



Prognosis

REST 717 Winter 2022

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BIOLOGICAL
CONSIDERATIONS

BIOMECHANICAL
CONSIDERATIONS

FUNCTIONAL
CONSIDERATIONS

ESTHETIC
CONSIDERATIONS





" My tooth broke off ... "



...then this

Esthetic ?

Shade matching ?

Type of restoration ?

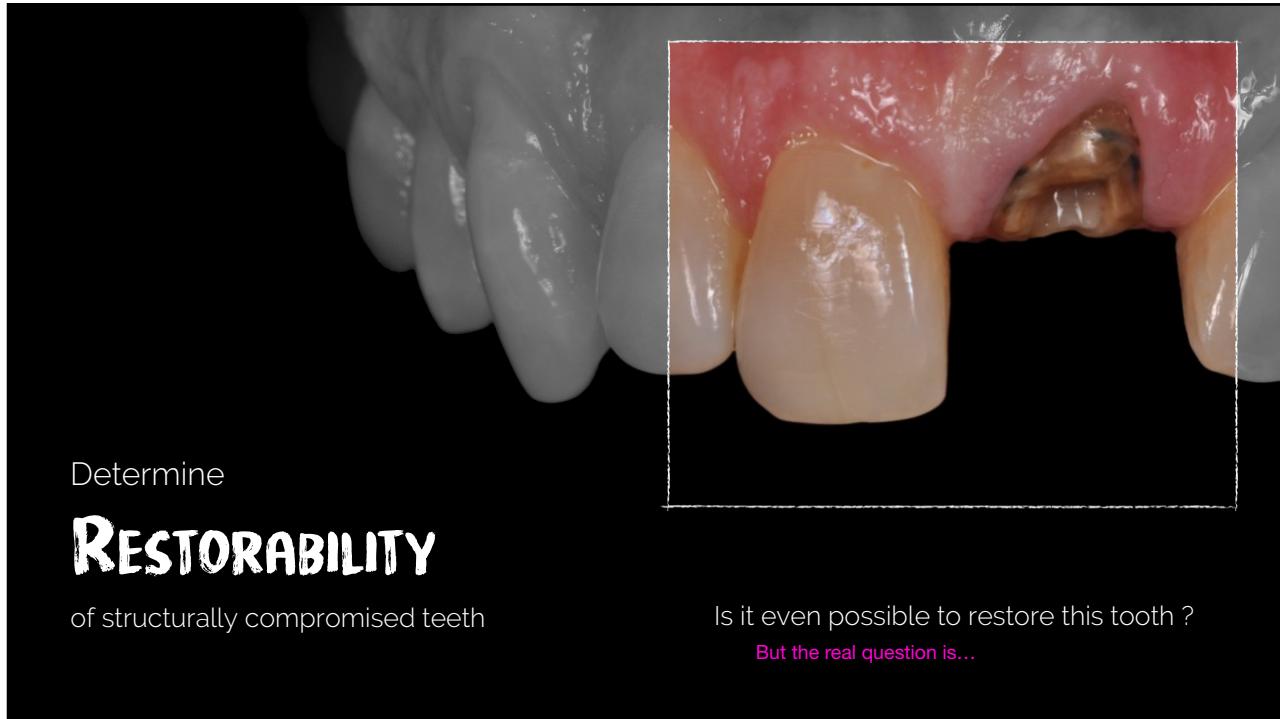
Restoration design ?

Material ?

When you first see this, need to think about this first

Is it even possible to restore this tooth ?

"Restorability"



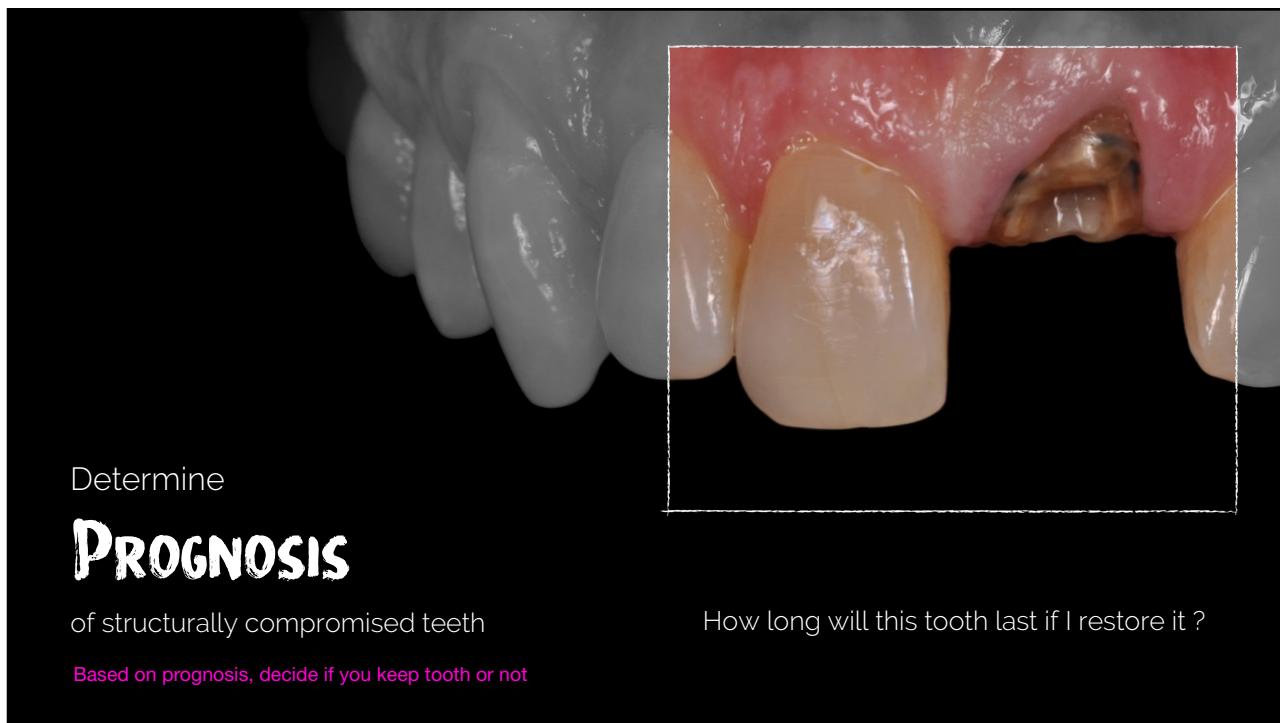
Determine

RESTORABILITY

of structurally compromised teeth

Is it even possible to restore this tooth ?

But the real question is...



Determine

PROGNOSIS

of structurally compromised teeth

How long will this tooth last if I restore it ?

Based on prognosis, decide if you keep tooth or not



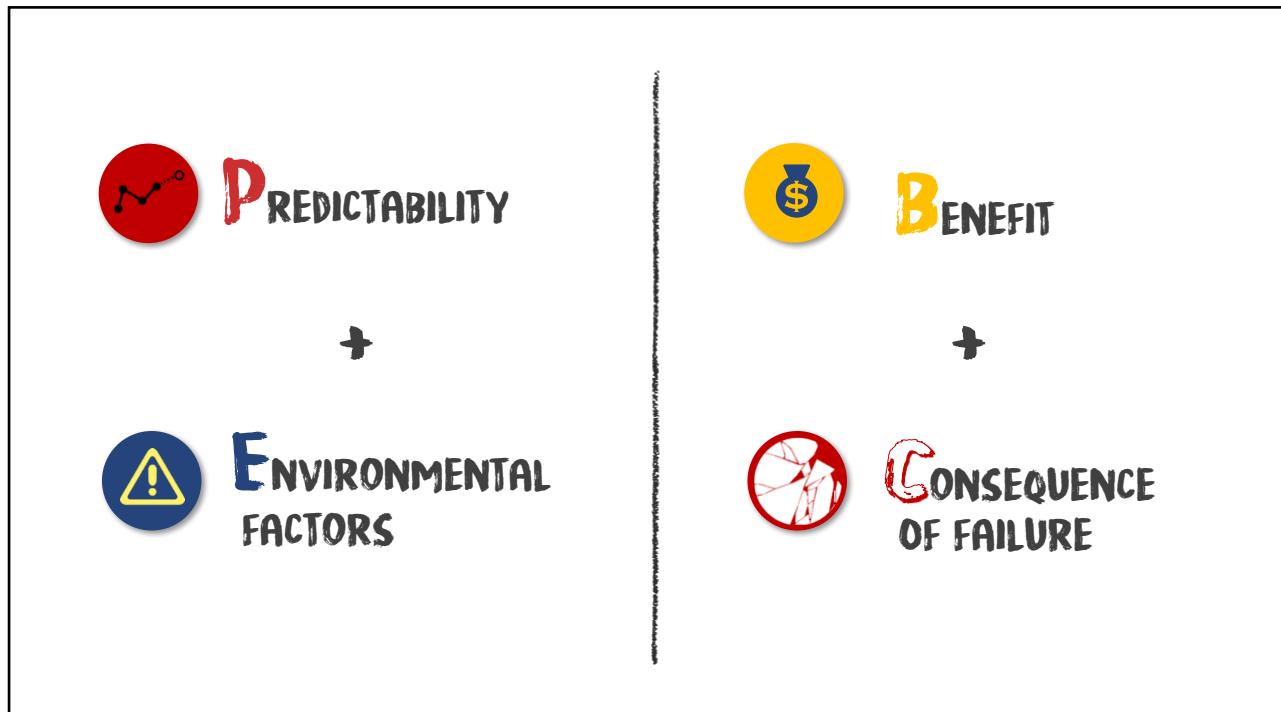
#9 TREATMENT OPTIONS

OPTION 1 Endo. tx + Post & Core + Crown

OPTION 2 Extraction + Single implant restoration

OPTION 3 Extraction + #8-10 fixed dental prosthesis
Clinical decision making situation — predictability, environmental, benefit, consequence

The best decision ?



 **PREDICTABILITY**

 ENVIRONMENTAL FACTORS

 BENEFIT

 CONSEQUENCE OF FAILURE

HANNAHAN et al, JE 2008¹

- ✓ Success rate
 - : 129 Single implants : 98.4% (36months)
 - : 143 Endodontically treated teeth : 99.3% (22months)
 - : No statistically significant difference

IQBAL et al, IJOMI 2007²

- ✓ Review 55 studies related to single tooth implant and 13 studies related to restored root canal treated teeth were included.
- ✓ No significant differences in survival between root canal treated teeth and single tooth implants.

Both are predictable tx

1. Hannahan JP, Eleazer PD. Comparison of success of implants versus endodontically treated teeth. *J Endod.* 2008 Nov;34(11):1302-5
 2. Iqbal MK, Kim S. For teeth requiring endodontic treatment, what are the differences in outcomes of restored endodontically treated teeth compared to implant-supported restorations? *Int J Oral Maxillofac Implants.* 2007;22 Suppl:96-116.

 **PREDICTABILITY**

 ENVIRONMENTAL FACTORS

 BENEFIT

 CONSEQUENCE OF FAILURE

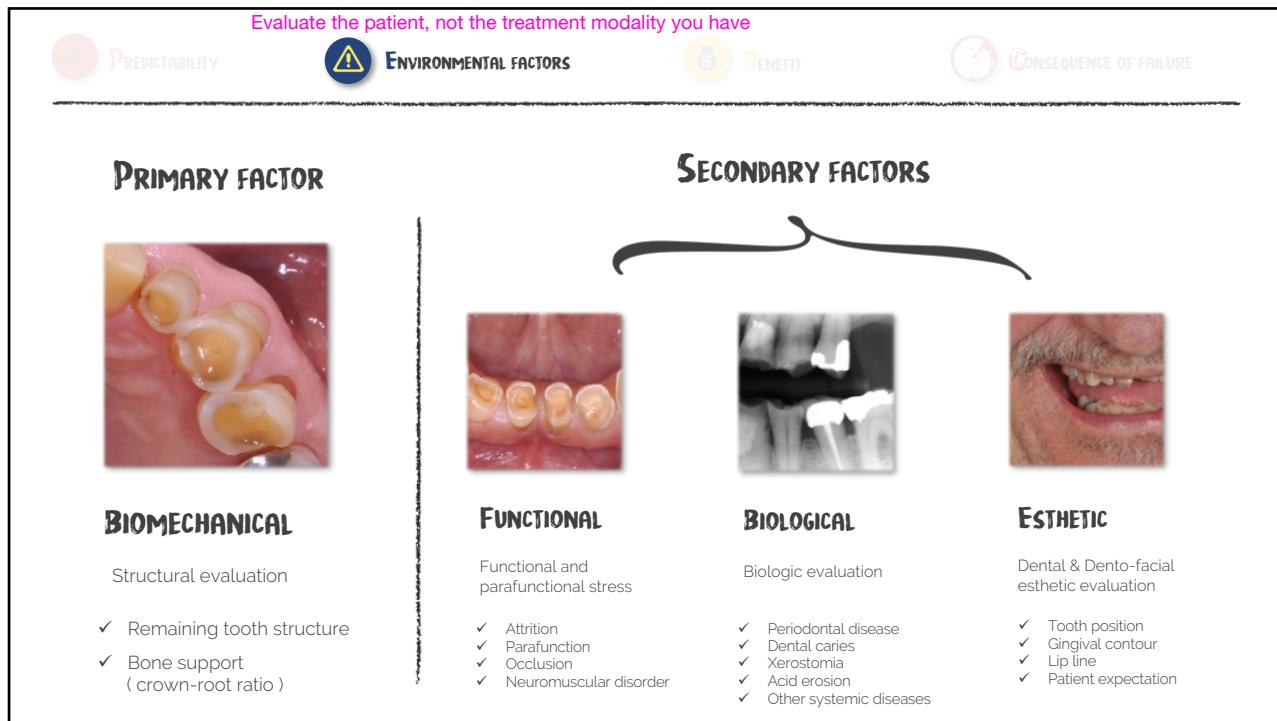
TORABINEJAD et al, JPD 2007³

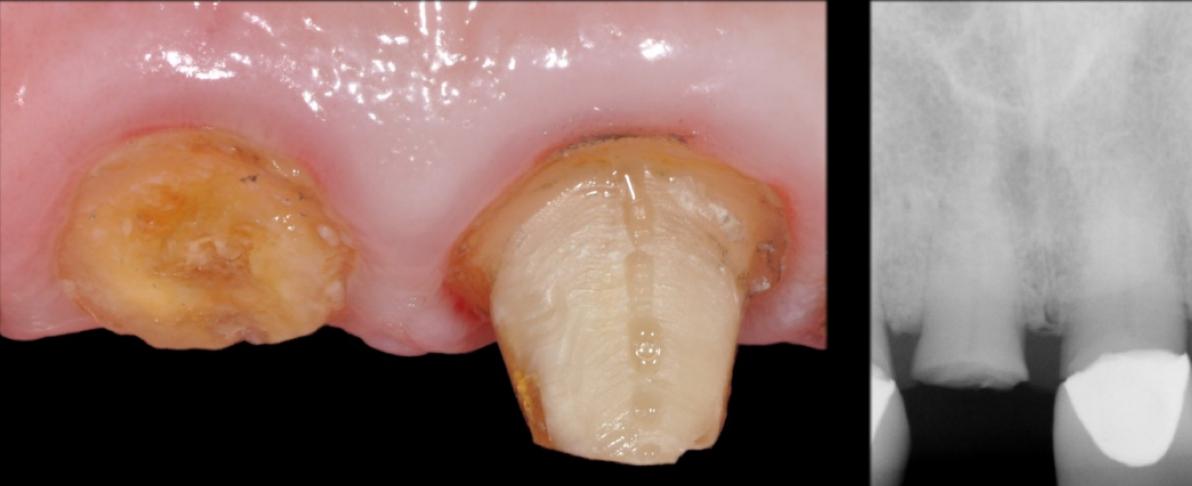
- ✓ A systematic review of 101 selected clinical studies
 - (46 single implant studies, 31 FPD studies and 24 RCT/single crown studies)
- ✓ 6+ year weighted survival rate.

ENDO TX + SINGLE CROWN	IMPLANT (single)	FDP (short-span)
97%	=	82%

- ✓ Long-term survival rates for single implant restorations and RCT/single crowns are superior to those for fixed dental prostheses.

3. Torabinejad M, Anderson P, Bader J, Brown LJ, Chen LH, Goodacre CJ, Kattadiyil MT, Kutsenko D, Lozada J, Patel R, Petersen F, Puterman I, White SN. Outcomes of root canal treatment and restoration, implant-supported single crowns, fixed partial dentures, and extraction without replacement: a systematic review. *J Prosthet Dent.* 2007 Oct;98(4):285-311.



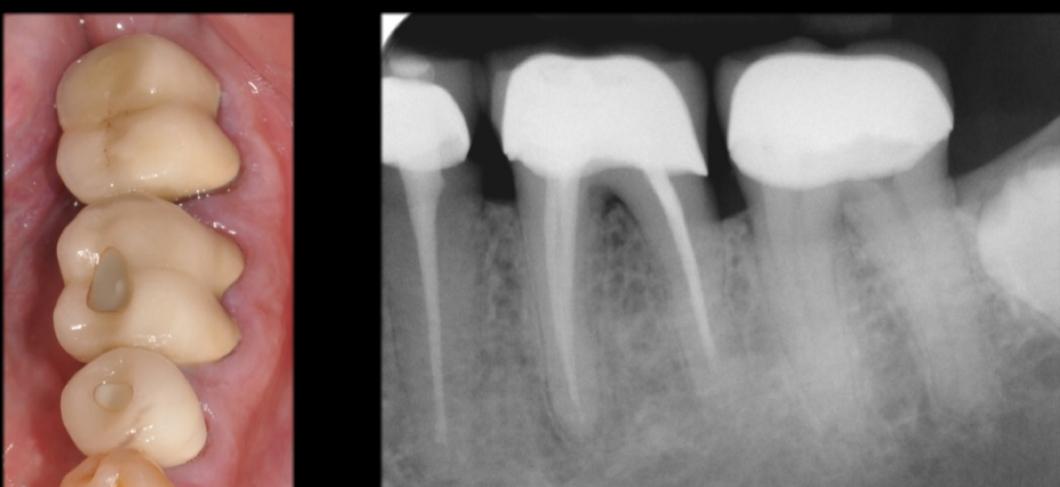


A clinical photograph on the left shows a tooth with a large, yellowish-brown cavity preparation. To the right is a corresponding dental radiograph showing the internal structure of the tooth, including the root and the extent of the cavity preparation.

MECHANICAL STABILITY ???

- ✓ Strength of structurally compromised teeth is mainly determined by the amount of the remaining, healthy, coronal tooth structure.

So this means everything else is secondary.



A clinical photograph on the left shows a tooth with multiple large, yellowish-brown composite restorations. To the right is a corresponding dental radiograph showing the internal structure of the tooth, including the root and the extent of the restorations.

REMAINING, HEALTHY & CORONAL TOOTH STRUCTURE..... ?

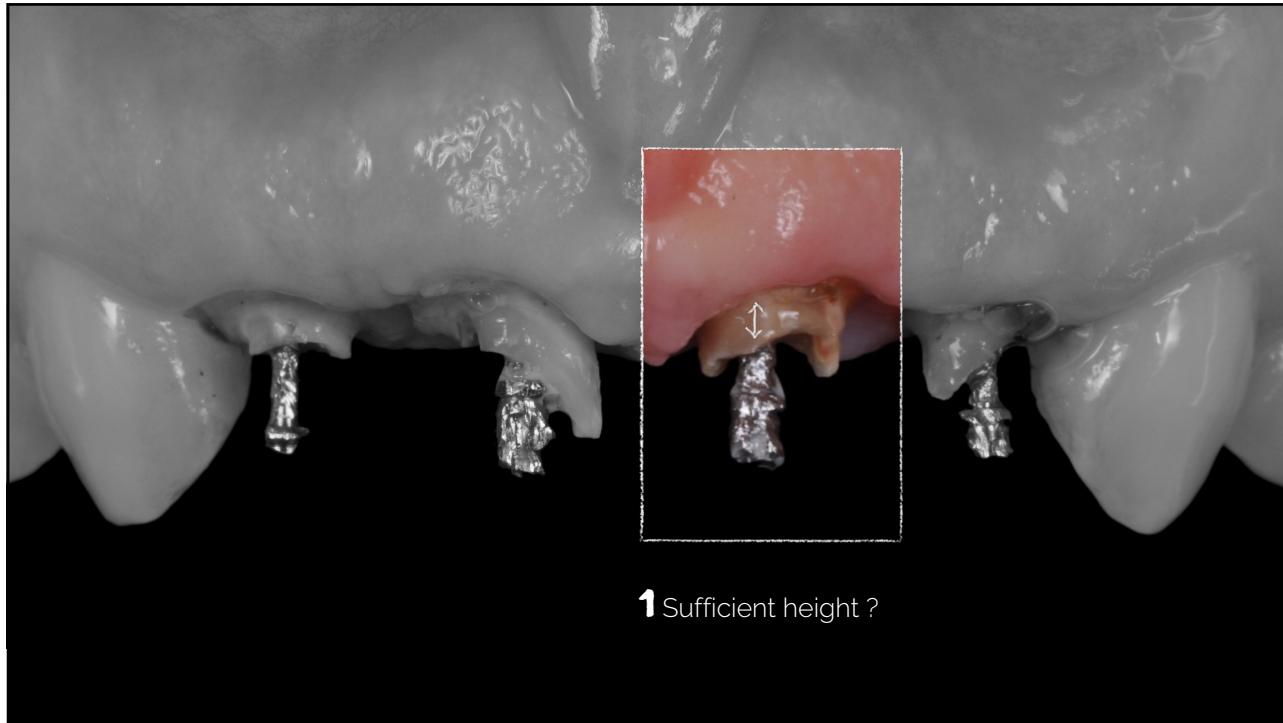
At this point, you can't see if you have enough coronal remaining healthy tooth structure. Need to remove cc



There's no way you can guarantee cc for this pt. Need to remove everything and evaluate remaining healthy tooth structure



Strong enough tooth structure to place crown? Little structure remaining



If you wanna do cc, theres no proper tooth prep. Need to build it up instead of taking structure down. Need a foundational restoration aka core buildup. If still not enough, place post in root canal (post) — post and core. We do this for structurally compromised tooth.

PREDICTABILITY	ENVIRONMENTAL FACTORS	BENEFIT	CONSEQUENCE OF FAILURE
"FERRULE" EFFECT Crown embracing tooth structure			
		 BIOMECHANICAL	
<ul style="list-style-type: none"> ✓ A ferrule (encircling band of cast metal around the coronal surface of the tooth) has been suggested to improve the integrity of the endodontically treated teeth.⁴ 			

4. Sorensen JA, Engelman MJ. Ferrule design and fracture resistance of endodontically treated teeth. J Prosthet Dent. 1990 May;63(5):529-36.

Mode of failure usually: fracture root, post + core dislodged, post breaks

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

SORENSEN ET AL. JPD 1990 4

✓ 1mm of coronal dentin above the crown margin significantly increased the failure threshold.



Fig. 2. Six experimental tooth preparation designs.

Fig. 9. Illustration of ferrule effect between crown and coronal tooth structure.

4. Sorensen JA, Engelman MJ. Ferrule design and fracture resistance of endodontically treated teeth. *J Prosthet Dent.* 1990 May;63(5):529-36.

Compare str of tooth w various levels of ferrule. 1mm ferrule height critical to for fracture resistance

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

FERRULE HEIGHT (> 1.5-2.0mm) Know this number



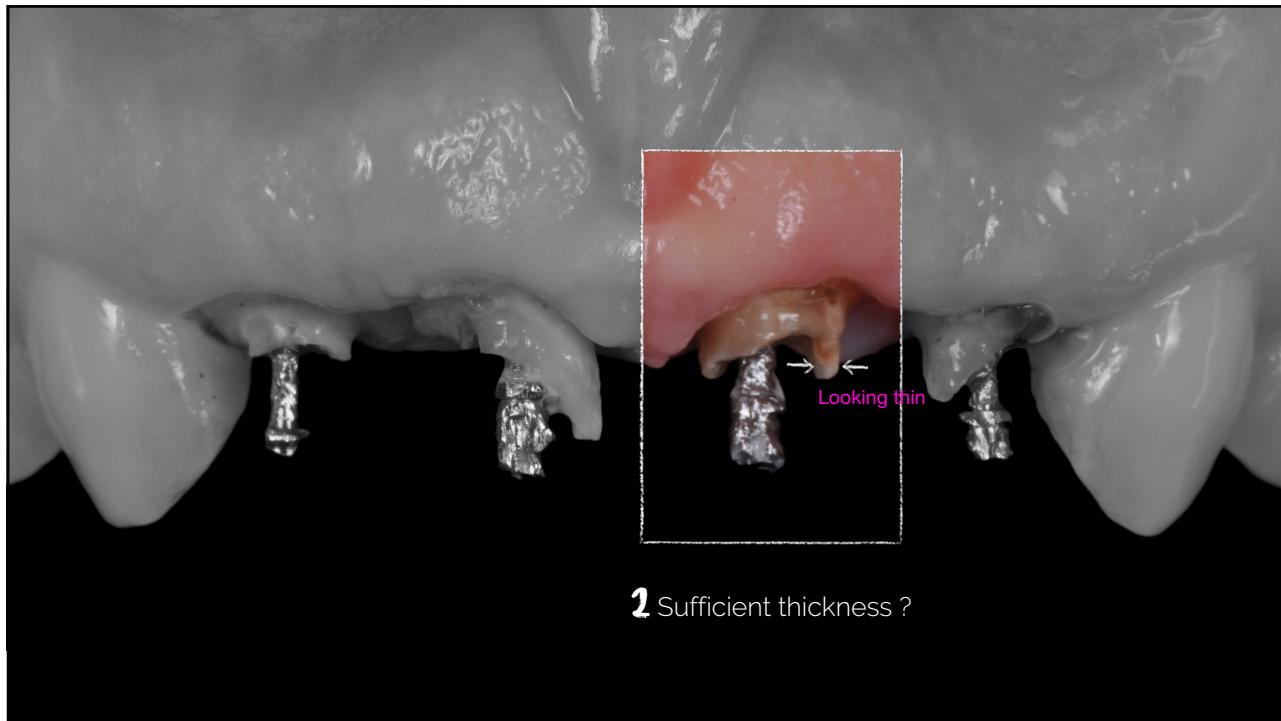
LOAD-TO-FAILURE TEST

- ✓ Those prepared with a 2-mm dentin ferrule more effectively enhanced the fracture strength of custom cast post-core restored endodontically treated maxillary central incisors.⁵
- ✓ The results of this study showed that an increased amount of coronal dentin significantly increases the fracture resistance of endodontically treated teeth. (0mm<1mm<2mm<3mm)⁶
- ✓ Fracture thresholds were higher for all 4 dowel systems when the specimens were prepared with a 2.0-mm ferrule length⁷
- ✓ Fracture resistance of endodontically treated teeth depends on the length of the ferrule, as shown by the significantly increased fracture resistance in the 2 mm ferrule group compared to the groups with shorter ferrule lengths and without post.⁸

CYCLIC FATIGUE LOADING

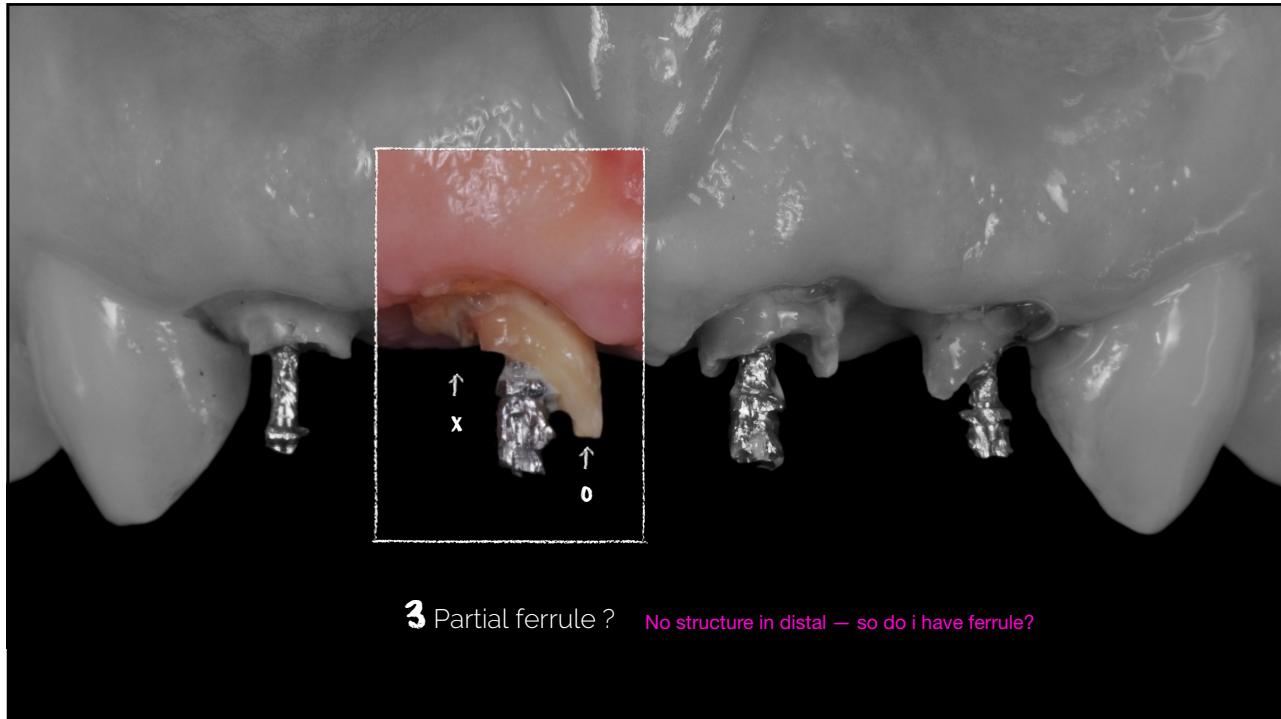
- ✓ Fracture resistance to cyclic loading increased significantly with increasing ferrule length (0mm<1.25mm<2.5mm).⁹
- ✓ Teeth with 1mm ferrule exhibited significantly higher fatigue cycle count over 0mm group.¹⁰

5. Zhi-Yue L, Yu-Xing Z. Effects of post-core design and ferrule on fracture resistance of endodontically treated maxillary central incisors. *J Prosthet Dent.* 2003 Apr;89(4):368-73.
 6. Perez-Gomez O, Ramirez PE, et al. Effect of the ferrule on the fracture resistance of teeth restored with prefabricated titanium posts. *J Prosthet Dent.* 2006 Jan;95(1):30-4.
 7. Sorenson B. A *de novo* study evaluating the effect of ferrule length on fracture resistance of endodontically treated teeth restored with fiber-reinforced and zirconia-dosed systems. *J Prosthet Dent.* 2004 Aug;92(2):155-62.
 8. Kim AR, Lim HP, Yang HS, Park SW. Effect of ferrule on the fracture resistance of mandibular premolars with prefabricated posts and cores. *J Adv Prosthodont.* 2017 Oct;9(5):328-34.
 9. Isidor F, Bronlund K, Ramfjord G. The influence of post length and crown ferrule length on the resistance to cyclic loading of bovine teeth with prefabricated titanium posts. *Int J Prosthodont.* 1999 Jan-Feb;12(1):78-82.
 10. Ma PS, Nicholls JI, Jungo T, Phillips KM. Load fatigue of teeth with different ferrule lengths, restored with fiber posts, composite resin cores, and all-ceramic crowns. *J Prosthet Dent.* 2009 Oct;102(4):229-34.



PREDICTABILITY	ENVIRONMENTAL FACTORS	BENEFIT	CONSEQUENCE OF FAILURE
FERRULE WIDTH (> 1mm)	Ferrule height = more is better		BIOMECHANICAL
<ul style="list-style-type: none"> ✓ More than <u>1 mm</u> thickness of labial dentin wall of post channel is required to prevent root fracture under horizontally directed force.¹¹ ✓ Dowel channels with <u>1 mm</u> of remaining buccal dentin walls were apparently more prone to fracture under horizontal impact than those that had 2 or 3 mm of buccal dentin walls.¹² ✓ Clinically, it is generally accepted that walls are considered too thin when they are less than <u>1mm</u> in thickness, <u>The minimal ferrule height is only of value if the remaining dentine has a minimal thickness of 1mm.</u>¹³ 			
<small> 11. Joseph J. Ramachandran G. Fracture resistance of dowel channel preparations with various dentin thickness. <i>Fed Oper Dent.</i> 1990 Aug;1(1):32-5. 12. Tjan AH, Whang SB. Resistance to root fracture of dowel channels with various thicknesses of buccal dentin walls. <i>J Prosthet Dent.</i> 1985 Apr;53(4):496-500. 13. Jotkowitz A, Samet N. Rethinking ferrule—a new approach to an old dilemma. <i>Br Dent J.</i> 2010 Jul 10;209(1):25-33. </small>			

When evaluate ferrule height, you eval height of tooth
structure >1mm



	PREDICTABILITY		ENVIRONMENTAL FACTORS		BENEFIT		CONSEQUENCE OF FAILURE
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INCOMPLETE OR PARTIAL FERRULE

ALL-AROUND FERRULE > INCOMPLETE FERRULE > NO FERRULE

- ✓ Teeth with a ferrule varying between 0.5 and 2-mm were less fracture-resistant than those with a uniform 2-mm ferrule, but more fracture-resistant than those with no ferrule.¹⁴
- ✓ Incomplete ferrule is associated with greater variation.¹⁵

NUMBER OF WALLS ?

- ✓ Teeth with four walls of ferrule (remaining coronal dentine) had a significantly higher fracture resistance than teeth with only three walls of ferrule.¹⁵
- ✓ In general, the more walls of ferrule present, the better the fracture resistance, but sometimes it is not the number of walls that are the focus of considerations, but rather the location of these walls.¹³

14. Tan PL, Aquilino SA, Gratton DG, Stanford CM, Tan SC, Johnson WT, Dawson D. In vitro fracture resistance of endodontically treated central incisors with varying ferrule heights and configurations. J Prosthet Dent. 2005 Apr;93(4):331-6.

15. Arunpraditkul S, Saengsanon S, Pakivwat W. Fracture resistance of endodontically treated teeth: three walls versus four walls of remaining coronal tooth structure. J Prosthodont. 2009 Jan;18(1):49-53.

13. Jotkowitz A, Samet N. Rethinking ferrule—a new approach to an old dilemma. Br Dent J. 2010 Jul 10;209(1):25-33.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

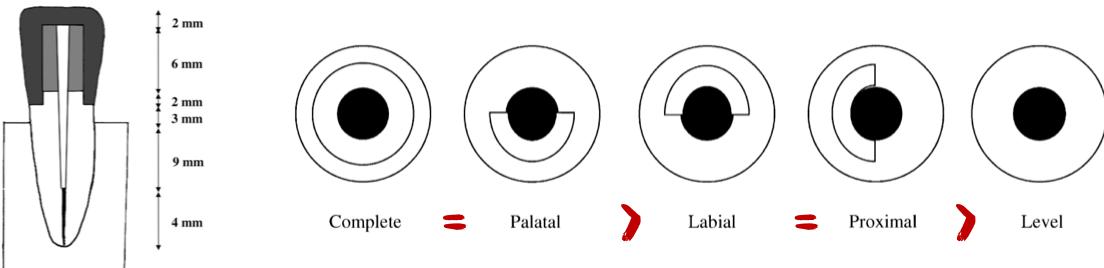
INCOMPLETE OR PARTIAL FERRULE - LOCATION ?

Location of walls

✓ The fracture resistance of teeth with only the palatal portion of axial tooth structure remaining (Palatal group) was not significantly different from than that of teeth in the complete group.¹⁶



BIOMECHANICAL



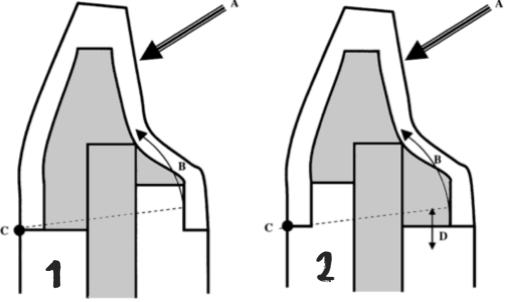
16. Ng CC, Dumbigue HB, Al-Bayan Ml, Griggs JA, Wakefield CW. Influence of remaining coronal tooth structure location on the fracture resistance of restored endodontically treated anterior teeth. J Prosthet Dent. 2006 Apr;95(4):290-6.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

INCOMPLETE OR PARTIAL FERRULE - LOCATION ?



BIOMECHANICAL



1 Partial ferrule on the tension side

✓ When the remaining axial wall is at the location where the load is applied, the arc of displacement of the complete crown places the remaining tooth structure under tension, buttressed against the post/core. Thus, the strength of the remaining tooth structure and not the bond between the post/core and the root is primarily challenged.¹⁶

2 Partial ferrule on the compression side

✓ If the remaining axial wall is on the labial aspect, the arc of displacement of the complete crown challenges the bond between the post/core and the root first, and root fracture results at a lower force level than the former¹⁶

Fig. 4. Arc of displacement of complete crown. (A) Direction of force; (B) arc of crown displacement; (C) fulcrum; (D) bond strength of post/core to root.

16. Ng CC, Dumbigue HB, Al-Bayan Ml, Griggs JA, Wakefield CW. Influence of remaining coronal tooth structure location on the fracture resistance of restored endodontically treated anterior teeth. J Prosthet Dent. 2006 Apr;95(4):290-6.

L = tension side?

ANTERIOR TEETH

- Primary load-bearing wall
 - Palatal (Mx)
 - Facial (Mn)



✓ In anterior teeth, where the load is generally bucco-lingual and lacks the occluso-gingival force component, the location of the wall becomes crucial.

✓ Since maxillary anterior teeth are loaded from the palatal, adequate ferrule on the lingual aspect of maxillary anteriors is of prime importance so as to resist the load.

✓ Similarly, mandibular anterior teeth are loaded from the buccal and here the presence of a buccal wall to resist to load is the one that has the most significance.

B = tension side, more important

POSTERIOR TEETH

- Primary load-bearing wall
 - Palatal & Facial



✓ Most of the forces in the posterior segment of the mouth are occluso-gingival and bucco-lingual in nature.

✓ Therefore, it is reasonable to assume that oral forces do not challenge a tooth that lacks a full 2mm ferrule on the proximal sides as much as when the buccal and/or lingual walls are missing.

13. Jotkowitz A, Samet N. Rethinking ferrule—a new approach to an old dilemma. Br Dent J. 2010 Jul 10;209(1):25-33.

MD tooth structure becomes less important than BL structure.

PROGNOSIS

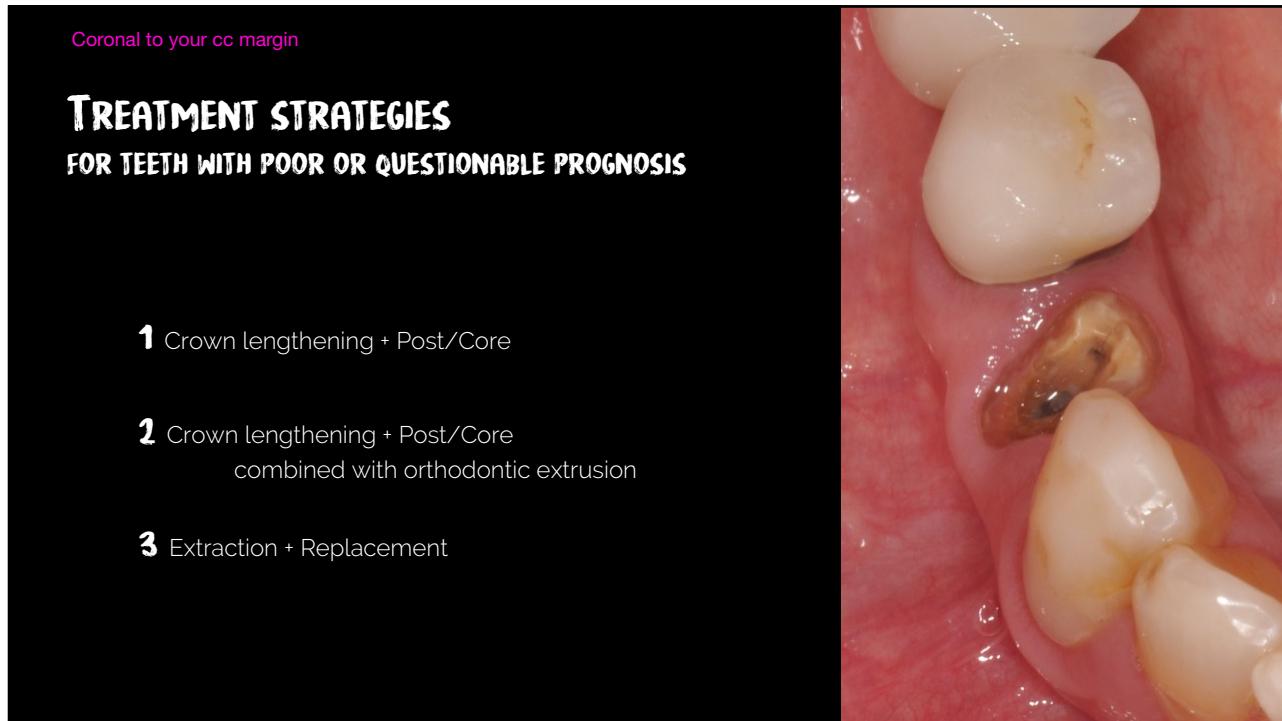
from a biomechanical perspective



Consider location of wall, # of wall. Dif opinions

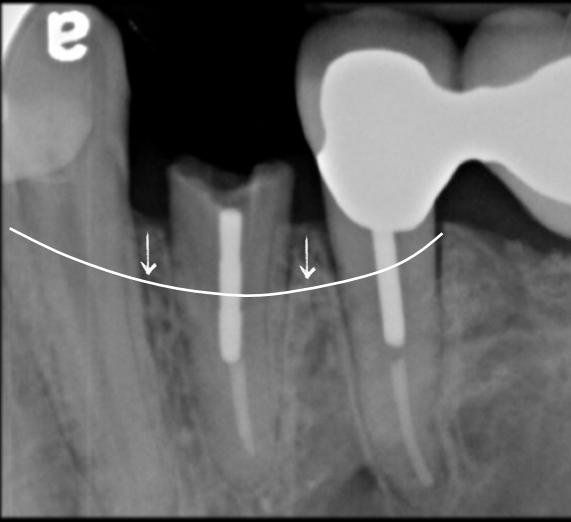
GOOD PROGNOSIS	QUESTIONABLE PROGNOSIS	POOR PROGNOSIS
Ferrule height > 1.5~2.0mm	Ferrule height < 1.5~2.0 mm	No ferrule
Ferrule width > 1.0 mm	Ferrule width < 1.0 mm	
Circumferential ferrule Most dentist restore	Partial ferrule	

Can we do anything to improve poor or questionable prognosis?



If you do cc lengthen, what happens to periodontal bone?

LIMITATIONS OF FUNCTIONAL CROWN LENGTHENING



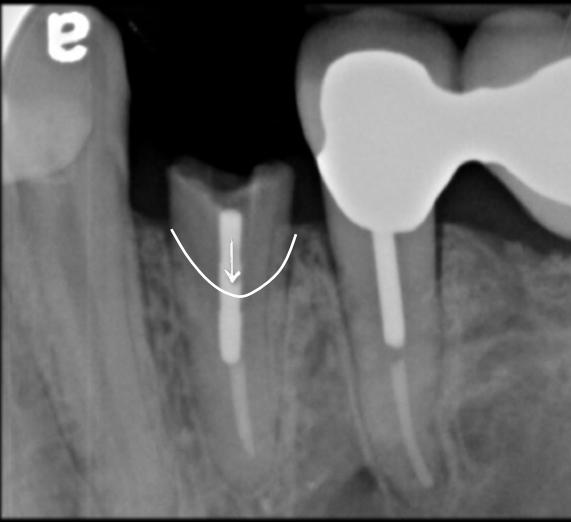
Cut 2 mm bone circumferentially. Lose bone in adjacent tooth.

2 Periodontal bone contour
Are you making perio prognosis bad for this tooth and adjacent teeth?

- ✓ At least 4.5mm of supra-alveolar tooth structure is required to achieve 1.5mm ferrule.¹⁷
- ✓ The clinical implications of a crown lengthening procedure with the risk of damaging adjacent teeth should be evaluated against the biomechanical risks of a crown that does not have 360° ferrule.¹³
- ✓ Preserve as much bone as possible for a future implant should it become necessary.¹⁷

17. Juloski J, Radovic I, Goracci C, Vulicevic ZR, Ferrari M. Ferrule effect: a literature review. *J Endod*. 2012 Jan;38(1):11-9.
13. Joikowitz A, Samet N. Rethinking ferrule—a new approach to an old dilemma. *Br Dent J*. 2010 Jul 10;209(1):25-33.

LIMITATIONS OF FUNCTIONAL CROWN LENGTHENING



Limited gain tooth structure. Do this if you need a little more.

2 Periodontal bone contour

- ✓ At least 4.5mm of supra-alveolar tooth structure is required to achieve 1.5mm ferrule.¹⁷
- ✓ The clinical implications of a crown lengthening procedure with the risk of damaging adjacent teeth should be evaluated against the biomechanical risks of a crown that does not have 360° ferrule.¹³
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LIMITATIONS OF FUNCTIONAL CROWN LENGTHENING

Exposing furcation → perio risk factor becomes high → is it worth it?



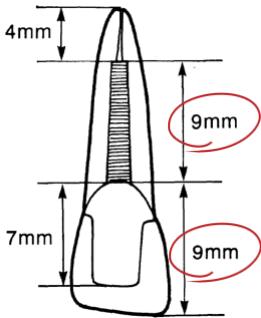
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EXPERIMENTAL MODELS OF IN-VITRO FERRULE STUDIES

- Fixed Dimensions -

<p>SORENSEN, JPD 1990⁴</p> 	<p>ZHI-YUE, JPD 2003⁵</p> <p>Table II. Tooth dimensions of each group (mm)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Group</th> <th>Root length</th> <th>Labiolingual</th> <th>Mesiodistal</th> </tr> </thead> <tbody> <tr> <td>Group A</td> <td>12.77 ± 0.86</td> <td>6.79 ± 0.41</td> <td>6.26 ± 0.49</td> </tr> <tr> <td>Group B</td> <td>12.86 ± 1.11</td> <td>6.87 ± 0.34</td> <td>6.28 ± 0.49</td> </tr> <tr> <td>Group C</td> <td>13.13 ± 1.24</td> <td>6.80 ± 0.43</td> <td>6.15 ± 0.55</td> </tr> <tr> <td>Group D</td> <td>12.98 ± 1.67</td> <td>6.85 ± 0.55</td> <td>6.05 ± 0.62</td> </tr> <tr> <td>F value</td> <td>0.566</td> <td>0.089</td> <td>0.279</td> </tr> <tr> <td>P value</td> <td>.641</td> <td>.965</td> <td>.840</td> </tr> </tbody> </table>	Group	Root length	Labiolingual	Mesiodistal	Group A	12.77 ± 0.86	6.79 ± 0.41	6.26 ± 0.49	Group B	12.86 ± 1.11	6.87 ± 0.34	6.28 ± 0.49	Group C	13.13 ± 1.24	6.80 ± 0.43	6.15 ± 0.55	Group D	12.98 ± 1.67	6.85 ± 0.55	6.05 ± 0.62	F value	0.566	0.089	0.279	P value	.641	.965	.840
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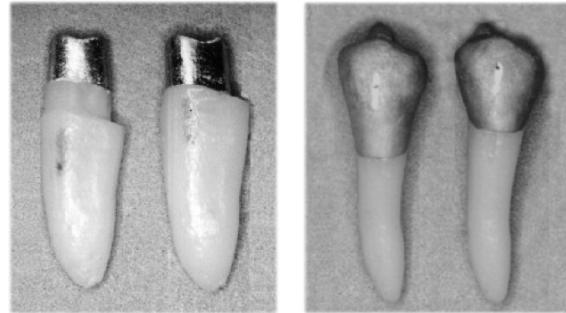
EXPERIMENTAL MODELS OF IN-VITRO FERRULE STUDIES

- Crown Lengthening Scenario (load-to-failure test) -

Tooth actually got weaker when you do cc lengthen to increase ferrule. Studies have dif conclusions tho

GEGAUFF, JPD 2000 ¹⁸

- ✓ The combination of simulated surgical crown lengthening and more apical crown margin placement to provide a 2-mm crown ferrule on a decoronated mandibular second premolar analog resulted in a reduction of static load failure for the restored analog tooth.



MENG, OD 2007 ¹⁹

- ✓ Crown lengthening with a 2.0 mm apical extended ferrule resulted in reduced fracture strengths for endodontically treated teeth restored using two dowel-core systems and cast metal crowns.

18. Gegauff AG. Effect of crown lengthening and ferrule placement on static load failure of cemented cast post-cores and crowns. *J Prosthet Dent.* 2000 Aug;84(2):169-79.
 19. Meng QF, Chen YM, Guang HB, Yip KH, Smales RJ. Effect of a ferrule and increased clinical crown length on the in vitro fracture resistance of premolars restored using two dowel-and-core systems. *Oper Dent.* 2007 Nov-Dec;32(6):595-601.

EXPERIMENTAL MODELS OF IN-VITRO FERRULE STUDIES

- Crown Lengthening Scenario (cyclic fatigue test) -

LIBMAN, IJP 1995 ²⁰

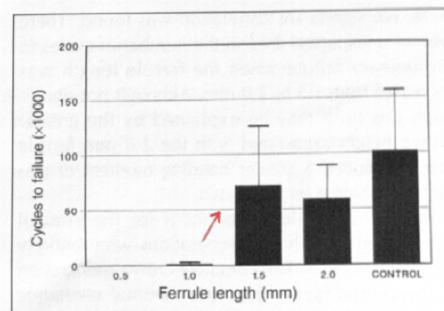
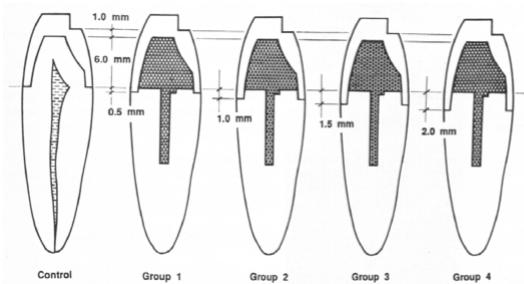
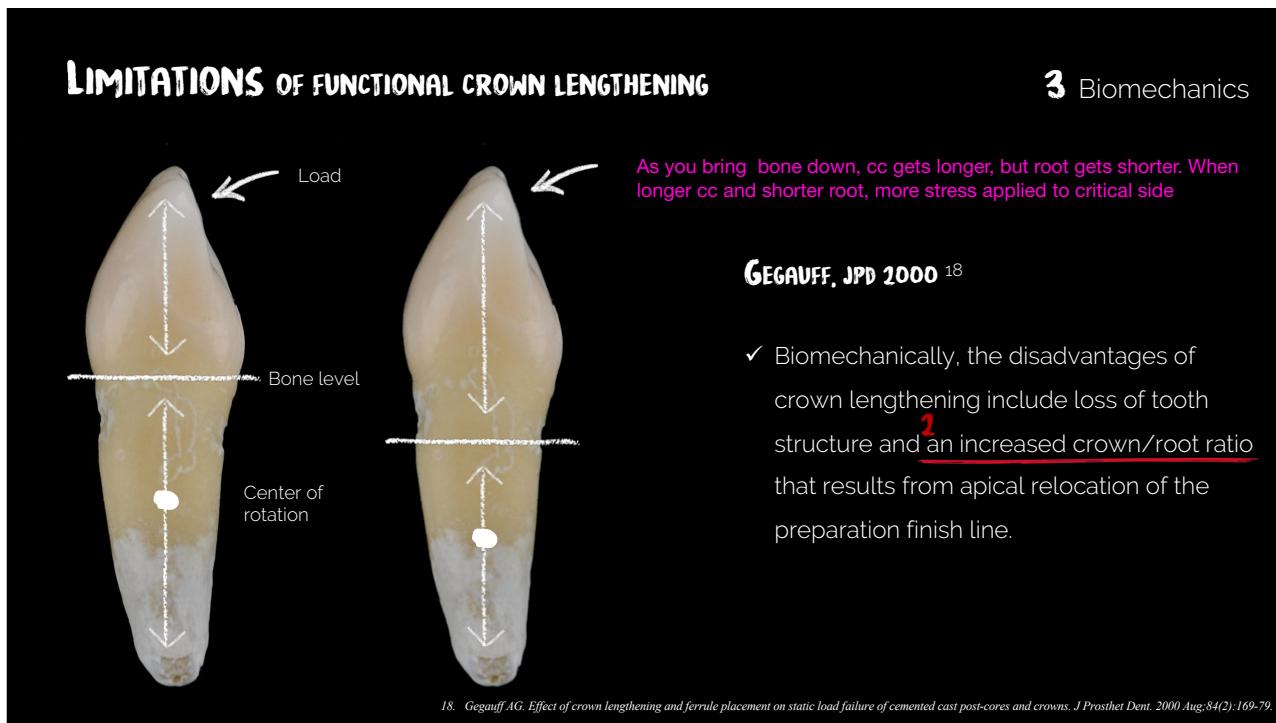


Fig 5 Number of load cycles to create preliminary failure.

- ✓ The results of this study showed that the 0.5 mm and 1.0 mm ferrule lengths failed at a significantly lower number of cycles than the 1.5 mm and 2.0 mm ferrule lengths and control teeth.

20. Libman WJ, Nicholls JI. Load fatigue of teeth restored with cast posts and cores and complete crowns. *Int J Prosthodont.* 1995 Mar-Apr;8(2):155-61.



CROWN / ROOT RATIO ?

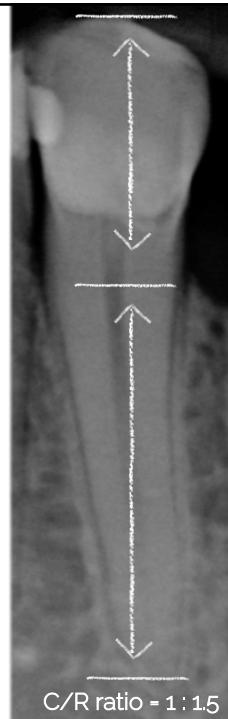
DEFINITION ²¹

- ✓ The ratio is defined as "the physical relationship between the portion of the tooth within the alveolar bone compared with the portion not within the alveolar bone, as determined radiographically."

NORMAL C/R RATIO ²²⁻²⁴

- ✓ Average – 1:1.29~1.89
- ✓ Maxilla – Canines > premolars, incisors > molars
- ✓ Mandible – Canines > premolars > incisors, molars
- ✓ Minimum acceptable ratio – 1:1 ?

21. Grossmann Y, Sadan A. The prosthodontic concept of crown-to-root ratio: a review of the literature. *J Prosthet Dent.* 2005 Jun;93(6):559-62
 22. Yun HJ, Jeong JS, Pang NS, Kwon IK, Jung BY. Radiographic assessment of clinical root-crown ratios of permanent teeth in a healthy Korean population. *J Adv Prosthodont.* 2014 Jun;6(3):171-6.
 23. Shillingburg HT. Fundamentals of fixed prosthodontics. 3rd ed. Chicago: Quintessence Pub. Co.; 1997. p. 85-103, 191- 202.
 24. Avila G, Galindo-Moreno P, Soehren S, Misch CE, Morelli T, Wang HL. A novel decision-making process for tooth retention or extraction. *J Periodontol* 2009;80:476-91.



CROWN / ROOT RATIO ?

You want to evaluate bone support for tooth

CONCEPT ²¹

- ✓ The crown/root ratio represents the biomechanical concept of Class I lever for evaluating abutment teeth.

LIMITATIONS ²¹

- ✓ The crown/root ratio is based on 1-dimensional linear measurements only. When evaluating abutment teeth, the clinician should assess the status of the alveolar bone height, root configuration and the total supported root surface of the abutment tooth.

PRACTICALITY ²¹

- ✓ The total remaining periodontal bone support provides more accurate information than the linear measurement of the ratio. The clinician should use the crown-to-root ratio only with other multiple clinical parameters, such as abutment mobility, total alveolar bone support, root configuration.

21. Grossmann Y, Sadan A. The prosthodontic concept of crown-to-root ratio: a review of the literature. *J Prosthet Dent.* 2005 Jun;93(6):559-62.

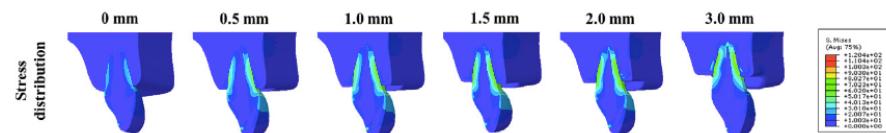
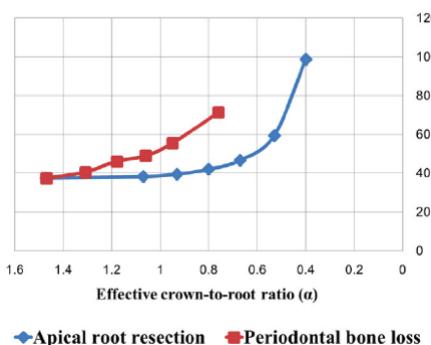
C/R ratio = 1 : 15

C/R RATIO & STRESS

Shorter root -> more stress transmitted to critical part

- ✓ Crown-to-root ratio influenced both the maximum stress and maximum tooth displacement.¹
- ✓ When 3mm of periodontal bone loss was indicated, the maximum stress increased by 90.6%.¹

Maximum von-mises stress (MPa)



25. Jang Y, Hong HT, Roh BD, Chun HJ. Influence of apical root resection on the biomechanical response of a single-rooted tooth: a 3-dimensional finite element analysis. *J Endod.* 2014 Sep;40(9):1489-93

LIMITATIONS OF FUNCTIONAL CROWN LENGTHENING

3 Biomechanics



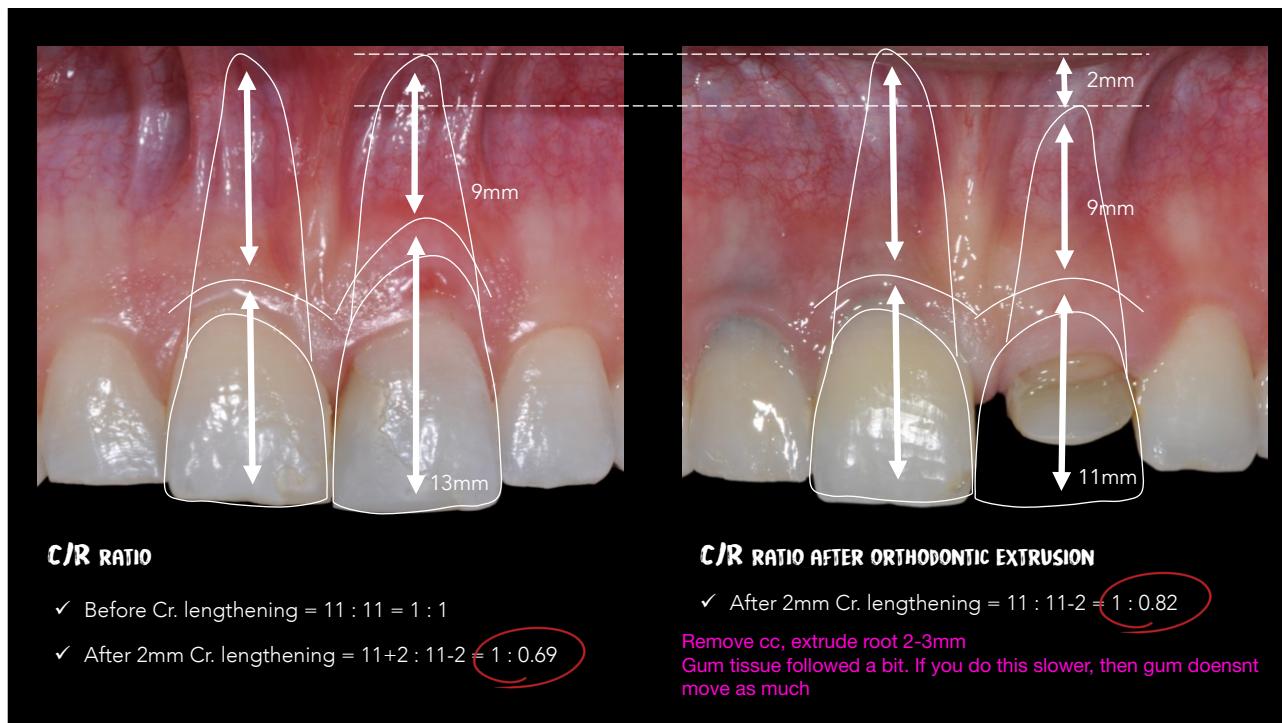
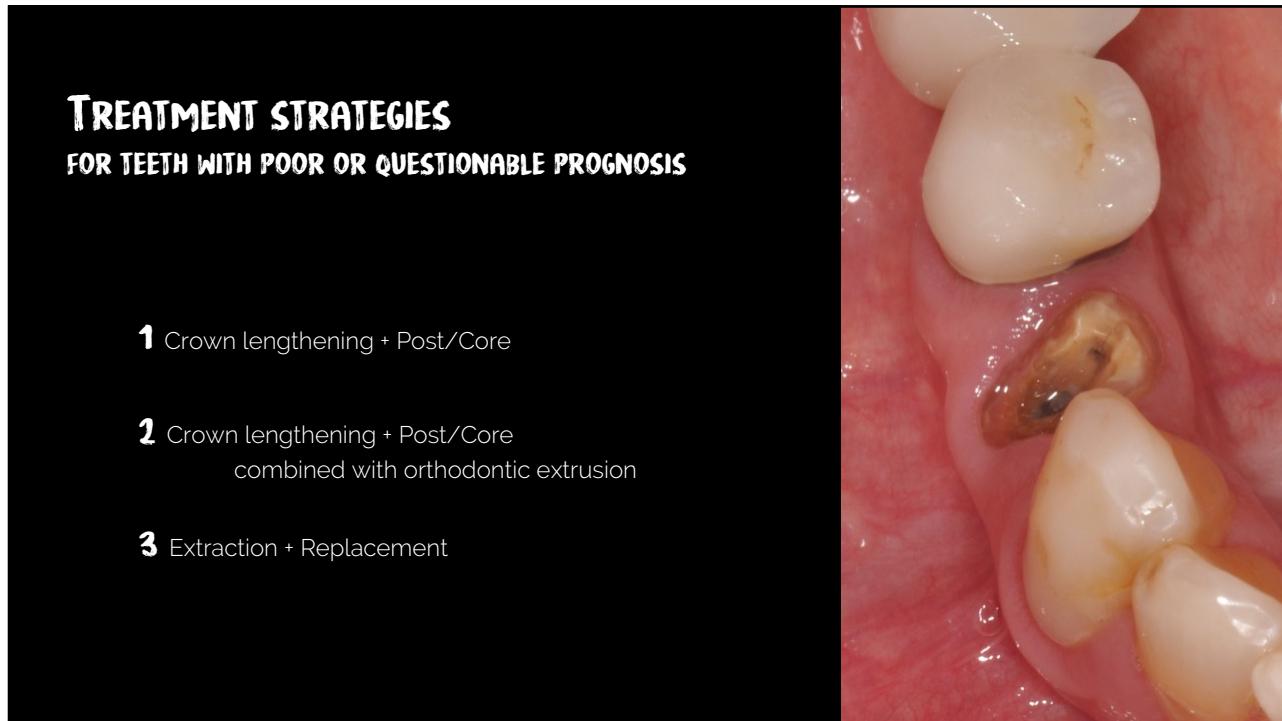
- ↑ Increased ferrule height
- + +
- ↓ Reduced ferrule width
- + +
- ↓ Unfavorable C/R ratio
- ||

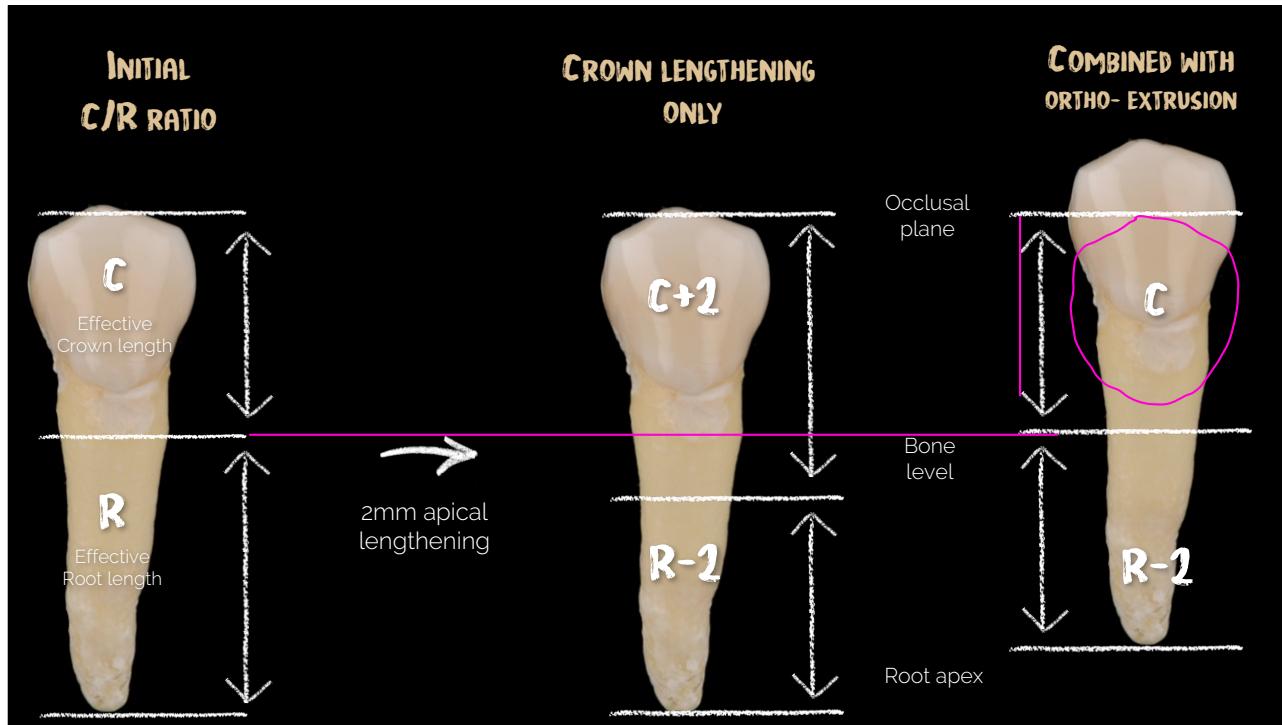
NET EFFECT ?
(+) -)

Risks from a mechanical point of view

- ✓ Although there is evidence that preserving as much coronal tooth structure as possible enhances prognosis, it is less clear whether the prognosis is improved by creation of ferrule in an extensively damaged tooth through a surgical crown-lengthening procedure.²⁶

26. Rosenstiel SF, Land MF, Fujimoto J. *Contemporary fixed prosthodontics: Fourth edition*. Mosby Inc.





EXPERIMENTAL MODELS OF IN-VITRO FERRULE STUDIES

- Crown Lengthening VS Forced Eruption -

MENG, AJD 2009²⁷

- ✓ Increased apical ferrule preparation lengths resulted in significantly increased fracture resistance for simulated forced tooth eruption, but not for simulated crown lengthening
- ✓ Surgical crown lengthening increases the crown portion of the fulcrum, with the root portion decreased and the center of rotation moved apically. However, forced tooth eruption only decreases the root portion of the tooth.

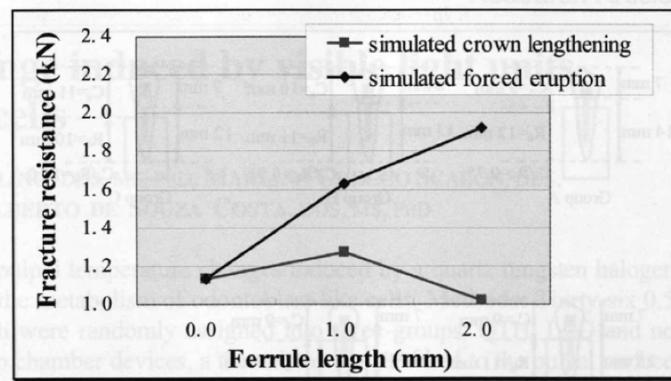


Fig. 3. Comparison of root fracture resistance for simulated crown lengthening and forced tooth eruption with different apical extended ferrule lengths.

27. Meng QF, Chen LJ, Meng J, Chen YM, Smales RJ, Yip KH. Fracture resistance after simulated crown lengthening and forced tooth eruption of endodontically-treated teeth restored with a fiber post-and-core system. Am J Dent. 2009 Jun;22(3):147-50.

LIMITATIONS OF FUNCTIONAL CROWN LENGTHENING

3 Biomechanics

- ↑ Increased ferrule height
- + +
- ↓ Reduced ferrule width
- + +
- ↓ Unfavorable C/R ratio
- " "

NET EFFECT ?
(+/-)

Depends on case selection

✓ Although there is evidence that preserving as much coronal tooth structure as possible enhances prognosis, it is less clear whether the prognosis is improved by creation of ferrule in an extensively damaged tooth through a surgical crown-lengthening procedure.²⁶

26. Rosenstiel SF, Land MF, Fujimoto J. Contemporary fixed prosthodontics: Fourth edition. Mosby Inc.

CASE SELECTION !!!

1 Expected ferrule width

- Root anatomy
- Crown preparation
- Endo. preparation

Narrow & Tapered
2mm cc lengthen compromised ferrule width

Wide & Straight
Cc lengthen – you can get some str

CASE SELECTION !!!

1 Expected ferrule width

- Root anatomy
- Crown preparation
- Endo. preparation



CASE SELECTION !!!

1 Expected ferrule width

- Root anatomy
- Crown preparation
- Endo. preparation



CASE SELECTION !!!

1 Expected ferrule width

- Root anatomy
- Crown preparation
- Endo. preparation



#11 has more tooth structure

CASE SELECTION !!!

1 Expected ferrule width

- Root anatomy
- Crown preparation
- Endo. preparation



#6

Not enough



#11

Maybe, right side better than left side



CONTROLLABLE RISK FACTORS FOR FRACTURES IN ENDODONTICALLY TREATED TEETH¹

ACCESS CAVITY PREPARATION

- ✓ The loss of structural tooth integrity associated with endodontic access preparation may lead to a higher occurrence of fractures in endodontically treated teeth.

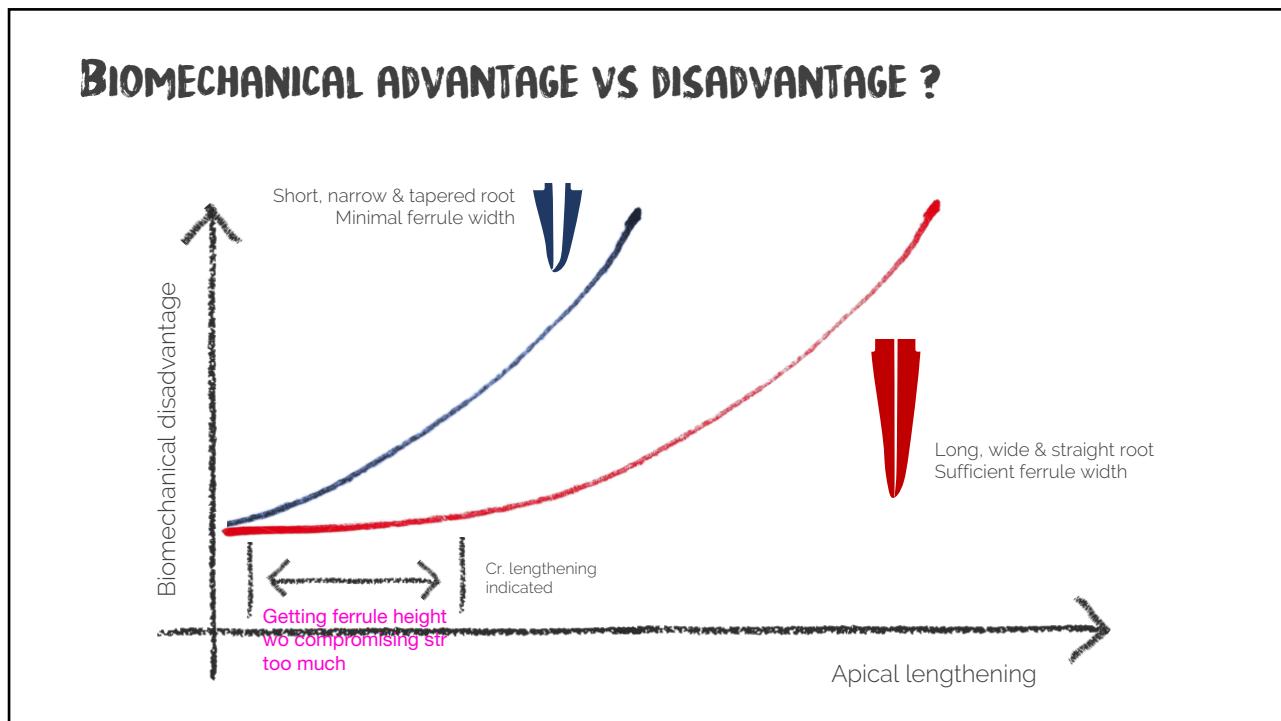
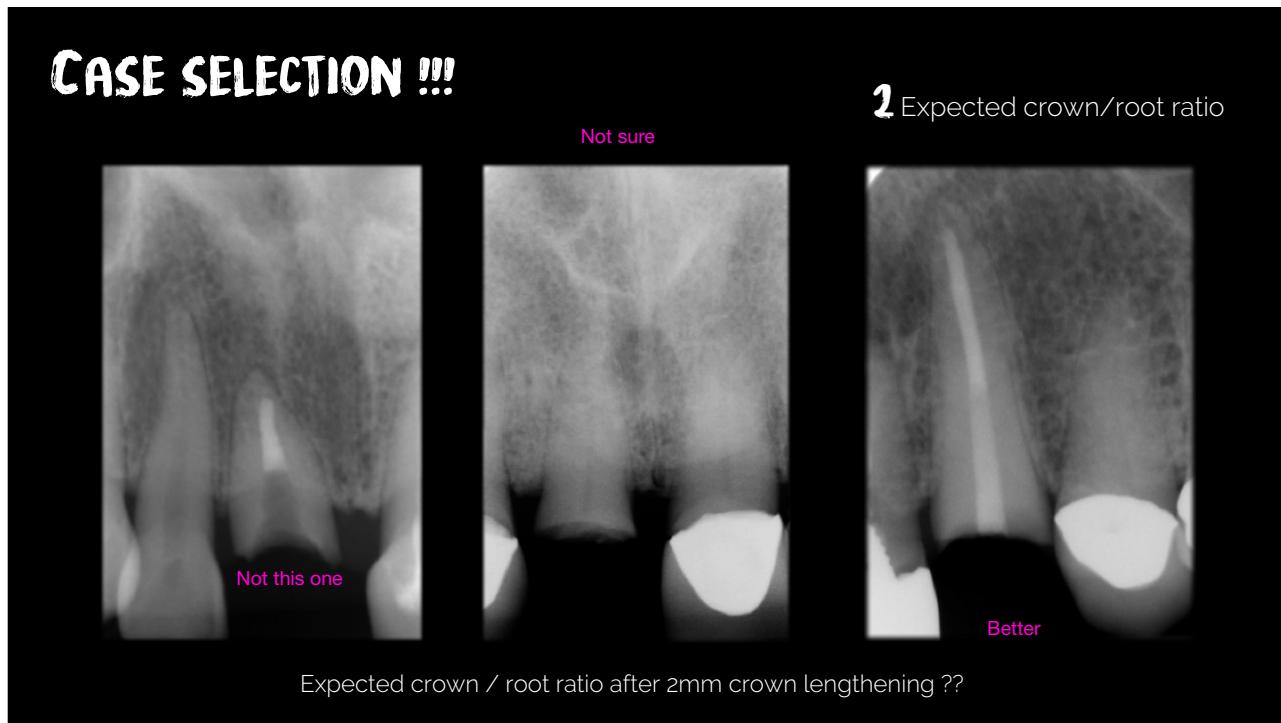
ROOT CANAL PREPARATION

- ✓ Overinstrumentation of root canals with excessive removal of dentin and the presence of noncircular canals and thin canal walls, particularly with certain tooth types, increase the risk of root fracture.

POST SPACE PREPARATION

- ✓ Posts do not usually strengthen roots. Excessive post-space preparations may result in reduced strengths and compromised apical endodontic seals and the risk of root perforations in premolar and mandibular incisors in particular.

28. Tang W, Wu Y, Smales RJ. Identifying and reducing risks for potential fractures in endodontically treated teeth. J Endod. 2010 Apr;36(4):609-17.



EXPERIMENTAL MODELS OF IN-VITRO FERRULE STUDIES

- Crown Lengthening Scenario (cyclic fatigue test) -

LIBMAN, IJP 1995²⁰

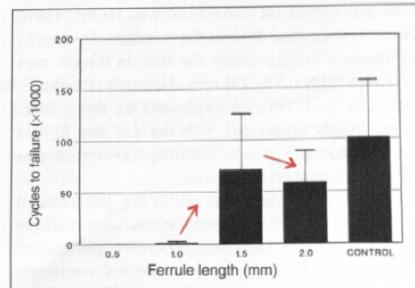
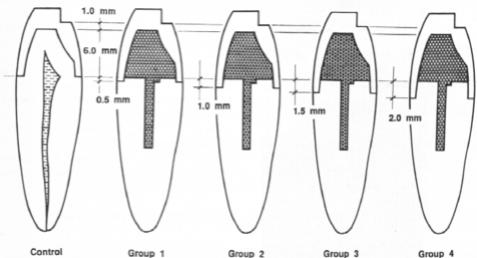


Fig 5 Number of load cycles to create preliminary failure.

- ✓ There was an unexpected drop in the number of cycles to preliminary failure when the ferrule length was increased from 1.5 to 2.0mm. Although not significant, this drop may be explained by the greater crown height associated with the 2.0mm ferrule that introduced a greater bending moment or dislodging moment on the crown

20. Libman WJ, Nicholls JL. Load fatigue of teeth restored with cast posts and cores and complete crowns. Int J Prosthodont. 1995 Mar-Apr;8(2):155-61.

PREDICTABILITY
ENVIRONMENTAL FACTORS
BENEFIT
CONSEQUENCE OF FAILURE

PRIMARY FACTOR



BIOMECHANICAL

Structural evaluation

- ✓ Remaining tooth structure
- ✓ Bone support (crown-root ratio)

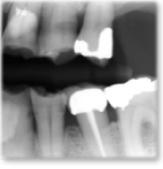
SECONDARY FACTORS



FUNCTIONAL

Functional and parafunctional stress

- ✓ Attrition
- ✓ Parafunction
- ✓ Occlusion
- ✓ Neuromuscular disorder



BIOLOGICAL

Biologic evaluation

- ✓ Periodontal disease
- ✓ Dental caries
- ✓ Xerostomia
- ✓ Acid erosion
- ✓ Other systemic diseases



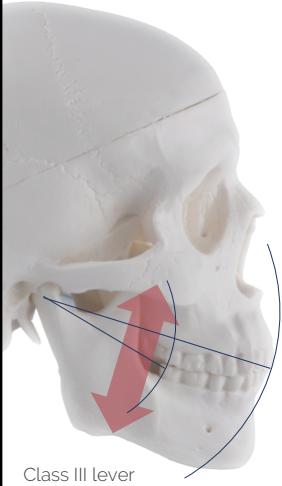
ESTHETIC

Dental & Dento-facial esthetic evaluation

- ✓ Tooth position
- ✓ Gingival contour
- ✓ Lip line
- ✓ Patient expectation

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

MAXIMUM OCCLUSAL FORCE ²⁹



- ✓ Incisors - 20~31N
- ✓ Canines - 26~27N
- ✓ Premolars - 89~92N
- ✓ Molars - 510~532N

OCCLUSAL FORCE - VERTICAL VS LATERAL

- ✓ The lateral forces contributes to greater damage to a tooth than axial load.¹⁵
- ✓ Lateral forces have a greater potential to damage the tooth-restoration interface when compared to vertical loads.¹³

29. Shinogaya T, Sodeyama A, Matsumoto M. Bite force and occlusal load distribution in normal complete dentitions of young adults. *Eur J Prosthodont Restor Dent.* 1999 Jun-Sep; 7(2):65-70.
 15. Arunpraditkul S, Saengsanon S, Pakviwat W. Fracture resistance of endodontically treated teeth: three walls versus four walls of remaining coronal tooth structure. *J Prosthodont.* 2009 Jan; 18(1):49-53.
 13. Jotkowitz A, Samet N. Rethinking ferrule—a new approach to an old dilemma. *Br Dent J.* 2010 Jul 10; 209(1):25-33.

How much force am i putting on restoration?

Is criteria for eval ferrule for dif teeth due to dif loads?

Direction of load - vertical and lateral. Dentin is resistant to vertical, but not so much lateral load.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

ANTERIOR TEETH



Mainly lateral force

- ✓ In anterior teeth, where the load is generally bucco-lingual and lacks the occluso-gingival force component, the location of the wall becomes crucial.
- ✓ An analysis of force distribution in different teeth shows that anterior teeth are loaded non-axially (= laterally).
- ✓ Maxillary anterior teeth are loaded from the palatal, mandibular anterior teeth are loaded from the buccal.

13. Jotkowitz A, Samet N. Rethinking ferrule—a new approach to an old dilemma. *Br Dent J.* 2010 Jul 10; 209(1):25-33.

PREDICTABILITY **ENVIRONMENTAL FACTORS** **BENEFIT** **CONSEQUENCE OF FAILURE**

POSTERIOR TEETH

Vertical and lateral force
Coming from everywhere

Fig. 5. Force vectors applied to molar on chewing. As depicted (difference in scaling on x and y axes), loading of teeth is roughly equal in axial and buccolingual directions.

A lot of vertical, some from lateral. Not as much lateral as anterior

13. Jotkowitz A, Samet N. Rethinking ferrule--a new approach to an old dilemma. *Br Dent J*. 2010 Jul;209(1):25-33.
30. Wiskott HW, Belser UC. A rationale for a simplified occlusal design in restorative dentistry: historical review and clinical guidelines. *J Prosthet Dent*. 1995 Feb;73(2):169-83.

FUNCTIONAL

- ✓ Most of the forces in the posterior segment of the mouth are occluso-gingival and bucco-lingual in nature.¹³
- ✓ As illustrated in Fig. 5, the intensity of occlusal forces along the buccolingual axis was roughly equal to their magnitude along the longitudinal axes of the teeth.³⁰
- ✓ During function, the teeth are actually "jiggled in several directions".³⁰

At this pt, there are no dif recommendations depending on location of tooth you're restoring?

But location of ferrule can be dif depending on tooth

PREDICTABILITY **ENVIRONMENTAL FACTORS** **BENEFIT** **CONSEQUENCE OF FAILURE**

INCREASED LATERAL LOAD

1 OCCLUSION

ANTERIOR TEETH

- ✓ Anterior teeth are exposed to relatively high lateral vectors of force. This becomes more significant in deep bite situations. (= restricted envelope of function)

POSTERIOR TEETH

- ✓ In posterior teeth, occlusal scheme patterns and cuspal heights significantly influence the type and direction of load that is applied to each tooth.
- ✓ Group function situations, especially when the buccal cusps of the maxillary teeth are long, generate higher lateral forces, when compared to canine guidance situations.
- ✓ Posterior teeth with high cusps translate higher lateral forces when compared to severely worn down teeth. Force vectors which have a significant lateral component, when cusps are present, may change into mainly vertical vectors once cusps are flattened.

- Depending on tooth position, what are situations w increased lateral load?
- Be more strict. Borderline tooth -> take tooth out so you can put in something stronger.¹³
- Anterior - deep bite situation is something you come across. Not necessarily increased lateral force -> check out chewing pattern. If you have horizontal chewing pattern, you have lots of lateral force.
- Restricted EOF: wear, fracture (tooth, resto, post and core), mobility
- Posterior - Canine guidance -> not much force if post disclude.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

INCREASED LATERAL LOAD

2 PARAFUNCTION

BRUXISM

- ✓ An oral habit consisting of involuntary rhythmic or spastic nonfunctional gnashing, grinding, or clenching of teeth, in other than chewing movements of the mandible, which may lead to occlusal trauma (GPT 9).

OCCULTAL FORCE DURING BRUXISM ³¹

Not chewing. This is bite down as hard as you can. Force you grind your teeth with is higher than this. Evidence of grinding seen everywhere else. Gotta be more strict about how much tooth structure you want.

- ✓ Up to 111.6% of daytime maximum bite force.
- ✓ These indicate that nocturnal bite force during bruxism can exceed the amplitude of maximum voluntary bite force during the daytime.

31. Nishigawa K, Bando E, Nakano M. Quantitative study of bite force during sleep associated bruxism. J Oral Rehabil. 2001 May;28(5):485-91.

4 unit bridge - 2 root supporting 4 teeth. Higher load than single tooth resto. So bridge abut can be overloaded, esp long span.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

INCREASED LATERAL LOAD

3 ABUTMENT OF FDP OR RPD

PROSTHETIC ABUTMENTS ²¹

- ✓ Abutment teeth of FDPs are subjected to higher than usual occlusal forces transmitted through the prosthesis. The clinicians must evaluate the abutment teeth carefully.
- ✓ Forces are transmitted to RPD abutment teeth by rests, guide planes and retainers.

STRUCTURALLY COMPROMISED TEETH AS ABUTMENTS ³²

- ✓ Abutments for FPDs and RPDs, that were endodontically treated had significantly higher failure rates than endodontically treated single crowns.

21. Grossmann Y, Sadan A. The prosthodontic concept of crown-to-root ratio: a review of the literature. J Prosthet Dent. 2005 Jun;93(6):559-62.

32. Sorensen JA, Martinoff JT. Endodontically treated teeth as abutments. J Prosthet Dent. 1985 May;53(5):631-6.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

INCREASED LATERAL LOAD

4 OTHER FACTORS



ATTRITION¹³

- ✓ Noteworthy wear faceting also implies the presence of high loads.
Excessive wear/pathologic: indicate load in that area is increased.
Chemical wear = not increased load. Its decreased pH in mouth.

DIETARY HABIT¹³

- ✓ Dietary habits may further increase the risk of failure.
Hard to evaluate

13. Jotkowitz A, Samet N. Rethinking ferrule--a new approach to an old dilemma. Br Dent J. 2010 Jul;209(1):25-33.

How strong are teeth? How much force put on tooth?

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

CAMBRA®

Caries Management By Risk Assessment
How long will you keep tooth you have right now?



RISK FACTORS FOR CARIES BASED ON HISTORY³³

1. Existing or recent history of caries
2. No dental visit in the past 6 months
3. Limited lifetime exposure to water fluoridation
4. Brushes once a day or less
5. Saliva reducing factors
6. Frequent (>3 times daily) snacking between meals
7. Health behavior risk indicator (smoking, eating disorder)
8. Low socioeconomic status and/or impaired cognitive ability
9. Low education level

RISK FACTORS FOR CARIES BASED ON CLINICAL EXAM³³

1. Medium or high S. mutans and Lactobacillus counts
2. Inadequate saliva flow by observation or measurement
3. Large number of filled teeth
4. Visible heavy plaque
5. Recession with exposed roots
6. Defective restorations with open margins
7. Fixed dental prostheses 7, 8 - caries risk increased
8. Removable dental prosthesis
9. Deep pit and fissures
10. Noncavitated lesions

33. Featherstone JD, Singh S, Curtis DA. Caries risk assessment and management for the prosthodontic patient. J Prosthodont. 2011 Jan;20(1):2-9.

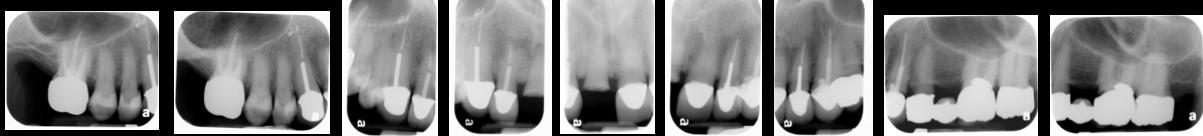



BIOMECHANICS OR BIOLOGY ?

Pt doesn't think her mouth is a problem. ~50% of teeth will have ferrule biomechanically. Periodontitis may be involved.

- ✓ CC: " My sister said I have bad breath "
- ✓ 68 years old, female
- ✓ Cognitive impairment
- ✓ Unemployed, Minimal social activity

He removed full arch xb + 22/27 implant. Biological consideration more important than biomechanical here. Extreme situation.




**BIOMECHANICS
OR BIOLOGY ?**

- ✓ CC: " My front tooth broke"
- ✓ 70 years old, male

 PREDICTABILITY
 ENVIRONMENTAL FACTORS
 BENEFIT
 CONSEQUENCE OF FAILURE

PERIODONTAL PROGNOSIS

- ✓ Based on the amount of attachment loss, residual probing depth or furcation involvement.³⁴
- ✓ This prognosis assessment is generally performed at different stages of periodontal therapy: first at base line, then during re-evaluation following the initial nonsurgical therapy and after the active phase of periodontal therapy, and then before the restorative treatment planning, including implant placement.³⁴

Implant - still have to worry about perio. Potential peri-implantitis even if hx periodontitis.

PERIODONTAL DISEASE AND IMPLANTS ?

- ✓ Active periodontitis - periodontitis subjects were at significantly higher risk for implant failure and marginal bone loss as compared with periodontally healthy subjects.³⁵
- ✓ History of periodontitis - patients previously suffered from periodontitis are more susceptible to peri-implantitis.³⁶

34. Zitzmann NU, Krastl G, Hecker H, Walter C, Waltimo T, Weiger R. Strategic considerations in treatment planning: deciding when to treat, extract, or replace a questionable tooth. *J Prosthet Dent.* 2010 Aug;104(2):80-91
 35. Safai SH, Palmer RM, Wilson RF. Risk of implant failure and marginal bone loss in subjects with a history of periodontitis: a systematic review and meta-analysis. *Clin Implant Dent Relat Res.* 2010 Sep;12(3):165-74.
 36. Dreyer H, Grischke J, Tiede C, Eberhard J, Schweitzer A, Toikkanen SE, Glöckner S, Krause G, Stiesch M. Epidemiology and risk factors of peri-implantitis: A systematic review. *J Periodontal Res.* 2018 Oct;53(5):657-681.

 PREDICTABILITY
 ENVIRONMENTAL FACTORS
 BENEFIT
 CONSEQUENCE OF FAILURE






DENTOFACIAL ESTHETIC EVALUATION & PATIENT EXPECTATION

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

BENEFITS OF TOOTH-BORNE RESTORATIONS OVER IMPLANT-BORNE PROSTHESES



Periodontal LIGAMENT Fewer COMPLICATIONS Lower ESTHETIC RISK Lower COST Less invasive PROCEDURES

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

PERIODONTAL LIGAMENT



Periodontal LIGAMENT

- ✓ The PDL is that soft, specialized connective tissue situated between the cementum covering the root of the tooth and the bone forming the socket wall.³⁷
- ✓ The PDL ranges in width from 0.15 to 0.38mm, with its thinnest portion around the middle third of the root.³⁷
- ✓ Physiologic mobility of teeth under axial load (central incisor)³⁸

Force (gram)	1	10	100	100
Movement (μm)	0.4	12	20	28

37. Nanci A, Somerman MJ. Ch 9. Periodontium. In: Ten Cate's Oral Histology.

38. Parfitt GJ. Measurement of the physiological mobility of individual teeth in an axial direction. J Dent Res. 1960 May-Jun;39:608-18.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

PERIODONTAL LIGAMENT & MASTICATION (PDL as a proprioceptor)

PERIPHERAL FEEDBACK CONTROL

- ✓ Masticatory forces can easily damage the teeth and the supporting tissues unless they are controlled precisely and effectively.³⁹

**1~3 closing stroke



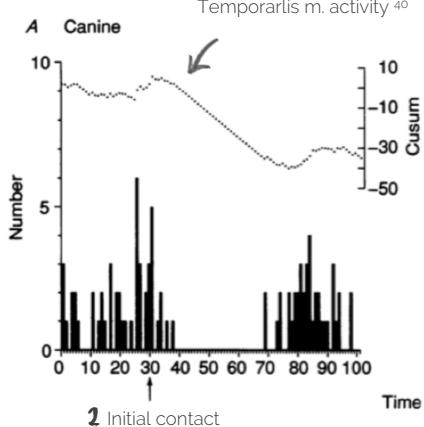
1 Closing (no contact) 2 Initial contact 3 Maximal intercuspal position

39. Türker KS, Sowman PF, Tuncer M, Tucker KJ, Brinkworth RS. The role of periodontal mechanoreceptors in mastication. Arch Oral Biol. 2007 Apr;52(4):361-4.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

PERIODONTAL LIGAMENT & MASTICATION (PDL as a proprioceptor)

A Canine Temporarlis m. activity⁴⁰



1 Initial contact

First initial contact, then hit canine -> sensory mechanism
So when upper and lower hit each other, bite force is not that high
(Sensory mechanism in PDL)

- ✓ Tooth tap stimuli induce a prominent inhibition of the jaw closing muscles by stimulating highly rate-sensitive, rapidly adapting periodontal mechanoreceptors.³⁹ **1**
- ✓ This reflex originates from vibration-sensitive muscle spindles in the jaw closing muscles, though the latency of this reflex appears shorter than the spindle mediated jaw jerk reflex.³⁹ **2**
Muscle feels some resistance

40. Bonte B, Linden RW, Scott BJ, van Steenberghe D. Role of periodontal mechanoreceptors in evoking reflexes in the jaw-closing muscles of the cat. J Physiol. 1993 Jun;465:581-94.
39. Türker KS, Sowman PF, Tuncer M, Tucker KJ, Brinkworth RS. The role of periodontal mechanoreceptors in mastication. Arch Oral Biol. 2007 Apr;52(4):361-4.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

PERIODONTAL LIGAMENT & MASTICATION (PDL as a proprioceptor)



- ✓ Osseoperception defined as mechanoreception in the absence of a functional periodontal mechanoreceptive input and it is derived from TMJ, muscles, cutaneous, mucosal, periosteal mechanoreceptors which provide mechanosensory information for oral kinaesthetic sensibility in relation to the jaw function and the contacts of artificial teeth.⁴¹
- No proprioception in implant.
- ✓ Studies of implant loading have reported sensory perception thresholds that are 10 to 100 times higher than those reported for natural teeth.^{42~45}
- ✓ Implants lack of a PDL and the ability to perceive functional load.⁴⁵

41. Bhatnagar VM, Karani JT, Khanna A, Badwaik P, Pai A. Osseoperception: An Implant Mediated Sensory Motor Control- A Review. *J Clin Diagn Res.* 2015 Sep;9(9):ZE18-20. Weiner S, Sirois D, Ehrenberg D, Lehrmann N, Simon B, Zohn H. Sensory responses from loading of implants: a pilot study. *Int J Oral Maxillofac Implants.* 2004 Jan-Feb;19(1):44-51.

42. Hämmrele CH, Wagner D, Brägger U, Lüssi A, Karayannidis A, Joss A, Lang NP. Threshold of tactile sensitivity perceived with dental endosseous implants and natural teeth. *Clin Oral Implants Res.* 1995 Jun;6(2):83-90.

43. Mühlbraudl L, Ulrich R, Möhlmann H, Schmid H. Mechanoperception of natural teeth versus endosseous implants revealed by magnitude estimation. *Int J Oral Maxillofac Implants.* 1989 Summer;4(2):125-30.

44. Jacobs R, van Steenberghe D. Comparative evaluation of the oral tactile function by means of teeth or implant-supported prostheses. *Clin Oral Implants Res.* 1991 Apr-Jun;2(2):75-80.

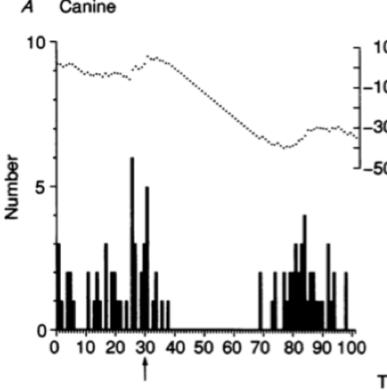
45. Schulte W. Implants and the periodontium. *Int Dent J.* 1995;45:16-26.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

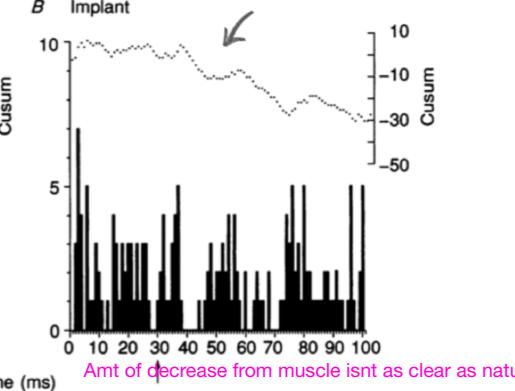
PERIODONTAL LIGAMENT & MASTICATION (PDL as a proprioceptor)



A Canine



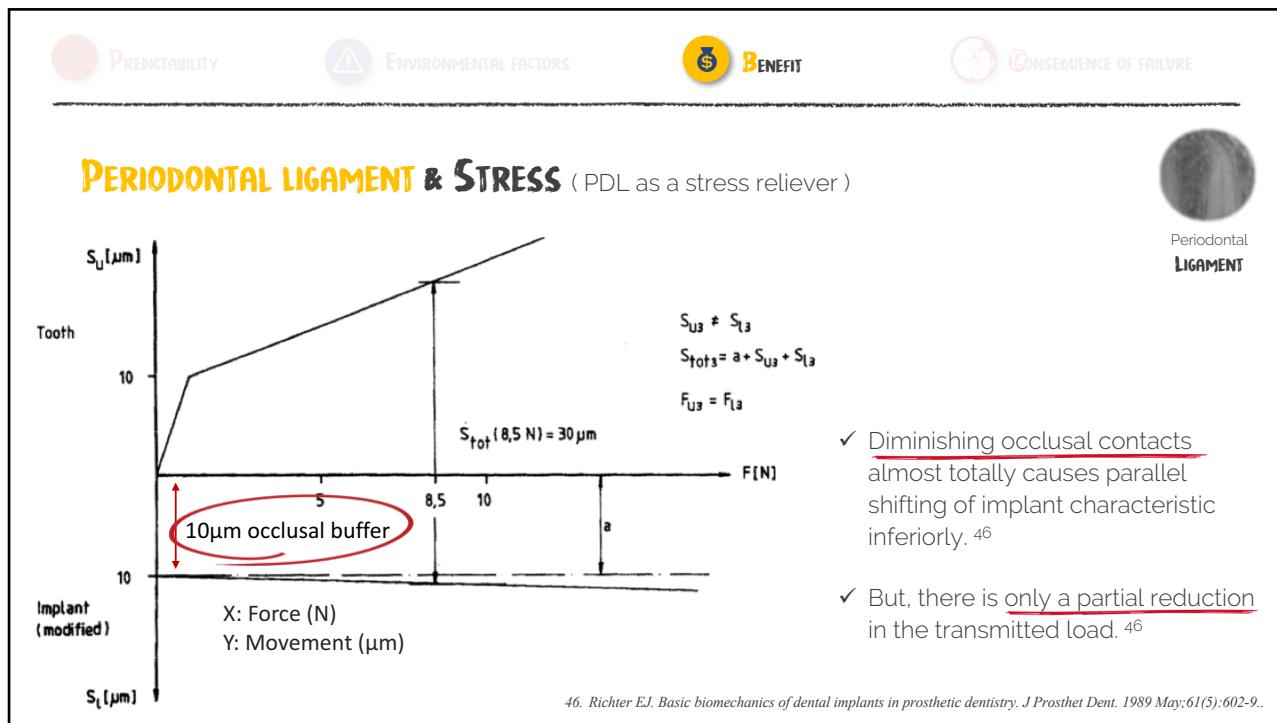
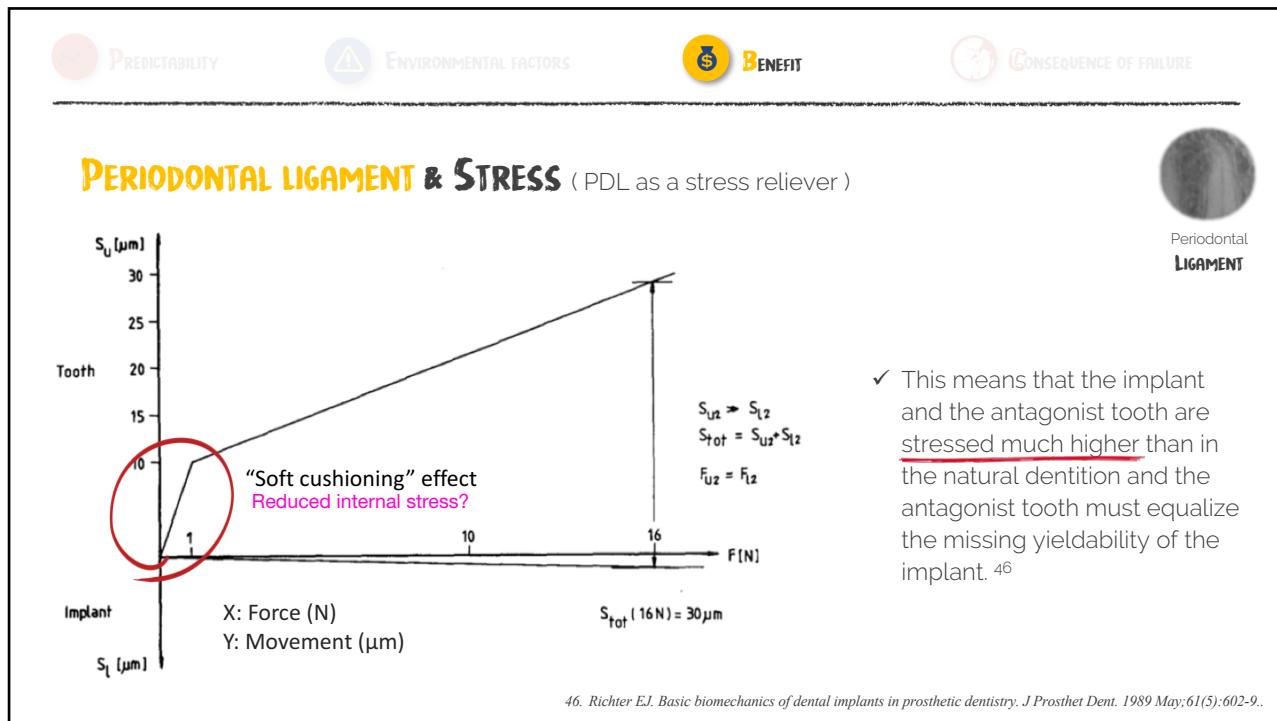
B Implant



Less steep reduction in muscle activity⁴⁰

Amt of decrease from muscle isn't as clear as natural dentition

40. Bonte B, Linden RW, Scott BJ, van Steenberghe D. Role of periodontal mechanoreceptors in evoking reflexes in the jaw-closing muscles of the cat. *J Physiol.* 1993 Jun;465:581-94.



 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

PERIODONTAL LIGAMENT & STRESS (PDL as a stress reliever)



NATURAL TEETH

- ✓ The PDL serves as a shock absorber and exhibits stress relaxation characteristics due to the adaptation of the PDL caused by extracellular fluid redistribution and the viscoelastic property of the ground substance in the periodontium.⁴⁷
- ✓ The periodontium under an axial load of 300g could dissipate the energy of 7.35×10^{-2} mJ and this is approximately 50 times higher than that of the dental implants.⁴⁷

IMPLANTS

- ✓ However, the degree of such phenomena was determined to be considerably lower for a dental implant than that of a natural tooth.⁴⁷
- ✓ Stress concentration may lead to mechanical failure in the long term.⁴⁷

47. Chang HH, Yeh CL, Wang YL, Huang YC, Tsai SJ, Li YT, Yang JH, Lin CP. Differences in the biomechanical behaviors of natural teeth and dental implants. Dent Mater. 2021 Apr;37(4):682-689.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

COMPLICATION RATES : IMPLANT COMPLICATIONS⁴⁸



Table I. Implant surgical complications

	Number of patients studied/affected	Mean incidence
Hemorrhage-related complications	379/92	24%
Neurosensory disturbance	2142/151	7%
Mandibular fracture	1523/4	0.3%

Table IV. Peri-implant soft tissue complications

	Number of implants placed/affected	Mean incidence
Fenestration/dehiscence	3156/223	7%
Gingival inflammation/proliferation	17,565/1,060	6%
Fistulas	11,764/117	1%

Table II. Implant loss

Arch/prostheses	Number of implants studied/lost	Mean incidence
Maxillary overdentures	1103/206	19%
Maxillary fixed complete denture	4559/443	10%
Maxillary fixed partial dentures	3297/213	6%
Mandibular fixed partial dentures	2567/157	6%
Mandibular overdentures	5683/242	4%
Mandibular fixed complete denture	9991/255	3%
Maxillary and mandibular single crowns	1512/42	3%

48. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. J Prosthet Dent. 2003 Aug;90(2):121-32.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

COMPLICATION RATES : IMPLANT COMPLICATIONS ⁴⁸

Table V. Mechanical Implant complications

	Number placed/affected	Mean incidence
Overdenture loss of retention/adjustment	376/113 prostheses	30%
Esthetic veneer fracture (resin)	663/144 prostheses	22%
Overdenture relines	595/114 prostheses	19%
Overdenture clip/attachment fracture	468/80 prostheses	17%
Esthetic veneer fracture (porcelain)	258/36 prostheses	14%
Overdenture fracture	570/69 prostheses	12%
Opposing prosthesis fracture	168/20 prostheses	12%
Acrylic resin base fracture	649/47 prostheses	7%
Prosthesis screw loosening	4501/312 screws	7%
Abutment screw loosening	6256/365 screws	6%
Prosthesis screw fractures	7094/282 screws	4%
Metal framework fractures	2358/70 prostheses	3%
Abutment screw fractures	13,160/244 screws	2%
Implant fractures	12,157/142 implants	1%

48. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. *J Prosthet Dent.* 2003 Aug;90(2):121-32.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

COMPLICATION RATES : SINGLE IMPLANTS VS ENDO-TREATED TOOTH

SINGLE IMPLANTS > ENDO-TREATED SINGLE TOOTH

- ✓ Dental implants were associated with about a 5-fold greater number of complications compared with restored RCT teeth.²
- ✓ Collectively, these data indicate that RCT teeth are not only associated with less postprocedural interventions than implants, but the restorations placed on these teeth are also associated with fewer complications when compared with single tooth implants.⁴⁹

2. Iqbal MK, Kim S. A review of factors influencing treatment planning decisions of single-tooth implants versus preserving natural teeth with nonsurgical endodontic therapy. *J Endod.* 2008 May;34(5):519-29.
49. Doyle SL, Hodges JS, Pesun IJ, Baisden MK, Bowles WR. Factors affecting outcomes for single-tooth implants and endodontic restorations. *J Endod.* 2007 Apr;33(4):399-402.

Despite survival rate, also consider complication rates.

More controversial w 3 unit bb.

 PREDICTABILITY
 ENVIRONMENTAL FACTORS
 BENEFIT
 CONSEQUENCE OF FAILURE

COMPLICATION RATES : IMPLANT VS SHORT-SPAN FDP

SINGLE IMPLANTS > FDP


- ✓ Success (= no complication) estimates were higher for tooth-supported FDPs than for implant single crowns.⁵⁰

SINGLE IMPLANTS < FDP


- ✓ Fewer complications with single dental implants compared with fixed partial dentures.⁴⁸

CONSTANTLY EVOLVING...


- ✓ The complication rates for the implant-supported single crown applied in this model were derived from studies published between 1999 and 2022 based on implant systems used in the early to mid 1900s. As most implant systems have changed in design, complication rates may now differ.⁵⁰

50. Flemmig TF, Beikler T. Decision making in implant dentistry: an evidence-based and decision-analysis approach. *Periodontol 2000*. 2009;50:154-72.
 48. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. *J Prosthet Dent*. 2003 Aug;90(2):121-32.

Quiz 1 - implant to preserve bone. But also esthetic.
 You can fix soft tissue esthetic w perio and ortho. You can get 80-90% of outcome you want. Implants are different.

 PREDICTABILITY
 ENVIRONMENTAL FACTORS
 BENEFIT
 CONSEQUENCE OF FAILURE

ESTHETIC OUTCOME OF IMPLANT THERAPY



- ✓ Esthetic failures in implant dentistry are known to outnumber mechanical failures, especially in the anterior dentition.²
- ✓ Esthetic failure⁴⁸
 : calculated from 7 clinical studies (493 implant crowns)
 : average esthetic failure : 10 %
- ✓ Failure to retain natural teeth and their subsequent replacement with implants can lead to unaesthetic results. The natural tooth restoration should be strongly considered when esthetic demands are of paramount significance.²

2. Iqbal MK, Kim S. A review of factors influencing treatment planning decisions of single-tooth implants versus preserving natural teeth with nonsurgical endodontic therapy. *J Endod*. 2008 May;34(5):519-29.
 48. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. *J Prosthet Dent*. 2003 Aug;90(2):121-32.

If you can keep tooth, achieving esthetic outcome is better (in most cases). But there are exceptions



EXCEPTIONS...



EXCEPTIONS...



Excessive lower incisor display

EXCEPTIONS...



EXCEPTIONS...

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

COST ?

(2006~2008 U.S. general practitioner average) ^{1,2}

SINGLE TOOTH RESTORATION	3-UNIT FDP	IMPLANT
Endodontic tx. Post & core Crown (PFM)	Extraction PFM retrainer & pontic High noble alloy	Extraction Implant placement Abutment + Crown
\$1,468 ~ 1,741	\$2,734	\$3,409

51. Christensen GJ. *Implant therapy versus endodontic therapy*. J Am Dent Assoc. 2006 Oct;137(10):1440-3.
 52. Christensen GJ. *Three-unit fixed prostheses versus implant-supported single crowns*. J Am Dent Assoc. 2008 Feb;139(2):191-4.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

COST-EFFECTIVENESS ?

COST-EFFECTIVENESS COMPARISON IN DENTISTRY

: Mathematical probabilistic model calculated based on

1. Initial cost
2. Survival probability (expected longevity) How long will it last? How happy are you with it?
3. Maintenance cost (complication rates and the cost associated with each complication)
4. Other factors
 - Effect on adjacent teeth
 - Insurance reimbursement
 - Patient satisfaction
 - Quality-adjusted longevity
 - etc....



 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

COST-EFFECTIVENESS ?

- SINGLE TOOTH RESTORATION -
(endodontic tx. + post&core + crown)



Lower COST

- ✓ More cost-effective than extraction & replacement.^{2, 53-54} E.g. replace w implant
- ✓ The restored implants are 70~400% less cost-effective than the restored endodontically treated teeth.²

2. Iqbal MK, Kim S. A review of factors influencing treatment planning decisions of single-tooth implants versus preserving natural teeth with nonsurgical endodontic therapy. *J Endod.* 2008 May;34(5):519-29.
53. Kim SG, Solomon C. Cost-effectiveness of endodontic molar retreatment compared with fixed partial dentures and single-tooth implant alternatives. *J Endod.* 2011 Mar;37(3):321-5.
54. Beikler T, Flemmig TF. EAO consensus conference: economic evaluation of implant-supported prostheses. *Clin Oral Implants Res.* 2015 Sep;26 Suppl 11:57-63.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

COST-EFFECTIVENESS ?

- SINGLE IMPLANT VS FIXED DENTAL PROSTHESIS -



Lower COST

<p>IMPLANT > FDP</p> <ul style="list-style-type: none"> ✓ Beikler et al. COIR 2015⁵⁴ (Europe) ✓ Goodacre et al. EJOI 2016⁵⁵ (US & Europe) ✓ Zitzmann et al. JDR 2013⁵⁶ (Europe) ✓ Vogel et al. IJOMI 2013⁵⁷ (US, Canada & Europe) ✓ Bouchard et al. COIR 2009⁵⁸ (Europe) 	<p>IMPLANT = FDP</p> <ul style="list-style-type: none"> ✓ Scheuber et al. COIR 2012⁵⁹ (US & Europe) 	<p>IMPLANT < FDP</p> <ul style="list-style-type: none"> ✓ Kim et al. JE 2011⁵³ (US)
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54. Beikler T, Flemmig TF. EAO consensus conference: economic evaluation of implant-supported prostheses. *Clin Oral Implants Res.* 2015 Sep;26 Suppl 11:57-63.
55. Goodacre CJ, Naylor WP. Single implant and crown versus fixed partial denture: A cost-benefit, patient-centred analysis. *Eur J Oral Implantol.* 2016;9 Suppl 1:S59-68.
56. Zitzmann NU, Krastl G, Weiger R, Kühn S, Sendt P. Cost-effectiveness of anterior implants versus fixed dental prostheses. *J Dent Res.* 2013 Dec;92(12 Suppl):183S-8S. Vogel R, Smith-Palmer J, Valentine W. Evaluating the health economic implications and cost-effectiveness of dental implants: a literature review. *Int J Oral Maxillofac Implants.* 2013 Mar-Apr;28(2):343-56.
57. Vogel R, Smith-Palmer J, Valentine W. Evaluating the health economic implications and cost-effectiveness of dental implants: a literature review. *Int J Oral Maxillofac Implants.* 2013 Mar-Apr;28(2):343-56.
58. Bouchard P, Renouard F, Bourgeois D, Fromentin O, Jeanneret MH, Berensniak A. Cost-effectiveness modeling of dental implant vs. bridge. *Clin Oral Implants Res.* 2009 Jun;20(6):583-7.
59. Scheuber S, Hicklin S, Brägger U. Implants versus short-span fixed bridges: survival, complications, patients' benefits. A systematic review on economic aspects. *Clin Oral Implants Res.* 2012 Oct;23 Suppl 6:50-62.
53. Kim SG, Solomon C. Cost-effectiveness of endodontic molar retreatment compared with fixed partial dentures and single-tooth implant alternatives. *J Endod.* 2011 Mar;37(3):321-5.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

POST-OPERATIVE PAIN & DISCOMFORT

Implant = invasive. Many complications esp in medical compromised pt

IMPLANT ⁶⁰

- ✓ Mild to moderate pain is expected after implant placement. (VAS 1~3)
- ✓ Some symptoms (swelling, bruising, bleeding, etc...) and limitations of daily activities (chewing, talking, sleeping, etc...) are expected in the first 3 days following implant placement.
- ✓ Additional procedures (extraction, hard/soft tissue augmentation, sinus lift ...)

ENDODONTICS ⁶¹

- ✓ Mild to moderate or mild to severe pain after endodontic treatment (VAS 1~5)
- ✓ When most individuals seek root canal therapy, pain is already present and is the most common reason for patient reporting to the dental office. A significant relationship exists between pre- and post-endodontic pain.
- ✓ Pre-treatment analgesic can reduce post-operative pain.

IMPLANT VS ENDODONTICS ²

- ✓ Implants evoke more surgical-induced pain/inflammation than endodontic treatments ¹

60. Sethi P, Agarwal M, Chourasia HR, Singh MP. Effect of single dose pretreatment analgesia with three different analgesics on postoperative endodontic pain: A randomized clinical trial. *J Conserv Dent.* 2014 Nov;17(6):517-21.
61. Hashem AA, Claffey NM, O'Connell B. Pain and anxiety following the placement of dental implants. *Int J Oral Maxillofac Implants.* 2006 Nov-Dec;21(6):943-50.
2. Iqbal MK, Kim S. A review of factors influencing treatment planning decisions of single-tooth implants versus preserving natural teeth with nonsurgical endodontic therapy. *J Endod.* 2008 May;34(5):519-29.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

COMPLICATIONS & CONTRAINDICATIONS OF IMPLANT THERAPY

SURGICAL COMPLICATIONS OF IMPLANT THERAPY ⁴⁸

- ✓ Swelling/Bruising
- ✓ Hemorrhage-related problems
- ✓ Neurosensory disturbance
- ✓ Mandibular fracture

SYSTEMIC CONTRAINDICATIONS OF IMPLANT THERAPY

ABSOLUTE CONTRAINDICATIONS ⁶²

- ✓ Recent myocardial infarction or cerebrovascular accident
- ✓ Recent valvular prosthesis replacement
- ✓ Bleeding disorder
- ✓ Immunosuppression
- ✓ Active cancer therapy
- ✓ Psychiatric disorders
- ✓ IV bisphosphonate

RELATIVE CONTRAINDICATIONS ⁶³

- ✓ Adolescence
- ✓ Smoking
- ✓ Uncontrolled diabetes
- ✓ Osteoporosis

48. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. *J Prosthet Dent.* 2003 Aug;90(2):121-32.
62. Hwang D, Wang HL. Medical contraindications to implant therapy: part I: absolute contraindications. *Implant Dent.* 2006 Dec;15(4):353-60.
63. Hwang D, Wang HL. Medical contraindications to implant therapy: Part II: Relative contraindications. *Implant Dent.* 2007 Mar;16(1):13-23.

PREDICTABILITY ENVIRONMENTAL FACTORS BENEFIT CONSEQUENCE OF FAILURE

BENEFITS OF TOOTH-BORNE RESTORATIONS OVER IMPLANT-BORNE PROSTHESES



Periodontal **LIGAMENT**

Fewer **COMPLICATIONS**

Lower **ESTHETIC RISK**

Lower **COST**

Less invasive **PROCEDURES**

PREDICTABILITY ENVIRONMENTAL FACTORS BENEFIT CONSEQUENCE OF FAILURE

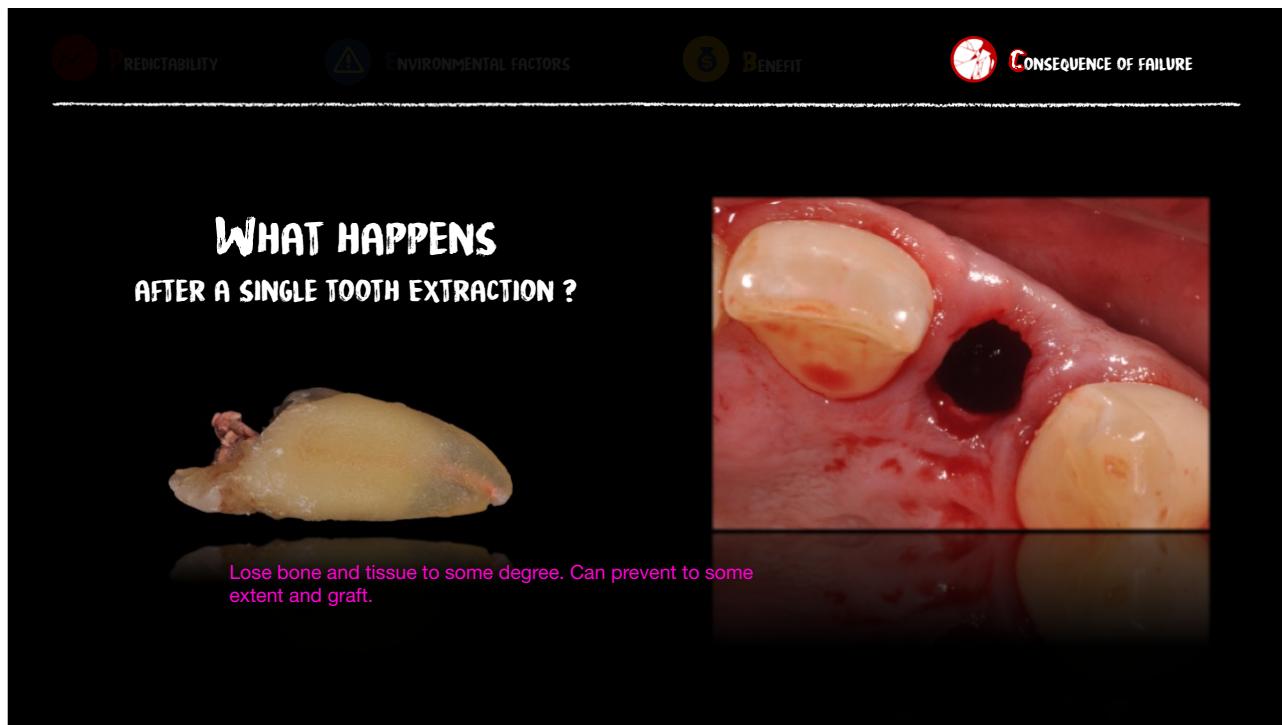
COMMON REASONS FOR FAILURE :

Restorations with post & core⁶⁴

- ✓ Post loosening (5%)
- ✓ Root/tooth fracture (3%)
- ✓ Caries (2%)
- ✓ Periodontal disease (2%)



64. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications in fixed prosthodontics. J Prosthet Dent. 2003 Jul;90(1):31-41.



 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

DIMENSIONAL ALTERATIONS OF THE ALVEOLAR RIDGE AFTER A SINGLE TOOTH EXTRACTION

Very manageable Likely soft tissue is mostly/all there.

- ✓ A ridge width reduction of up to 50% during the first year following tooth loss⁶⁶
- ✓ Volume loss of extraction site⁶⁷
 - Width : 2.6~4.5mm
 - Height : 0.4~3.9mm
- ✓ Bone graft⁶⁸
 - Even though attempts to preserve the ridge have failed to arrest inevitable biological process of dimensional ridge alterations post-extraction, studies have shown that grafting of extracted sockets with biomaterials and the use of barrier membranes is able to reduce the degree of dimensional alterations.³

66. Schropp L, Wenzel A, Kostopoulos L, Karring T. Bone healing and soft tissue contour changes following single-tooth extraction: a clinical and radiographic 12-month prospective study. *Int J Periodontics Restorative Dent.* 2003 Aug;23(4):313-23.
67. Ten Heggeler JM, Slot DE, Van der Weijden GA. Effect of socket preservation therapies following tooth extraction in non-molar regions in humans: a systematic review. *Clin Oral Implants Res.* 2011 Aug;22(8):779-88.
68. Chappuis V, Araújo MG, Buser D. Clinical relevance of dimensional bone and soft tissue alterations post-extraction in esthetic sites. *Periodontol 2000.* 2017 Feb;73(1):73-83.



 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

RISK FACTORS ?

THIN BIOTYPE

Lose more bone, cant fix soft tissue as well. Prob need xb + graft

- ✓ Direct correlation exists between gingival biotype and the susceptibility to gingival recession following surgical and restorative procedures.⁶⁹

DAMAGED / THIN BUCCAL BONE

- ✓ The amount of bone resorption often corresponds to the thickness of the surrounding bony walls.⁷⁰
- ✓ The frequency of advanced midfacial recession was high in patients with a damaged, thin buccal bone wall.⁷¹

69. Kan JY, Morimoto T, Rungcharassaeng K, Roe P, Smith DH. Gingival biotype assessment in the esthetic zone: visual versus direct measurement. *Int J Periodontics Restorative Dent.* 2010 Jun;30(3):237-43.
70. Kan JY, Rungcharassaeng K, Sclar A, Lozada JL. Effects of the facial osseous defect morphology on gingival dynamics after immediate tooth replacement and guided bone regeneration: 1-year results. *J Oral Maxillofac Surg.* 2007 Jul;65(7 Suppl 1):13-9. doi: 10.1016/j.joms.2007.04.006. Erratum in: *J Oral Maxillofac Surg.* 2008 Oct;66(10):2195-6.
71. Cosyn J, Hooghe N, De Bruyn H. A systematic review on the frequency of advanced recession following single immediate implant treatment. *J Clin Periodontol.* 2012 Jun;39(6):582-9.



 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

BRIDGE FAILURE? 64



64. *Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications in fixed prosthodontics. J Prosthet Dent. 2003 Jul;90(1):31-41.*

- ✓ ABUTMENT FAILURE
 - Secondary caries (18%)
 - Need for endodontic treatment (11%)
 - Periodontal disease (4%)
 - Tooth fracture (3%)

- ✓ PROSTHESIS FAILURE
 - Loss of retention (7%)
 - Esthetic (6%)
 - Prosthesis fracture (2%)
 - Veneering ceramic fracture (2%)

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

EXTRACTION OF MULTIPLE TEETH ?



- ✓ Extraction of multiple teeth is associated with significantly more bone remodeling compare to single tooth extraction sites.⁶⁵

- ✓ Bone remodeling was proportional to the number of contiguous teeth extracted. Vascular supply is compromised to a greater extent following extraction of multiple teeth.⁶⁶

- ✓ Reduced buccal and lingual bone thickness, bone-to-implant contact and vertical bone level were observed around implants in multiple contiguous extraction sites compared with those in a single extraction site.⁶⁶

65. Al-Shabeb MS, Al-Askar M, Al-Rasheed A, Babay N, Javed F, Wang HL, Al-Hezaimi K. Alveolar bone remodeling around immediate implants placed in accordance with the extraction socket classification: a three-dimensional microcomputed tomography analysis. *J Periodontol.* 2012 Aug;83(8):981-7.

66. Al-Rasheed A, Al-Shabeb MS, Babay N, Javed F, Al-Askar M, Wang HL, Al-Hezaimi K. Histologic assessment of alveolar bone remodeling around immediate implants placed in single and multiple contiguous extraction sites. *Int J Periodontics Restorative Dent.* 2014 May-Jun;34(3):413-21.

 PREDICTABILITY  ENVIRONMENTAL FACTORS  BENEFIT  CONSEQUENCE OF FAILURE

IMPLANTS PLACED IN THE SITES OF PREVIOUSLY FAILED IMPLANTS

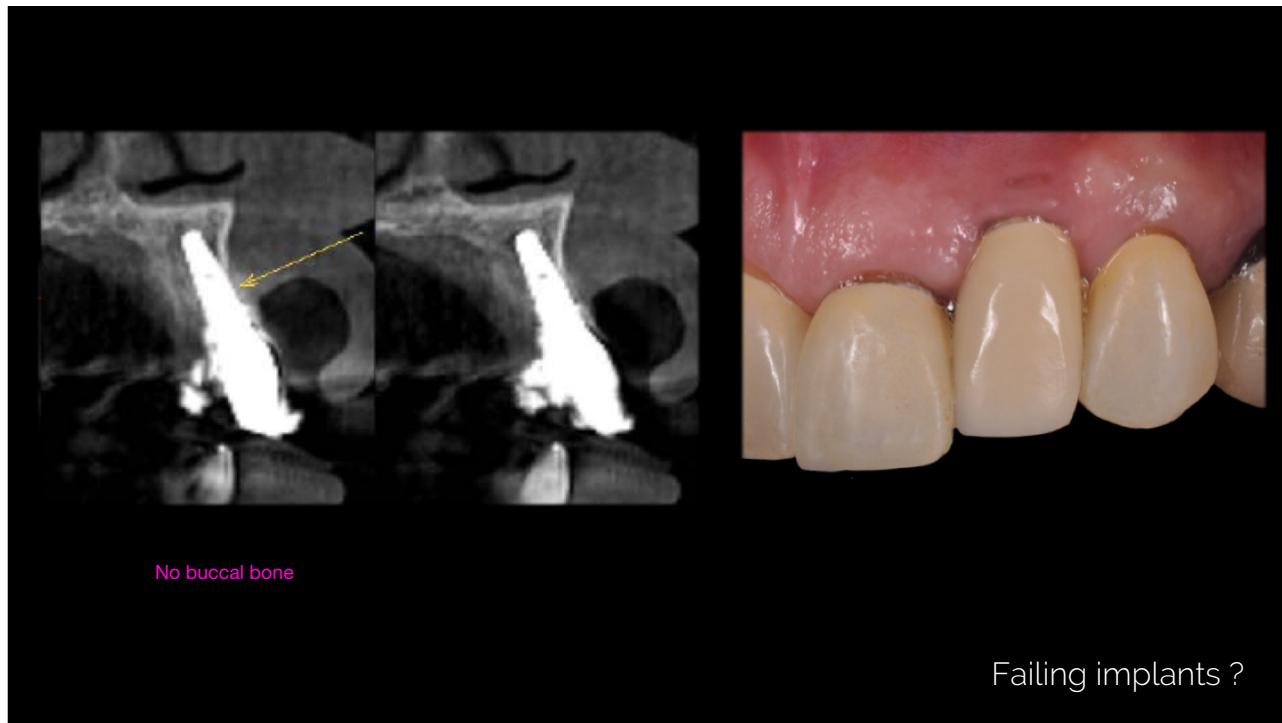
SURVIVAL RATE ^{3,67}

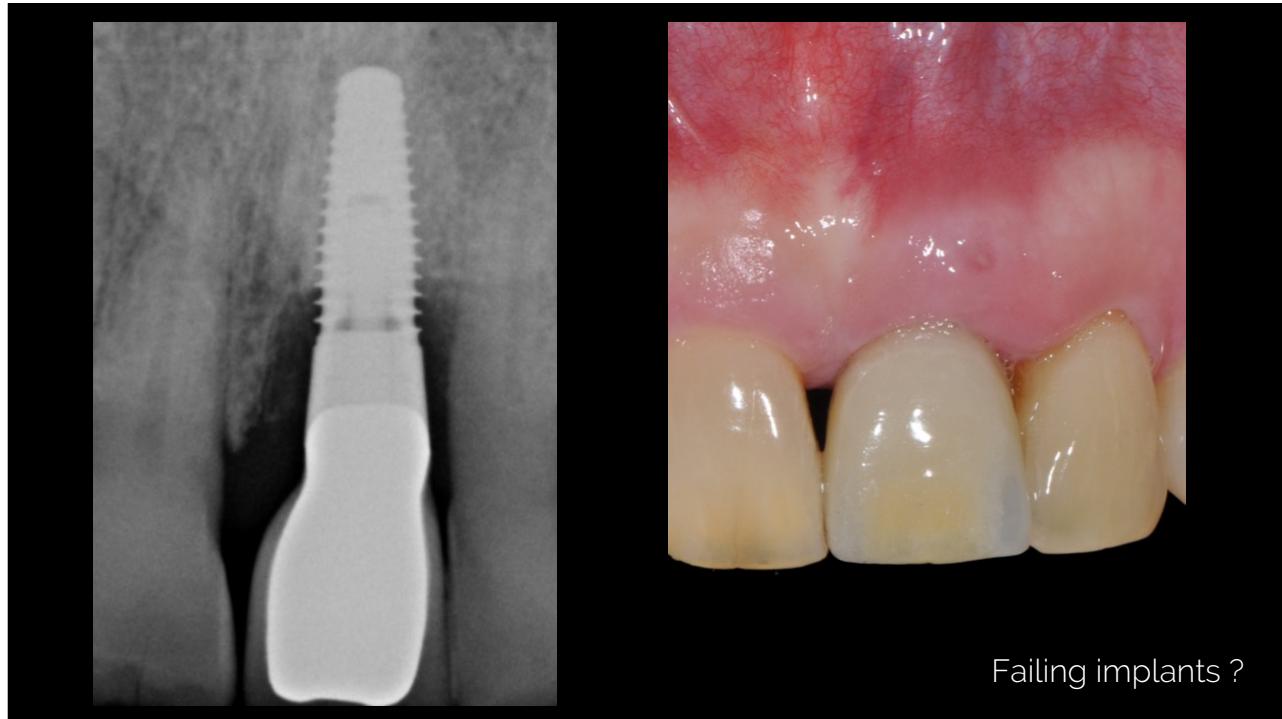
- ✓ 1st attempt : 97%
- ✓ 2nd attempt : 88.84% (average follow-up 3.5 yrs)
- ✓ 3rd attempts : 74.19% (average follow-up 2.5 yrs)
You can place implant again. But consider poor bone quantity and quality after failed implant.

POOR BONE QUANTITY & QUALITY ³

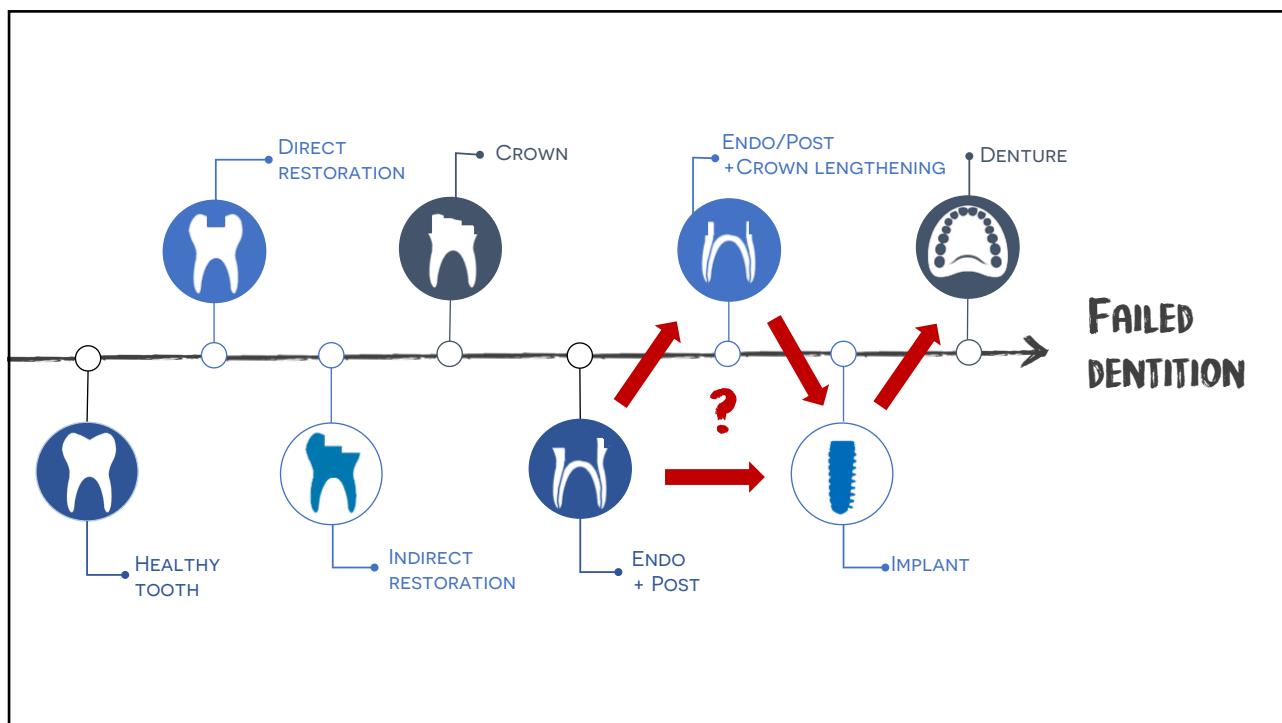
- ✓ Due to the poor bone quality/quantity, failed implant sites present a challenging therapeutic dilemma for clinicians.

67. Zhou W, Wang F, Monje A, Elnayef B, Huang W, Wu Y. Feasibility of Dental Implant Replacement in Failed Sites: A Systematic Review. *Int J Oral Maxillofac Implants*. 2016 May-Jun;31(3):535-45.
 3. Torabinejad M, Anderson P, Bader J, Brown LJ, Chen LH, Goodacre CJ, Kattadyl MT, Kuiseneko D, Lozada J, Patel R, Petersen F, Puterman I, White SN. Outcomes of root canal treatment and restoration, implant-supported single crowns, fixed partial dentures, and extraction without replacement: a systematic review. *J Prosthet Dent*. 2007 Oct;98(4):285-311.

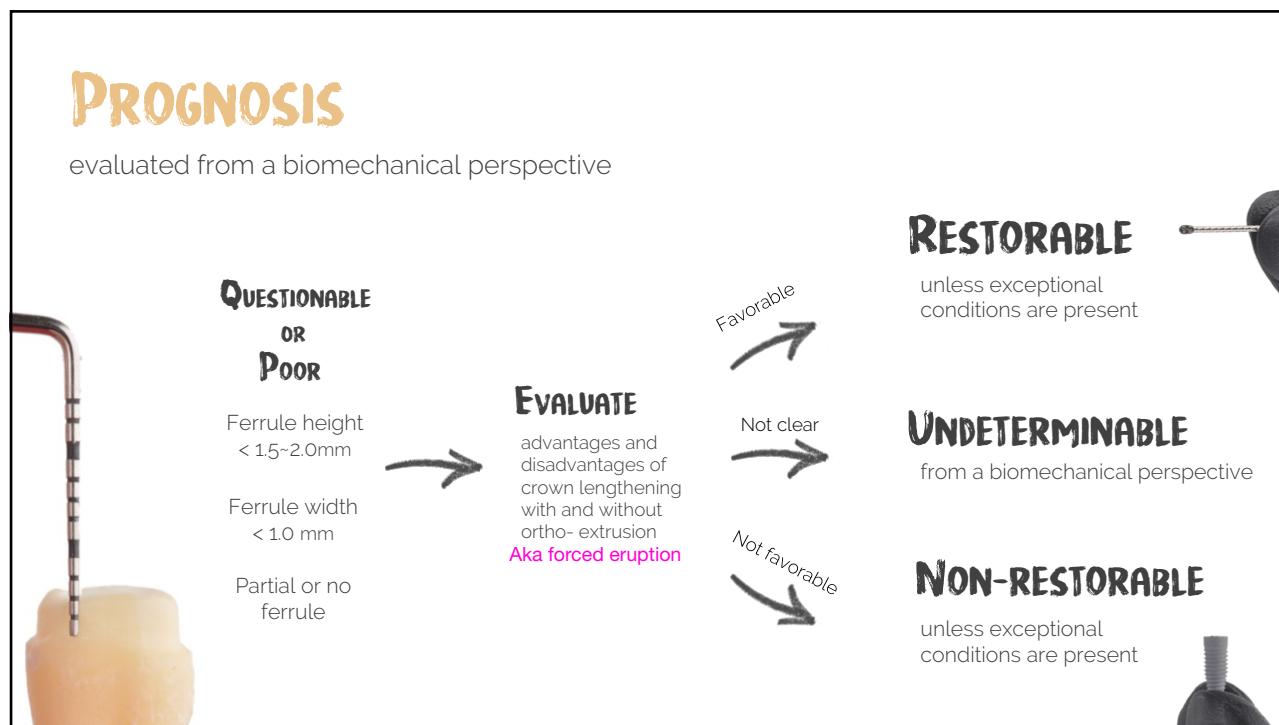
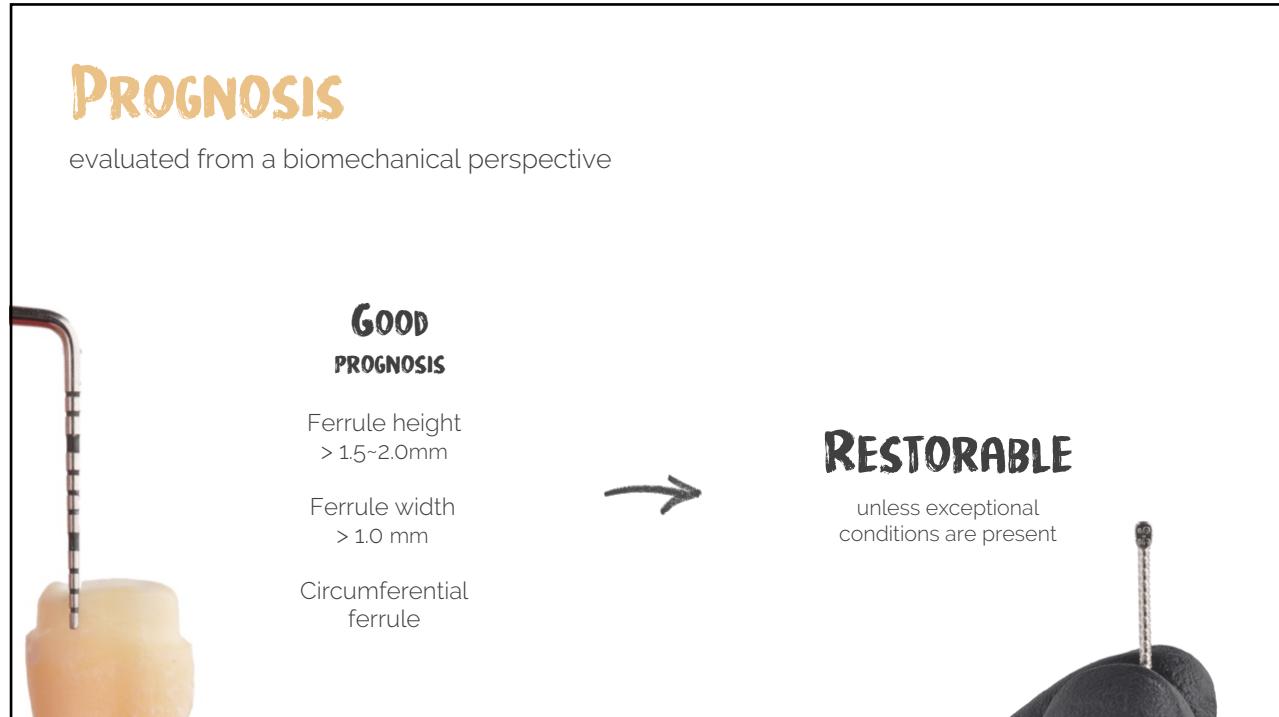





Once you take implant out, tissue goes down. Implant doesn't fail by itself



Being conservative is more important for young person.



CLINICAL DECISION MAKING

- RESTORE OR EXTRACT ? -



PREDICTABILITY



ENVIRONMENTAL
FACTORS



BENEFIT



CONSEQUENCE
OF FAILURE



80%
Most important!!

IF A CROWN HAS BEEN DETERMINED FEASIBLE....

- 1 Careful evaluation of the need for a post based on the remaining tooth structure's ability to retain the core.
 - If a post is necessary, determine a type, diameter & length of the post.
- 2 Minimally invasive post space preparation
- 3 Minimal tooth reduction for a restoration, especially cervical 1/3..

13. Jotkowitz A, Samet N. Rethinking ferrule—a new approach to an old dilemma. Br Dent J. 2010 Jul 10;209(1):25-33.