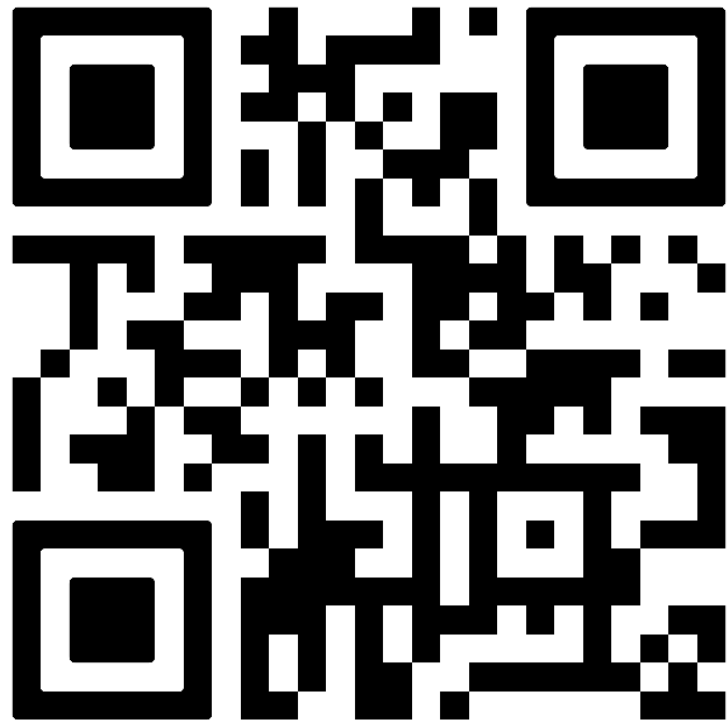
∞ BIOCLEAR

The Bioclear Direct Contact Strut

Creating Contacts for Diastemas, Peg Laterals, and Bioclear 360° Veneers

- PART 1 + PART 2 PREVIEW -

For a copy of today's presentation,
Learning Center info or the essential
Learning Center Library



- Why things break...
- Modern cavity preparations
- Injection Molding of composite
- FEA of both load and shrinkage
- Long term outcomes & case studies
- The Bioclear Method as a “3rd option”

■ When to do endo, when to extract