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## Rationale for Definitive Mini Dental Implant Treatment

--Manuscript Draft--

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<b>Abstract:</b>	<p>Mini dental implants can be used to support crowns and partial and complete dentures in compromised edentulous sites. Lack of bone width or site length may be treated with mini implants. Mini implants have less percutaneous exposure and displacement that may reduce complications. Nonetheless, mini implants transmit about twice the load to the supporting bone and thus control of occlusal loading is important. In fixed prosthetics, rounded flat cusps, splinting, implant protective occlusal schemes and only placement in dense bone sites are features of successful mini implant treatment. With removable prosthetics, multiple mini implants may be needed for appropriate retention and load resistance. Maxillary lateral incisor and mandibular incisor sites may be best suited for mini implant treatment.</p> <p>Caveat: Past research of dental implants has been directed at standard sized implants. While mini implants are dental implants, indeed, they behave somewhat differently under functional load and the clinician should be circumspect and very judicious in their use.</p>

# RATIONALE FOR MINI DENTAL IMPLANT TREATMENT

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Key words: dental implant; occlusal load; osseous resistance; off-axial load; percutaneous exposure.

## ABSTRACT

Mini dental implants can be used to support crowns and partial and complete dentures in compromised edentulous sites. Lack of bone width or site length may be treated with mini implants. Mini implants have less percutaneous exposure and displacement that may reduce complications. Nonetheless, mini implants transmit about twice the load to the supporting bone and thus control of occlusal loading is important. In fixed prosthetics, rounded flat cusps, splinting, implant protective occlusal schemes and only placement in dense bone sites are features of successful mini implant treatment. With removable prosthetics, multiple mini implants may be needed for appropriate retention and load resistance. Maxillary lateral incisor and mandibular incisor sites may be best suited for mini implant treatment.

Caveat: Past research of dental implants has been directed at standard sized implants. While mini implants are dental implants, indeed, they behave somewhat differently under functional load and the clinician should be circumspect and very judicious in their use. This article is a mini

review and not a systematic review. The topics covered are not pervasive since each would require a monograph or textbook for a complete discussion.

## INTRODUCTION

Mini implant dental treatment has become mainstream over the last several years (1). This modality can provide a better quality of life for many patients who in the past may have been considered unrestorable. Recent research has found small diameter implants may be as successful as standard diameter ( $>3.0\text{mm}$ ) implants when placed appropriately (1, 2).

Although there is no classification criterion for mini implants, generally an implant with a diameter equal to less than 3mm can be considered a mini implant (1).

Since economics may limit some patient's ability to afford treatment with standard diameter implants and mini implant treatment may be affordable for these patients. Mini implants and the associated instrumentation are much less expensive than standard diameter implants so there is a cost savings that makes treatment much more affordable.

Some patients have adverse feelings for grafting procedures. Mini implants may be able to support prosthetics in an atrophic site without osseous or soft tissue grafting.

Some clinicians may fear extensive surgical procedures. Mini implants may be placed without raising a mucoperiosteal flap in some conditions making the procedure less complex.

Nonetheless, an appropriate referral should be made if the treatment requires such.

Some patients retain an inordinate fear of dentistry. Since mini implant treatment can be much less invasive, the treatment may alleviate that fear. Because mini implants are much less invasive

mini implant treatment may facilitate or enable treatment for frail or medically compromised patients. Nonetheless, mini implants cannot be placed in all osseous sites.

The text herein is a short review of available evidence to delineate clinical parametric guidelines for mini dental implant treatment. This work cannot be a true systematic review or meta-analysis since the review criteria are not met.

## REVIEW OF LITERATURE

A search was made in The Cochrane Library, PROSPERO and PubMed using the search terms: mini implant OR small diameter implant AND systematic review. There were no results in The Cochrane Library due to the stringent criteria. PROSPERO search yielded 3 articles in progress, 2 deal with mandibular overdentures and 1 on pain on insertion of mini implants (Table 1). The PROSPERO articles had not yet passed review. 85 articles were found in PubMed. Articles on orthodontic temporary anchorage devices (TAD) were eliminated because these implants are under minimal load of 2-5N, used in the short term, generally very narrow and short, and not used for prosthetics. Articles on orthopedics, gynecology, pediatric dentistry and short implant length were eliminated as well. Additional articles were eliminated for patient reported outcomes, general reasons for implant failures, implants in children, technique issues, and ectodermal dysplasia. After these eliminations, 10 articles remained and these articles were reviewed for appropriate inclusion (Table 2). Most of these are evidence reports on mandibular overdenture outcomes, which are favorable.

During the review process of this work, an article was published that discussed the use of narrow diameter implants in “permanent” dental prosthetics and had not yet been entered into the search libraries (3). Nonetheless, only anterior single crowns and overdentures were covered. There was

no coverage of fixed partial and complete dentures. The evidence for fixed mini implant supported prosthetics is severely lacking.

No high-level credible studies were found on mini implants supporting fixed prostheses.

Nonetheless, the clinician may use mini implants to support fixed prostheses based on known physiologic parameters. These parameters are based on mechanical physiologic principles for successful outcomes and herein are discussed. However, the fact remains that use of mini implants requires significant clinical experience and training, these implants cannot be placed any every anatomical site.

#### OSSEOUS ATROPHY

Subsequent to extraction, bone atrophies and bone volume decreases. Generally, the facial cortical wall migrates to the lingual while the lingual cortex does not remodel to the facial (4). This remodeling sequence results a decrease of medullary bone and brings the facial and lingual cortices in close proximity. When the atrophy is severe the two cortices can be almost in contact with one another. This can create an optimal bone condition for mini implant placement. The two cortices are generally 1.5-2mm thick (4). A mini implant placed in such a situation is provided dense cortical bone support along its full length (Fig. 1,2,3). Thus, atrophic bone may not require extracortical grafting or ridge splitting and expansion to provide enough bone volume and density for appropriate mini implant placement and adequate osseous resistance to loading.

#### DENSITY VARIATION IN EDENTULOUS SITES

After extraction bone heals and remodels, these sites can have variable bone densities that may not impart adequate support for mini implants. The denser the bone then there will be better

support for a mini implant. Note the various radiographic densities in the panoramic orthopantograph (Fig. 4).

## FLAPLESS VS FLAPPED PLACEMENT

Mini implants are well suited to flapless placement, but the clinician should be well-aware of the underlying osseous contour to prevent dehiscence, fenestration or mal-position (5). Generally, the clinician can visualize bone contour on CBCT or by ridge mapping (6). Any defect encountered should be addressed before or during the implant placement. A defect can be grafted before implant placement if deemed necessary or possibly at implant placement time, but this would require a flap access to the underlying bone.

A site with atrophic bone that presents a knife edge may be reduced to provide a wider crest site for easier placement (Fig. 5). A mucogingival flap can be raised where that is full thickness at the crest and partial thickness at the facial. (Generally, a lingual flap may not be necessary for the experienced clinician.) The crestal bone is now exposed for visualization and reduction if necessary and the facial submucosa is available for engaging a suture that holds the flap intimately against the submucosa.

Flapless placement generally has better healing and fewer complications than flapped procedures (5). Nonetheless, there needs to be an assessment of the underlying osseous contour. This can be done by CBCT or ridge mapping. A ridge should be wide enough to accept the implant diameter and at least 1.8mm facial and lingual cortices (7). Thus, the thinnest acceptable ridge may be 3.6mm plus the diameter of the proposed implant unless the ridge is to be split and expanded.

## ANGIOGENESIS AND OSTEOGENESIS

Because the displacement of mini implants is small, there may less obstruction to angiogenesis and osteogenesis. One study in dogs found that large diameter implants were associated with less bone formation (8). Thus, larger diameter implants may impede new bone formation and small diameter implant may do less so. Bone remodeling may be inhibited as well (9).

#### FRICTIONAL HEAT DURING MINI IMPLANT PLACEMENT

One study found that there is substantial heat imparted to bone during seating of mini implants in dense bone (10). Since the thermal conductivity of titanium is about 70 times that of bone, the implant will absorb any frictional heat. However, a large implant has enough volume to absorb the heat and keep it away from the bone. A mini implant does not have the volume of a large diameter implant and thus becomes much hotter and liberates the heat back into the surrounding bone (10).

Irreparable osseous heat damage occurs after a 54 degree C temperature held for 2 minutes (11,12,13). Since the implant remains in the bone the hot implant can potentially damage the surrounding bone that can cause an early failure.

The implant drill may feel hot after an osteotomy, but the bone is not (14). An osteotomy drill is removed from the site and the heat is taken away as well. Thus, during mini implant placement in dense Type 1 bone, this author recommends irrigation of the implant to prevent any osseous thermal damage.

Blood and tissue fluid can provide lubrication during implant seating and vasculature can remove any generated heat (15). In the anterior mandible the blood supply mostly comes from the periosteum from the facial artery (16). The bone in the anterior mandible can be dense Type 1 bone which may create significant frictional heat. If the vasculature is not significant and there is

not much tissue fluid and the bone is dense then there may be significant heat generated from seating mini implants. Thus, seating mini implants in dense bone in the anterior mandible should be irrigated to prevent undue heat damage to the bone. Additionally, the rate of rotation should be less than 12 rpm and during seating there should “rest stops” to prevent undue heating.

#### PERCUTANEOUS EXPOSURE

Percutaneous exposure is much smaller with mini implants. The circumference of a 4mm implant is 12.56mm while a 2.5mm implant is 7.85mm. Empirically, the smaller circumference may reduce peri-implant epithelial attachment complications such as implant peri-mucositis or peri-implantitis. Long term complications may be reduced as well.

Adequate attached tissue or immovable mucosa should be surrounding mini implants just as with standard diameter implants (17). Augmentations can be accomplished via a multitude of techniques, including grafts that are free gingival, subepithelial, dermal allograft and others.

#### OCCLUSAL LOADING

Since mini implants are very narrow, the implant profile and displacement are smaller and thus impart a much larger load on the supporting bone. An off-axial load will impart 1.5-2.5 times the load imparted by a larger standard sized implant (18). Thus, occlusal loads must be controlled to prevent an over-load and subsequent failure. Narrow flat occlusal tables, rounded cusps, splinting and implant protective occlusal schemes are indicated. An anterior guided scheme for fixed restorations or lingualized occlusal schemes for removable dentures may be best. An appropriate occlusal scheme where the implants are protected from off-axial loads is extremely important.



The surface area of two 2.5mm mini implants is about equal to the surface area of a 5.7mm implant so two closely placed mini implants may be adequate to provide adequate osseous resistance to occlusal loads (Fig. 6). Two mini implants may be best used between two adjacent teeth to alleviate the functional loading. Nonetheless, the prudent clinician may test the patient for maximum bite force capability (19). There are three companies that sell oral bite load capacity devices: KUBE, Montreal, Canada and FUTEK, Irvine, California and Tekscan, South Boston, Mass. Any patient with an excessive capability may require an appropriately sized implant to resist occlusal loading and an occlusal scheme to protect from off-axial loads.

Natural teeth can be part of an arch being restored with implant supported crowns or fixed partial dentures. Natural teeth intrude up to 250 microns under functional loading (20). Implants may intrude up to 8 microns (20). If the implant supported prosthetics are not provided occlusal relief for this discrepancy, there is a risk of overloading the supporting implants. Occlusal relief up to 100 microns may be indicated to insure a long-term favorable outcome.

Mini implants are subject to lateral, off-axial loading which may cause metal fatigue. One study placed horizontal 200N cyclic loads on 2.5mm mini implants (21). Only a minority of implants fractured after over a million cycles. The 200N directly lateral load is excessive and unlikely in clinical situations. Nonetheless, the issue for success of treatment is not the strength of the implant but the ability of the supporting bone to resist the occlusal loading.

#### OPPOSING REMOVABLE COMPLETE DENTURES

The bite load capability of complete denture patients is much lower than dentate patients (22).

Thus, these patients may not be able to overload a mini implant supported crown or fixed partial

or complete denture. Nonetheless, occlusal load control can be instituted by using a lingualized or flat zero-degree occlusal scheme.

## TWO PIECE SYSTEMS

One-piece narrow diameter implants do well in appropriate sites, but those with screw retained abutments appear to suffer from a high rate of abutment screw fracture (23). When a 180N load was repeatedly placed against these types of implants most of the abutment screws fractured under this load. This may be important in the anterior maxilla where the mandibular anterior teeth would occlude directly off-axially to maxillary implant supported crowns. Nonetheless, patients who are not capable of generating such a load may not be subjected to abutment screw fracture.

## IMMEDIATE PLACEMENT

Mini implants can be placed in immediate extraction sites with appropriate a grafting procedure (Fig. 7,8,9) (24). Appropriate grafting procedures should be used just as with standard sized implants. Coverage of the surgical site with barrier membranes or primary closure may be best (24).

## MINI IMPLANTS RETAINING REMOVABLE DENTURES

Mini implants can successfully retain removable dentures, but implant retention will not “save” a case with an ill-fitting denture or inappropriate occlusal scheme. The removable denture should have a well-fitting intaglio and be stable. A lingualized or zero-degree flat occlusal scheme may be best for removable dentures (25).

Since mini implants retaining removable dentures are immediately loaded these parameters should be met before implant placement. For immediate loading of mini implants retaining removable dentures, the seating torque should be a minimum of 32ncm (26).

Generally, the retention of 4 mini implants is not as retentive as a 2 implant Locator<sup>tm</sup> type scheme (Fig. 10). More than 4 mini implants can be placed for increased retention, but anatomical conditions may prevent additional implant placements.

Placing multiple implants in the maxilla for retention of a complete maxillary removable denture can be done. Maxillary bone generally may not be appropriate for mini implant treatment. Less dense bone can be compressed. The clinician should seriously consider placing as many implants as space and the anatomy allows. This distributes the load over as many implants as possible. While an implant length does not contribute as much load resistance as an implant diameter, every advantage should be taken, so it may be best to use a long as implant as anatomically possible. It may be best to space the implants at 8mm (27).

The clinician should evaluate each implant for initial stability. The stability should be “rock hard”. This can be done by tapping the implant and the clinician “sensing” the stiffness and stability, or commercial stability devices are available. The appropriately placed mini implant should feel “rock-hard-solid”. The clinician should not expect a non-rock-hard-solid implant to “tighten” with bone healing. Commercially available stability measurements devices may have not been calibrated for mini implants so the clinician should consult the manufacturer. Any implant that is not at high stability should be removed and repositioned in a site with more dense bone.

## FIXED CROWNS AND PARTIAL DENTURES

Mini implants can support single crown and partial and complete fixed restorations, but the occlusal loading must be controlled (Fig. 11,12,13,14,15,16). Off axial forces may cause overloading and failure (28, 29).

Standard, off-the-shelf, coping abutments can be used in a telescoping technique for fixed crowns and partial dentures. The abutments are placed on the implants, temporarily linked together with fast-set bis-acryl to prevent movement and picked-up in an over-impression for direct laboratory fabrication of a telescoped crown or fixed retainers.

## COMPLICATIONS

Systemic factors can influence the clinical outcomes of dental implant treatment, mini or standard (30). While many studies show the well-controlled diabetics can have successful implant treatment. Nonetheless, long-term outcomes may be fraught with local complications due to the disease itself or the medications used to treat that disease (30, 31). Implants in these patients should be carefully monitored for soft tissue and bone levels. Because mini implants are so much less invasive with low percutaneous exposure and displacement there may be less risk for long-term complications in these patients. A thorough health history is needed to make the clinician aware of any adverse systemic conditions and the associated medications that may affect healing and bone remodeling.

Adequate attached tissue or immobile soft tissue is needed to prevent muscle pulls from stressing the epithelial attachment (32). Bone loss can occur if there is inadequate protection from this. Late loss of attached or immobile tissue can occur and be prevented or corrected with an augmentation procedure.

There have been no reports of fracture on seating mini implants or any other implants that were found by this author. Nonetheless, an anecdotal radiographic demonstrates that it may be possible to fracture a mini implant if it is fatigued. After several attempts at seating a mini implant did indeed fracture (Fig.17). It may be best to discard a mini implant after 3 attempts at seating in very dense Type 1 bone. Alternatively, it may be best to re-drill an osteotomy if the implant does not readily seat to the desired depth on the first attempt.

After some time of function with implant supported crowns and dentures, the mesial natural tooth may move to the mesial creating a small gap. This may cause caries to form just below the previously established interproximal contact area (Fig. 18). Of course, this should be restored with conventional restoratives and the patient made aware of this phenomenon.

Mini implant supported crowns and dentures should be cemented with insoluble luting agents. Resin cements are generally the appropriate choice. Soluble cements should be avoided because of the potential for retainer loosening. The crown or fixed denture could loosen from loss of purchase. Crowns can be recemented but if one retainer of a fixed denture loosens from cement dissolution, then the still-cement-retained retainer/s may undergo repeated rotation or lifting under occlusal loading and cause a loss of integration or overload and failure (Fig. 19).

Any implant placed in the anterior mandible can sever the sublingual artery that can subsequently retract into the floor of the mouth creating a significant hematoma (16, 33).

## FOOD AND DRUG ADMINISTRATION

The Food and Drug Administration in 2010 has classified 510(k) mini dental implants for “long term use” (33). Thus, mini dental implants may be used to support or retain dental prostheses.

With off label use, mini implants may be used with a guarded prognosis.

## CONCLUSIONS

Since most research in oral implantology has been directed at standard sized implants, there are large lacunae in the knowledge base for mini implant treatment (33). There needs to be research directed at mini implant technology. While there are similarities with standard diameter implants, the clinical performance of small diameter implants in oral rehabilitation needs to be elucidated.

Mini implants cannot be placed in just any anatomical site. The clinician needs to be aware of the osseous and soft tissue features of a prospective site, the patient's bite force capability, esthetic expectations, appropriate occlusal schemes and treatment of complications. Complications can occur and should be addressed early.

Indications for mini implant treatment include inadequate site length or width, atrophic bone, medical issues, fragility, financial hardship, patient declination of grafting, and patient fear of surgery. Maxillary lateral incisor and mandibular incisor sites may be most amenable for mini implant restoration due space limitations, favorable bone density and decreased occlusal force impartment.

Caveat: There are multiple randomized controlled trails of standard sized dental implants. Mini implants have not enjoyed such attention. There is a dearth of randomized controlled trials on the clinical behavior of mini implants. Mini implants may not withstand an occlusal load as well as a standard-sized implants and this should be addressed by using multiple implants, limiting their use to dense bone and controlling the occlusal loading. Therefore, the clinician should use prudent clinical judgement in the use of mini dental implants. This article is a short review and the topics covered are not in-depth since each would require a monograph or textbook for a complete discussion.

## GUIDELINES FOR MINI IMPLANT TREATMENT

Be aware of the osseous contour before placement especially for flapless treatment.

Place only in Type 1 and 2 bone sites and be certain of excellent initial stability.

Irrigate during seating to prevent overheating.

Insure adequate soft tissue protection of the epithelial attachment with attached tissue or immovable mucosa.

Control off-axial loading with an appropriate occlusal scheme and occlusal design.

Maintenance is imperative.

Complications should be addressed expeditiously.

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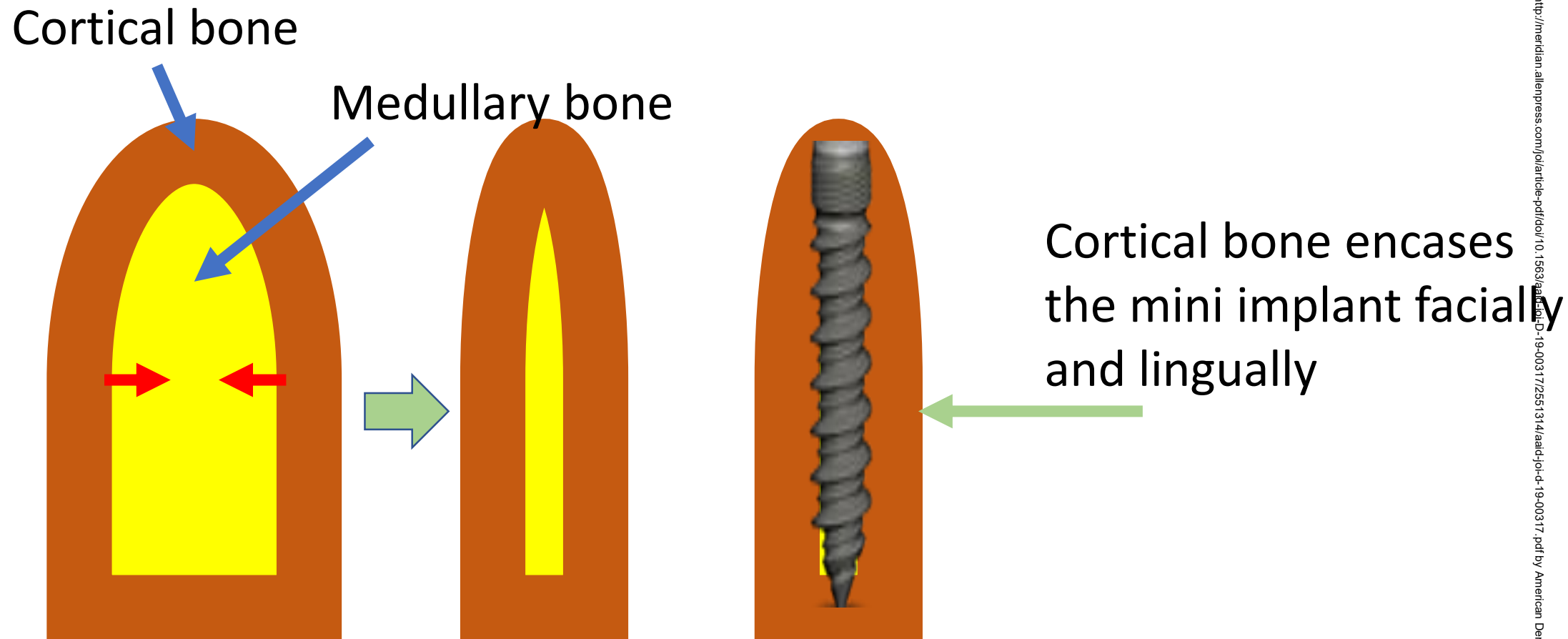
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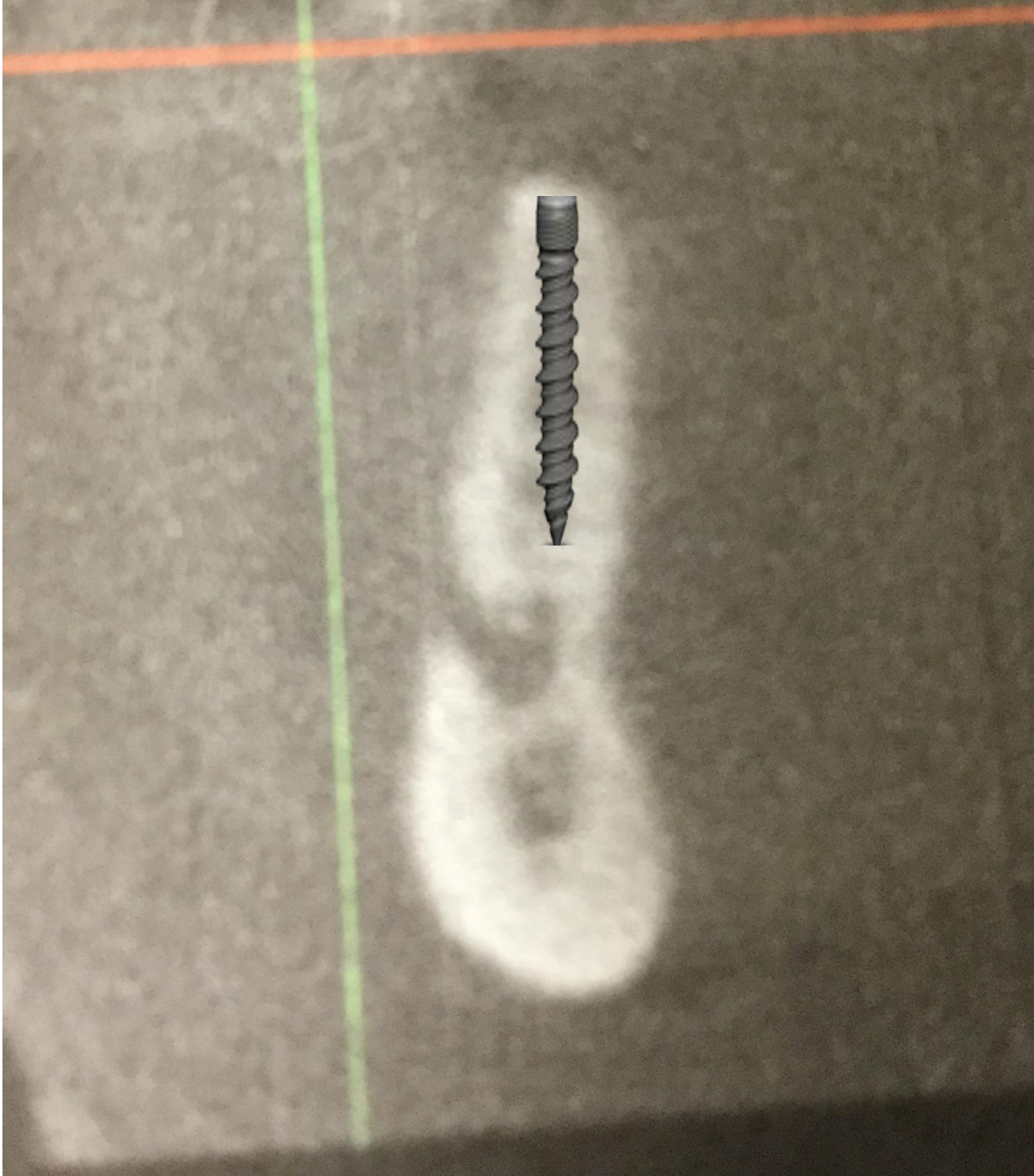
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## FIGURE CAPTIONS- Mini Implant Rationale

- 1- After an extraction the bone remodels and the cortices approach each other. The facial cortex generally approaches the lingual cortex.
- 2- A cone beam computerized image of a severely atrophic edentulous site.
- 3- The atrophic cortices can provide dense osseous support for mini implants.
- 4- After tooth extraction bone may remodel and produce different densities of bone.
- 5- A peaked atrophic ridge may be reduced with a bone burr to produce a flat wider surface for a mini implant osteotomy.
- 6- Two mini implants may provide enough support for a molar site.
- 7- Immediately after extractions mini implants were placed.
- 8- Mini implants immediately placed were grafted with particulate allograft and covered with dermal allograft, any resorbable barrier membrane will suffice. No flap was raised.
- 9- Splinted crowns supported by mini implants after two months of service.
- 10- Four mini implants are generally adequate retention for a complete removable overdenture.
- 11- A single mini implant may support a single crown in the anterior mandible where occlusal loads are less, and space may be limited.
- 12- A clinical view of the mini implant supported crown.
- 13- A year 2001 radiograph of a single mini implant in the anterior mandible.
- 14- A 2010 image of the implant supported crown placed in year 2001. The crown is still in situ at the time of this writing.
- 15- A radiograph of multiple mini implants supporting splinted crowns in the posterior jaw where occlusal loads are increased.
- 16- A clinical image of the multiple mini implants supporting splinted crowns.
- 17- An anecdotal image mini implant fractured after several attempt in seating. Metal fatigue may have caused such a fracture. Re-drilling the osteotomy may relieve the osseous resistance and allow appropriate seating.
- 18- Teeth may drift mesially and open the interproximal contact between the implant supported crown and the tooth. Caries can occur inferior to the prior contact area and should be restored to remove caries and restore the contact area.
- 19- Insoluble cements should be used to retain mini implant retainers. Soluble cement dissolution may occur and subsequently cause an over load of the retained retainers and cause an implant failure.



During atrophy the facial and lingual cortices approach each other providing facial and lingual dense bone for support

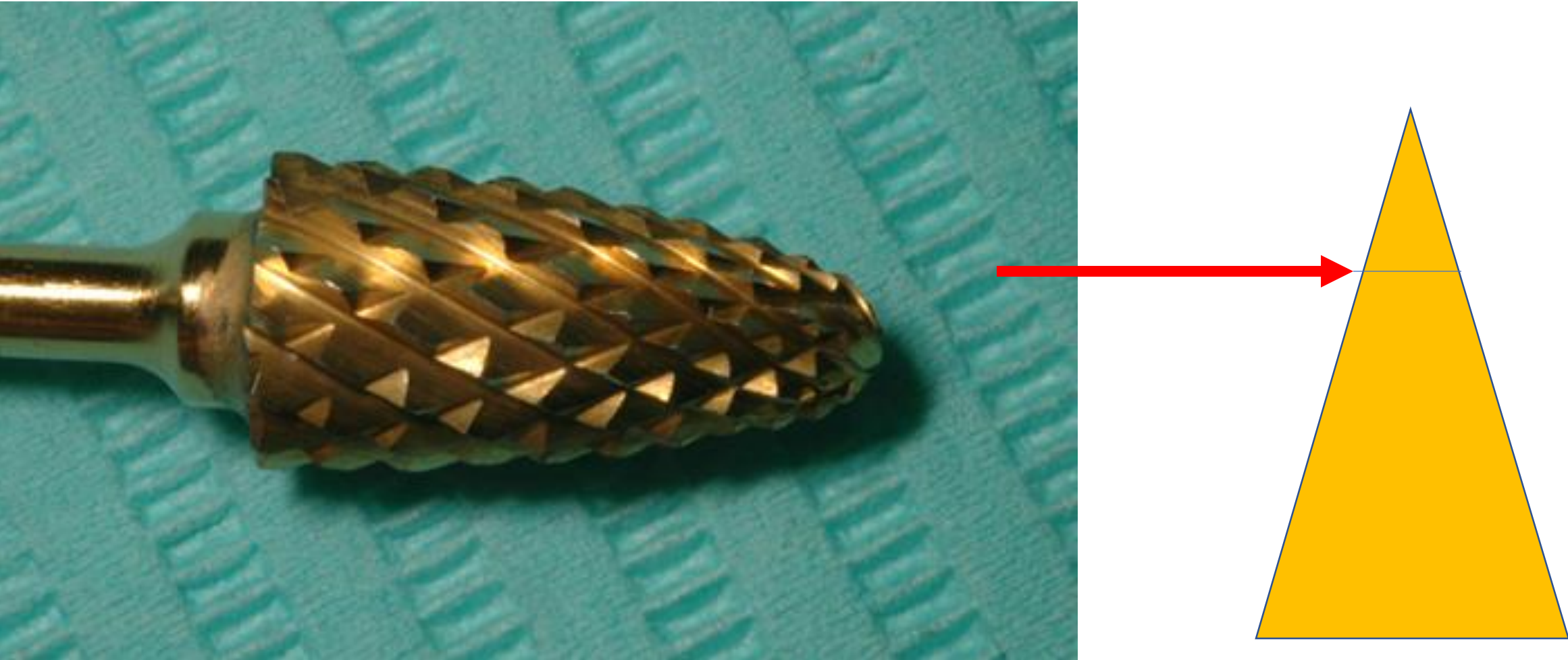






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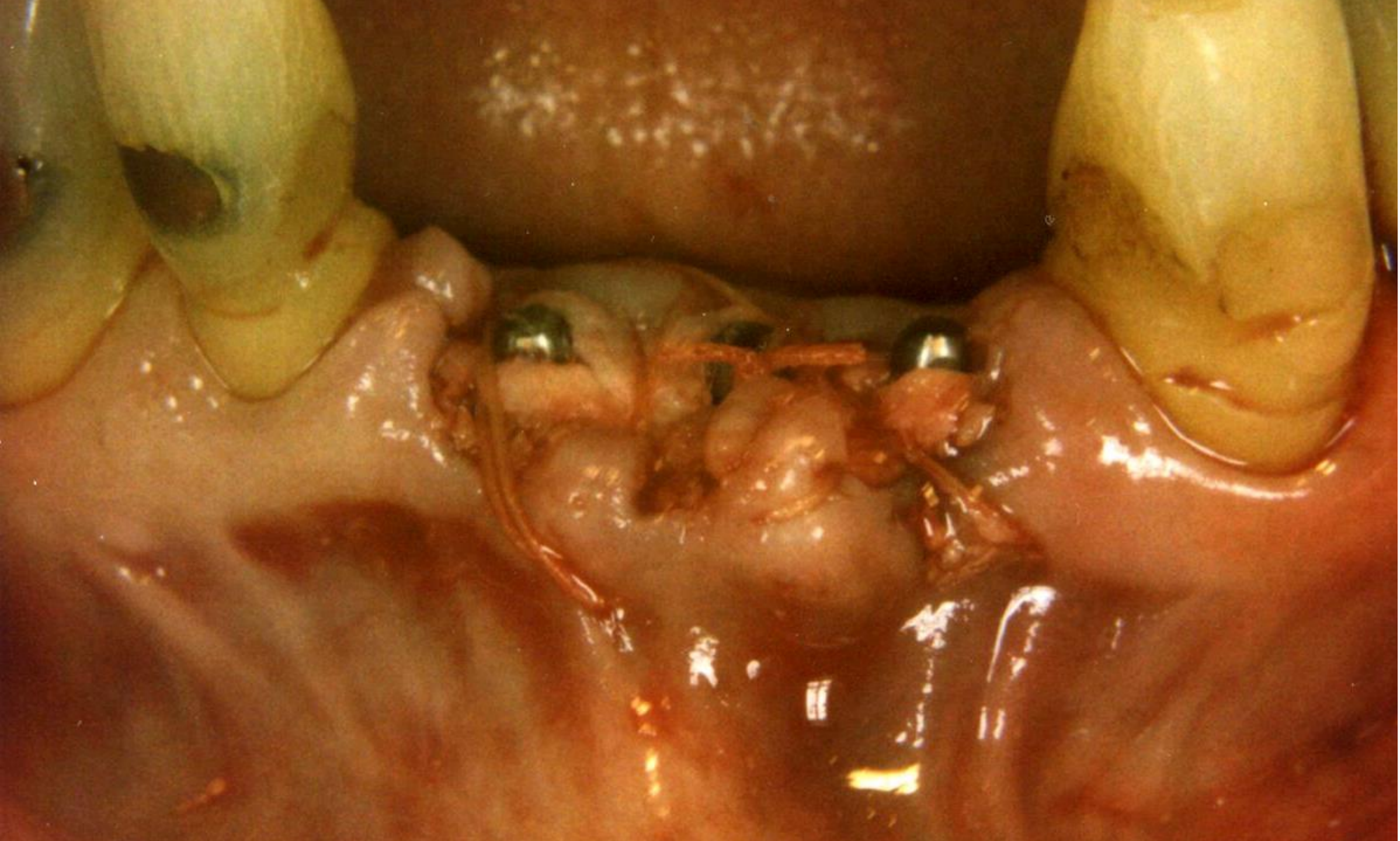




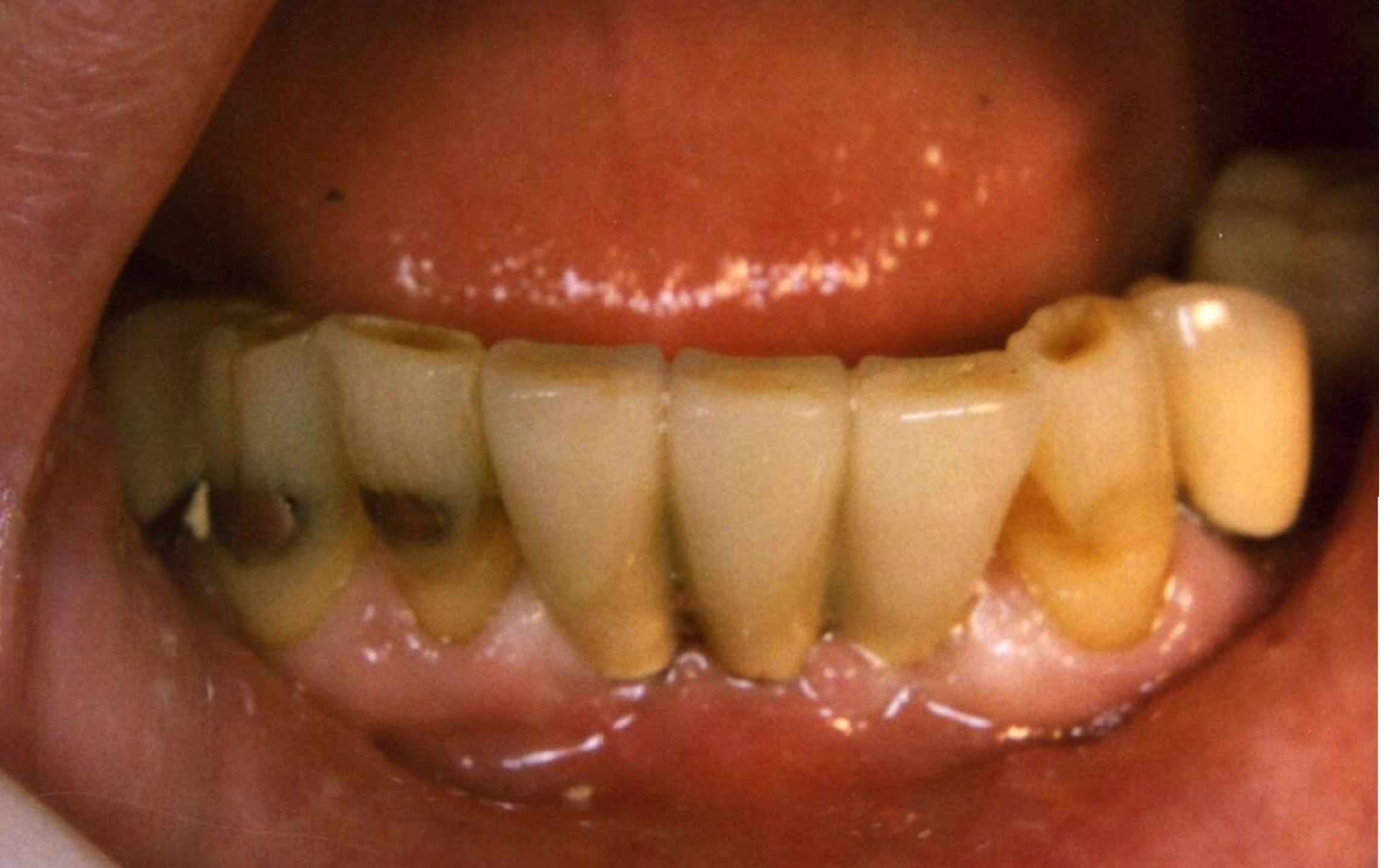




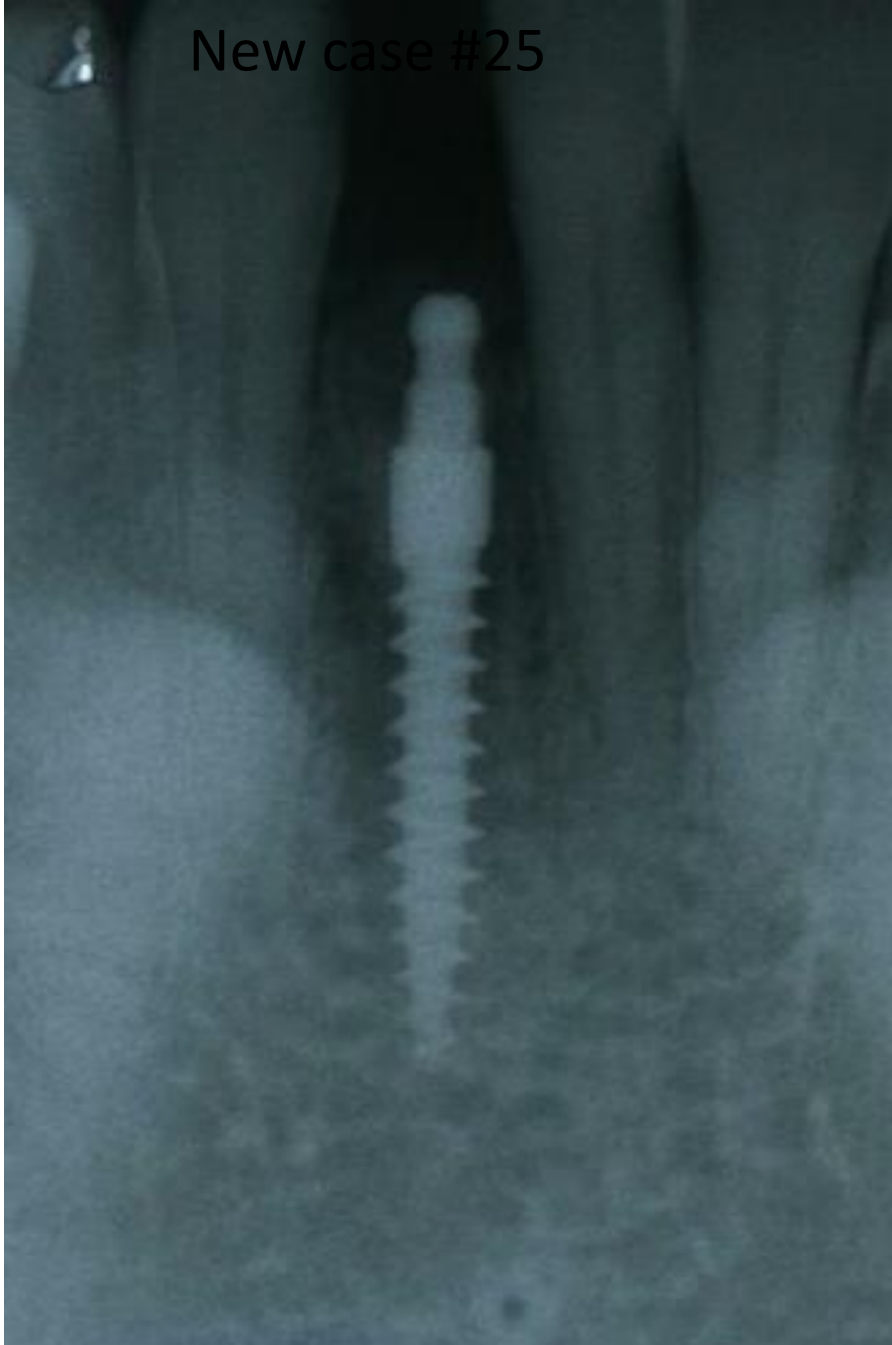






















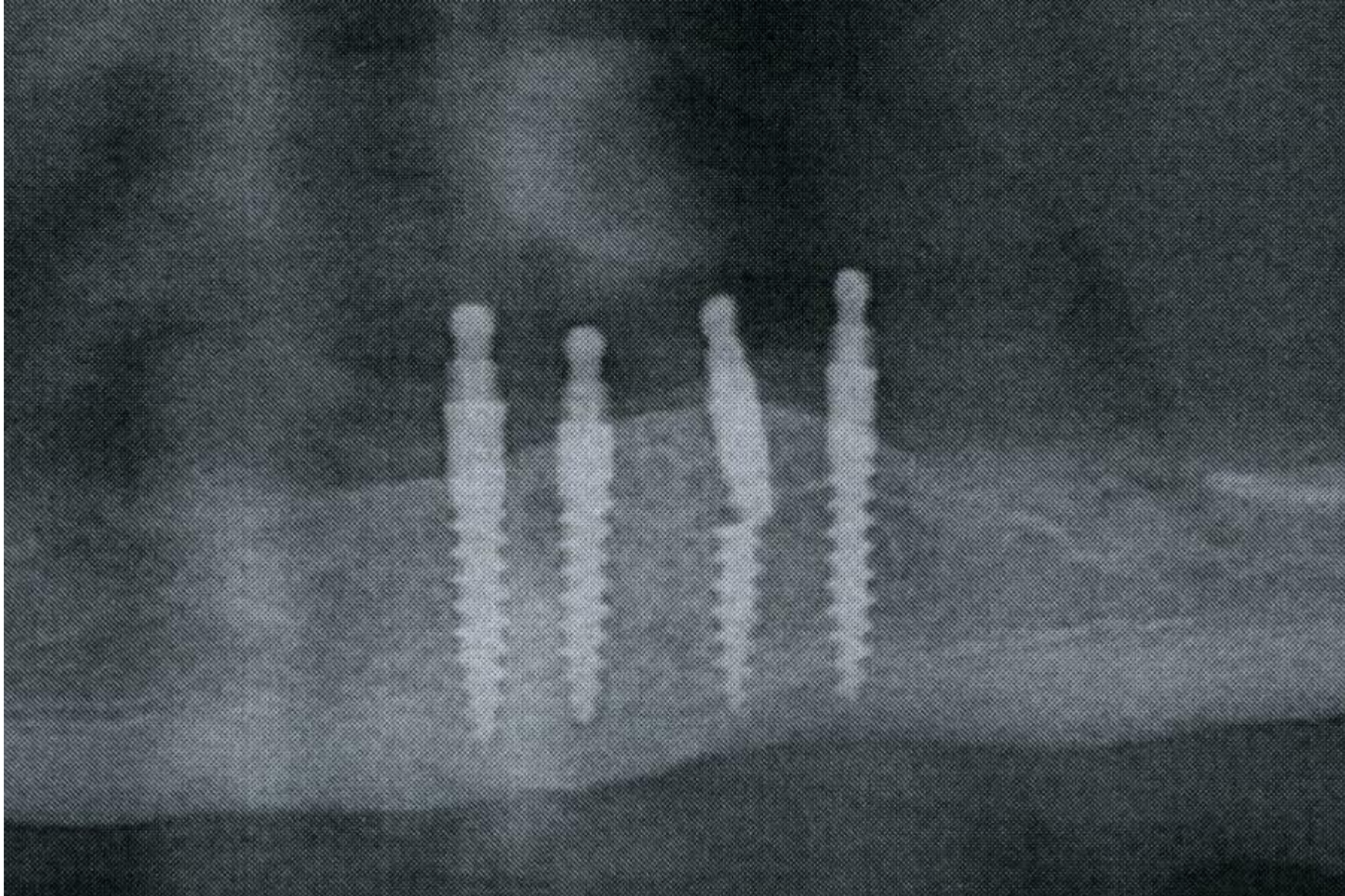
2010



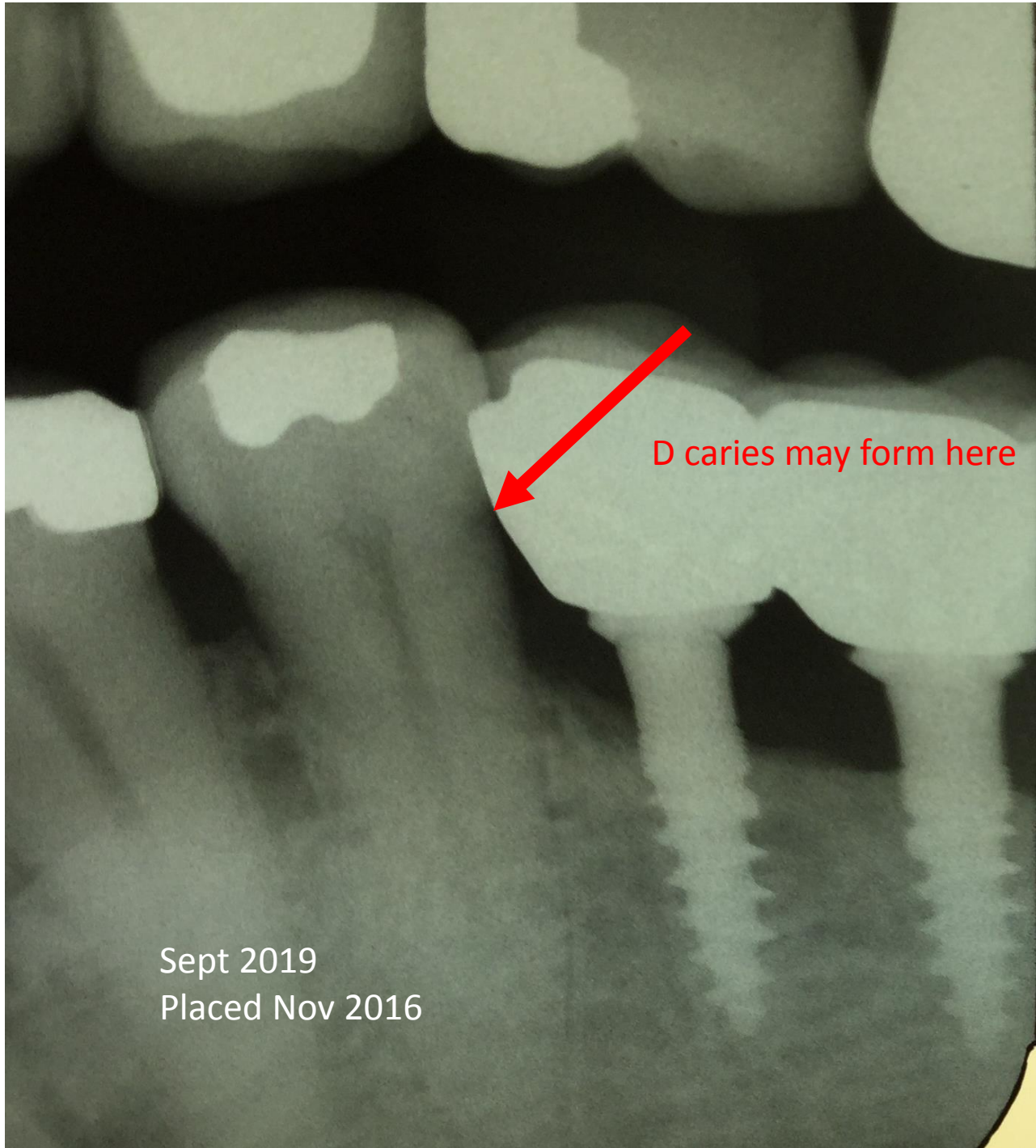
2004-2017





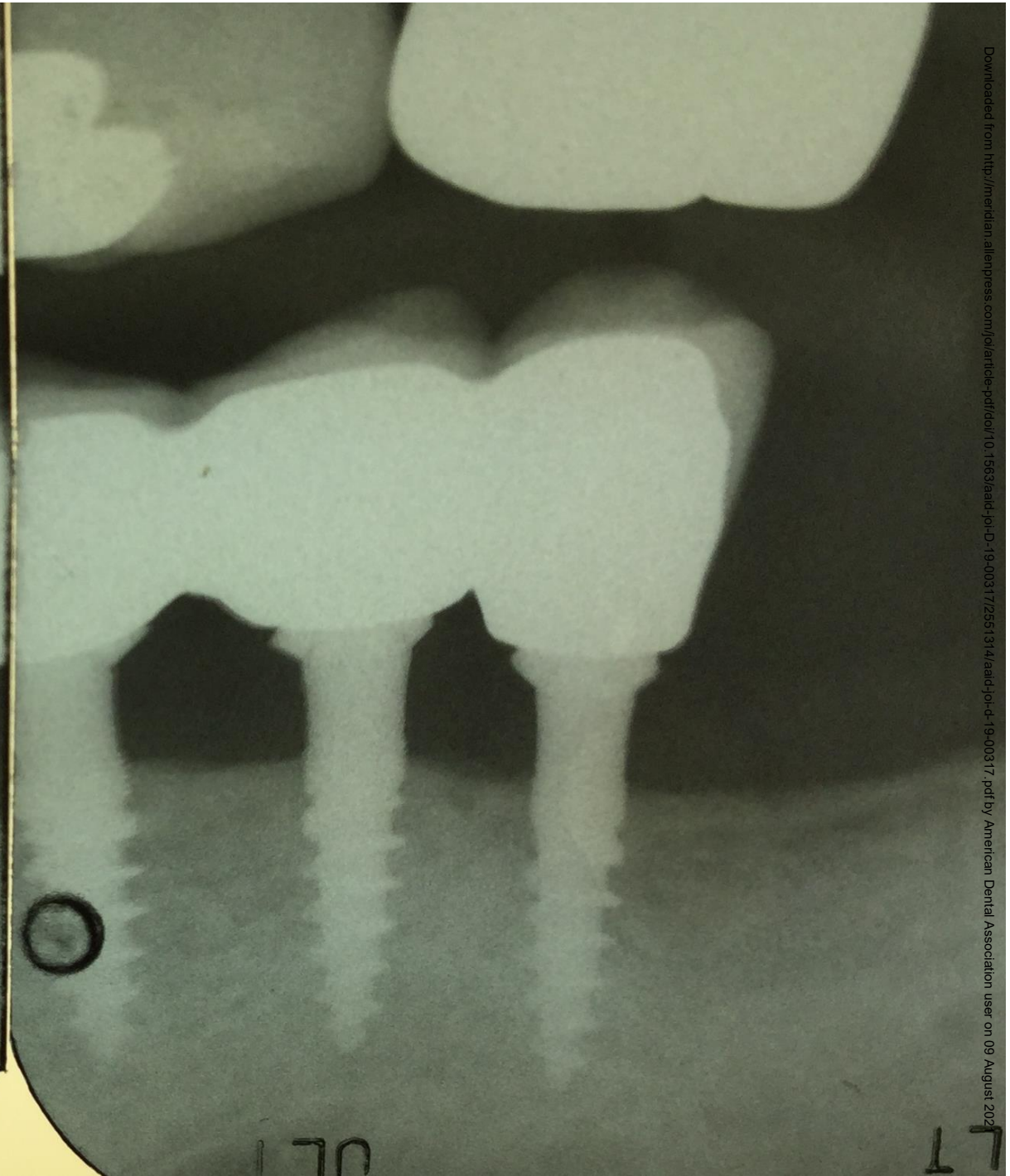






D caries may form here

Sept 2019  
Placed Nov 2016



DON'T USE ZnPO<sub>4</sub> CEMENT





PROSPERO Search TABLE 1

Lead Author	Topic	Card #	Submission Date
Hassan	Mandibular overdentures	42017068623	04/06/2017
Elsadek	Mandibular overdentures	42017063904	07/04/2017
Paiva	Pain and discomfort	42017059031	10/03/2017



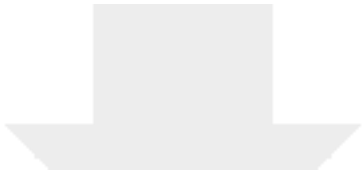
Lead Author of Systematic Review	Year	Modality	Comments	Conclusions
Schiegnitz et al	2018	Fixed and removable	High risk for bias	Long term data are missing
Marcello-Machado et al	2018	Mandibular overdentures	High survival and success rates	Adequate clinical behavior
Park et al	2017	Mandibular overdentures	High survival rates Significant satisfaction rates	Predictable results
Sivaramakrishnan et al	2017	Patient satisfaction Overdenture comparison	Limited data available	Good patient satisfaction as compared to standard implants
Lemos et al	2017	Overdentures	High survival rates and satisfaction	Alternative to standard implants
Goiato et al	2018	Mandibular overdentures	Most placed flapless High survival rates	Improved function Viable and safe
Klein et al ?	2014	Fixed and removable <3.5mm	Same survival as standard implants	High survival rates
Jawad et al ?	2019	Mandibular overdentures	Excellent survival rates	Reasonable alternative
Bidra et al	2013	Overdentures	Dearth of evidence No comparison studies High survival rates	True survival unknown Terminology is not definitive
Kim et al	2017	Mandibular overdentures	Better function High failure with short minis Use for <6mm bone width	4 or more minis >10mm bone height needed

TABLE 2



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**Rebuttal Letter (for revisions)**  
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