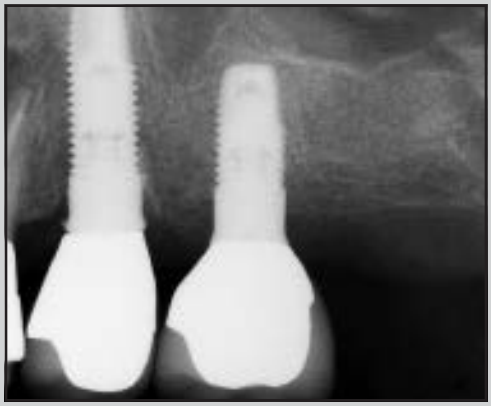
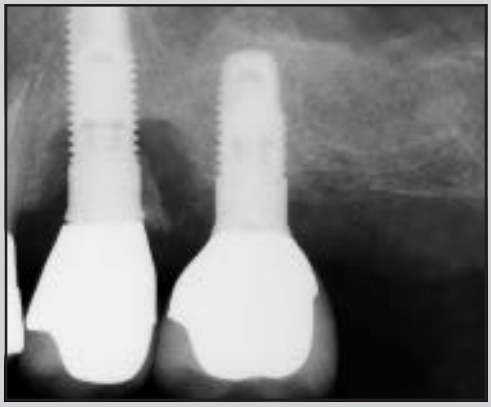
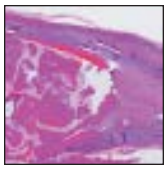




Unintentional Root Fragment Retention in Proximity to Dental Implants: A Series of Six Human Case Reports



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There has been renewed interest in intentionally placing dental implants in proximity to or in contact with tooth root fragments. In clinical practice, human teeth are usually extracted due to nonrestorable caries, vertical or horizontal root fractures, periodontal disease, or endodontic failure, which is commonly accompanied by inflammation and bacterial contamination. The aim of this case series is to present the adverse effects in humans of clinically undetected root-to-implant contact (CURIC), where implants were unintentionally placed in proximity to undetected retained root fragments. The adverse effects of small (3 to 5 mm) root fragments were detectible 6 to 48 months post implant placement. Three out of seven implants in six patients were removed due to severe coronal bone loss. This differs from retrograde peri-implantitis, where only the apical area of the implant is affected and the coronal portion remains integrated. The detrimental effect of root fragment-to-implant contact is described along with its clinical management. Based on the review of currently relevant data, mixed results have been documented regarding the success of dental implants in proximity to tooth-root fragments. Careful evaluation of long-term, postloading results in humans where hopeless teeth have been extracted due to infection and significant bone loss are required before intentional root fragment retention is considered a safe and reliable clinical option for implant placement. (Int J Periodontics Restorative Dent 2015;35:305–313. doi: 10.11607/prd.2410)

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Recently there has been renewed interest in patient outcomes related to dental implants placed in close proximity to or in contact with intentionally retained root fragments.[1–3] In the early 1990s, it had been proposed that placing a dental implant in the presence of a retained root could serve as a source of cells for healing. These early monkey studies reported a histologic presence of newly formed cementum and periodontal ligament (PDL) on the implant surface close to the retained root in the mandible.[4,5] The PDL that was observed between the newly formed cementum and bone was continuous with the PDL space of the adjacent root. Importantly, this suggested that PDL and not alveolar bone is a source of progenitor cells for root cementum.[5] This led to the speculation that, ideally, implants could be surrounded by a PDL, which would serve as a "shock absorber" and simulate the function of natural teeth. It was thought that by having a PDL surrounding an implant, the occlusal and lateral forces of an implant would be dissipated, and the implant could share the same mobility as a natural tooth.[5]

More recently, a beagle dog study reported histologic evidence of cementum and no signs of an inflammatory reaction on the implant surface placed lingual to the tooth remnant shell (socket-shield

Table 1 Literature review of retained root fragment-to-implant contact

Study	Year	Study population	Implants in root contact or proximity (n)	Implant type	Initial implant-root contact or proximity	Immediate implant
Animal reports						
Buser et al[4]	1990	5 monkeys	6	TPS cylinder (Straumann)	I	No
Warrer et al[5]	1993	7 monkeys	14	Astra (Meditec)	I	No
Gray and Vernino[17]	2004	10 baboons	10	Osseotite (Implant Innovations)	U	No
Jahangiri et al[18]	2005	6 beagle dogs	6	Bio-Lok Int'l	I	No
Parlar et al[19]	2005	9 mongrel dogs	9	Customized	I	N/A
Hürzeler et al[1]	2010	1 beagle dog	2	SPI Element (Thommen)	I	Yes
Bäumer et al[2]	2013	3 beagle dogs	12	SPI	I	Yes
Human reports						
Guarnieri et al[6]	2002	1 human	1	TPS cylinder	U	No
Park et al[7]	2004	1 human	1	Mk III (Nobel Biocare)	U	No
Davarpanah and Szmukler-Moncler[11]	2009	5 humans	5	Osseotite (Biomet 3i)	I	Yes
Hürzeler et al[1]	2010	1 human	1	SPI	I	Yes
Bäumer et al[2]	2013	1 human	1	SPI	I	Yes
Kan and Rungcharassaeng[3]	2013	1 human	1	NobelActive (Nobel Biocare)	I	Yes
Siormpas et al[12]	2014	46 humans	46	EZ Plus Internal (MegaGen)	I	Yes

EMD = Emdogain; PDL = periodontal ligament; TPS = titanium plasma-sprayed; I = intentional; U = unintentional; N/A = not applicable; NS = not specified; NF = nonfunctional loading; ? = uncertain; FE = fibrous encapsulation.

technique), which was coated with an enamel matrix derivative (EMD; Emdogain, Straumann).[1] The authors suggested the use of this technique to help preserve the buccal bone plate after immediate implant placement. The authors further investigated the socket-shield technique using vertically separated root fragments in beagle dogs without the use of Emdogain.[2] They reported new bone between dentin and the implant; however, there was no cementum formation at 4 months.

Conflicting data have been reported when implants were placed into or near retained roots in humans. The first human histologic case of a failed titanium plasma sprayed implant in contact with an undetected residual root reported hypercementosis (possibly due to the inflammatory stimulus) and no PDL.[6] This raised the question of whether the past results of generating PDL on implants in contact with roots in animal studies can be replicated in humans. Furthermore, it was speculated that retained roots may be a source of bacteria from the PDL and/or root canal, which could compromise the osseointegration of the implant.

The presence of a retained root tip undetected during implant placement has been reported as a potential source of pathogens in the etiology of retrograde peri-implantitis.[7] Retrograde peri-implantitis was first introduced by McAllister et al[8] and is defined as a rapid "implant-associated osteolysis."[9] It was also defined as a symptomatic periapical lesion with a sound coronal bone-implant interface, which develops within months of implant placement.[10] From the limited human research available, microbial contamination from residual endodontic infection from either the extracted tooth or from adjacent teeth appeared to be the most common causative factor in the development of retrograde peri-implantitis.[7] However, in one human study, implants were intentionally placed into partially or fully ankylosed root fragments. No adverse clinical outcomes were reported at 12 to 42 months (mean: 27 months) postloading.[11] A more recent study described as the "root-membrane" technique intentionally placed immediate implants in

EMD	Loading duration (mo)	Histology	PDL	Cementum	Adverse effect reported	Length of study (mo)
No	No	Yes	Yes	Yes	None	12
No	No	Yes	Yes	Yes	None	3
No	NS	Yes	?	?	None	1.5+
No	No	Yes	4/6 implants	4/6 implants	None	3.5–4
No	No	Yes	No	2/9 implants	FE 7/9 implants	4
Yes	No	Yes	No	Yes	None	4
No	No	Yes	No	No	None	4
No	NS	Yes	No	Yes	Pain, mobility, bone loss, removed	12
No	No	No	N/A	N/A	Swelling, fistula	6.75
No	12–42	No	N/A	N/A	None	12–49
Yes	6 NF	No	N/A	N/A	None	6
No	No	No	N/A	N/A	None	6
No	6	No	N/A	N/A	None	12
No	24–60	No	N/A	N/A	None	24–60

contact with buccal root fragments and reported no adverse clinical results in 24 to 60 months (median: 40 months) postimplant placement. This technique excludes teeth with acute inflammation, moderate or severe periodontal disease, and/or sites exhibiting facial clinical attachment loss greater than 3 mm.[12] The studies described above are summarized in Table 1.

The aim of this case series is to retrospectively evaluate the effects in humans of clinically undetected root-to-implant contact (CURIC).

Method and materials

Six patients ranging from 59 to 74 years of age were included in this report of seven implants in contact with or in close proximity to previously undetected root fragments. There was no significant medical or social history noted. Table 2 summarizes the human cases of bone loss around implants in contact with undetected retained root fragments. Digital radiographs (Dexis) taken at the time of implant placement were retrieved from the referring dentists and enhanced in an attempt to determine the initial cause of the bone loss. All patients were treated with mucoperiosteal flap elevation, removal of the root fragment, degranulation, appropriate antibiotics, and pain management.

Patient 1

A 59-year-old woman presented with a fractured mesial root of the mandibular first molar (Fig 1a). This molar had undergone endodontic treatment twice due to residual symptoms. A postextraction radiograph was taken to ascertain that all root fragments and gutta percha had been removed from the resulting bony defect. An implant (Osseo-Tite, Biomet 3i) was inserted and then restored following 3 months of submerged healing. At 16 months post implant placement, there was radiographic evidence of a small root fragment on the mesial aspect of the implant and an incomplete bony fill of the distal root socket, which had previously appeared

Table 2 Summary of patient data and observation period

Patient	Sex	Age (y)	Site	Reason for tooth extraction	Previous endodontic treatment	Immediate placement
1	F	59	Mandibular left first molar	Fracture	Yes (twice)	Yes
2	M	74	Maxillary left second premolar	Fracture	Yes	Yes
3	M	74	Maxillary left first premolar	Periodontal disease	Yes	Yes
4	F	59	Maxillary left second premolar	Fracture	Yes	Yes
5	M	68	Maxillary right lateral incisor	Caries	Yes	No
5	M	68	Maxillary right lateral incisor	N/A	N/A	No
5*	M	69	Maxillary right lateral incisor	N/A	N/A	No
6	F	70	Mandibular right first molar	Caries, fracture	Yes	Yes

N/A = not applicable.
*Second replacement implant not in contact with root fragment.

Fig 1a *Radiograph of mandibular first molar with fractured mesial root.*

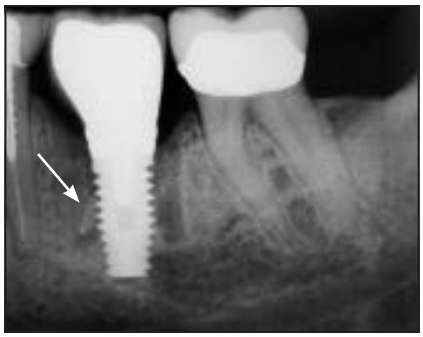


Fig 1b *Radiograph at 16 months postloading demonstrates what appeared to be a small root fragment* (arrow) *on the mesial aspect (which was not apparent previously) and incomplete bone fill of the distal root socket.*

Fig 1c *Radiograph at 21 months postloading reveals progressive bone resorption and a large root fragment adjacent to the implant on the mesial aspect. The apical portion of the distal socket appears more radiopaque.*

Fig 1d (left) *Open-flap procedure revealing a large area of bone loss and a root fragment* (arrow) *embedded into the mesial and buccal bone. The implant was 50% osseointegrated.*

Fig 1e (right) *The 4 × 5–mm root fragment and implant were removed.*

consolidated; however, the implant was stable (Fig 1b). At 21 months post implant placement, a new radio graph showed progressive bone loss, revealing a larger root fragment than previously observed (Figs 1b and 1c). During the open-flap procedure, severe bone loss and the root fragment were observed on the mesial and buccal surfaces. Bone loss was also evident on the distal surface. Due to the stability of the implant, with the apical 50% of the length of the implant still embedded in bone, a trephine was needed to remove the implant. The 4 × 5–mm root fragment embedded in the buccal bone was also removed (Figs 1d and 1e). The defect was regrafted for possible future implant placement.

Implant type	Time from initial implant placement to root fragment discovery (mo)	Bone loss	Implant removed	Follow-up after implant loading (mo)
OsseoTite (Biomet 3i)	21	Yes	Yes	N/A
Replace Select TiUnite (Nobel Biocare)	25	Yes	No	60
Replace Groovy (Nobel Biocare)	12	Yes	No	48
Replace Groovy	48	Yes	No	46
BiModal (Neoss)	13	Yes	Yes	N/A
BiModal	9	Yes	Yes	N/A
Replace Select TiUnite	N/A	No	No	33
Replace Select TiUnite	6	Yes	No	31

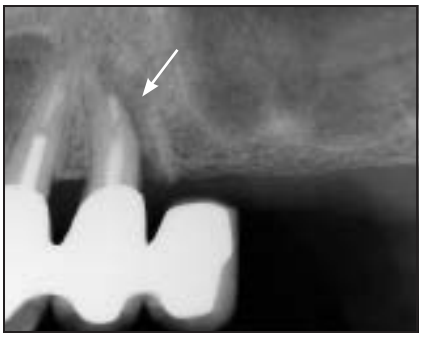


Fig 2a *Radiograph of the fractured maxillary left second premolar* (arrow).

Fig 2b *Radiograph at 6 months post implant placement demonstrating uneventful osseointegration. Retained cement is evident at the implant to abutment and abutment to crown interface on the second premolar.*

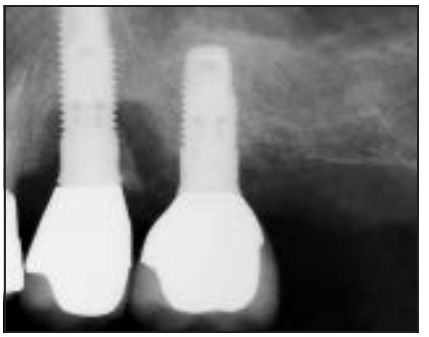
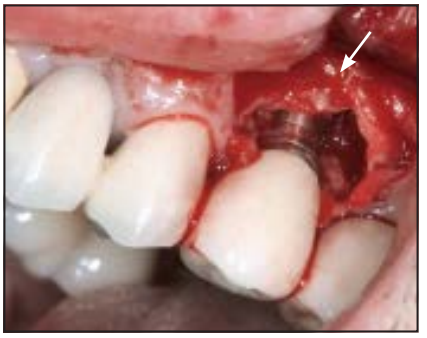


Fig 2c *Radiograph at 25 months post implant placement reveals extensive bone loss on the mesial and distal aspects of the second premolar.*

Fig 2d (left) *Flap surgery revealed a root fragment* (arrow) *embedded in buccal bone.*

Fig 2e (right) *Follow-up radiograph at 60 months revealing stable bone levels at the treated implant. The prosthesis has been changed with the addition of an anterior implant-supported partial denture.*



Patient 2

A 74-year-old man presented with a fractured maxillary left second premolar. The treatment plan included extraction of the fractured premolar and immediate implant placement (Replace Select, Nobel Biocare) of the fractured premolar and a sinus elevation procedure for a future first molar implant (Fig 2a). Each site was allowed to heal for 6 months post implant placement, and osseointegration proceeded uneventfully (Fig 2b). At 25 months post implant placement, clinical inflammation and 7-mm probing depth on the buccal and distal surfaces of the implant in the second premolar position were noted at a routine maintenance visit. Digital

Fig 3a *Buccal swelling* (arrow) *visible around the maxillary left first premolar position at 12 months post implant placement.*

Fig 3b *Mucoperiosteal flap elevated to expose the buccal bone and the root fragment.*

Fig 3c *Buccal plate and the root fragment removed.*

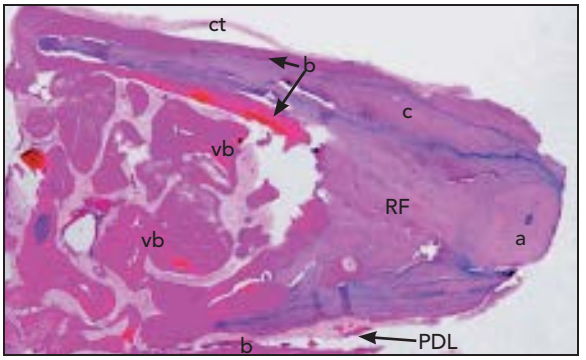


Fig 3d *Photomicrograph of root fragment* (RF), *horizontal orientation, with root apex* (a) *noted at the right. The external surface of the root fragment is surfaced by acellular cementum* (c) *with PDL and alveolar bone* (b) *noted peripherally. The mid-portion of the root fragment is filled with viable bone* (vb) *and fibrous connective tissue* (ct) *devoid of any significant inflammatory component (hematoxylin-eosin stain; original magnification ×20).*

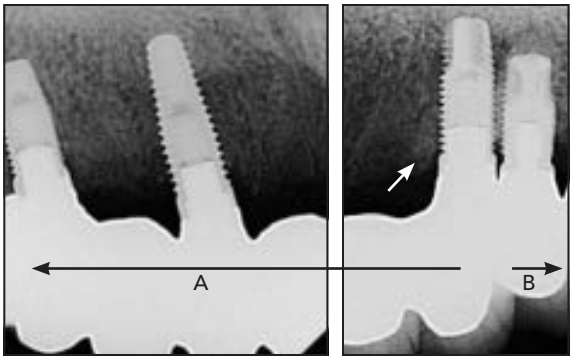


Fig 3e *Radiographs at 48 months after root fragment removal reveal stable bone levels mesially and distally on the treated implant* (arrow). *A = maxillary anterior partial denture 4.5 years after loading; B = separate posterior partial denture at 12.5 years.*

radiographic evaluation revealed pronounced bone loss on the distal aspect of the implant in the second premolar position and evidence of extravasated cement. Upon flap elevation, a significant bony defect, granulation tissue, and a 3-mm root fragment embedded in the buccal bone were observed (Figs 2c and 2d.) Excess cement was found at the abutment junction. The root fragment was extracted, the defect was debrided, the implant was disinfected using an airborne particle–abrasion instrument (Prophy-Jet, Dentsply), and a demineralized freeze-dried bone allograft (DFDBA, Miami Bone Bank) was placed into the defect. A follow-up radiograph at 60 months post loading demonstrated stable bone levels (Fig 2e).

Patient 3

A 74-year-old man presented with buccal swelling at the implant in the maxillary left first premolar position, which was the terminal abutment of the eight-unit implant-supported fixed partial denture placed 1 year previously (Fig 3a). Since it was noted that the first premolar was ankylosed at the time of extraction and immediate implant placement (Replace Groovy, Nobel Biocare), the presence of a root fragment was suspected. A cone beam computed tomography (CBCT) scan was inconclusive as to the source of the infection. The patient was placed on

Figs 4a to 4c *Interim radiographs taken during the extraction of the maxillary left second premolar and immediate implant placement.*

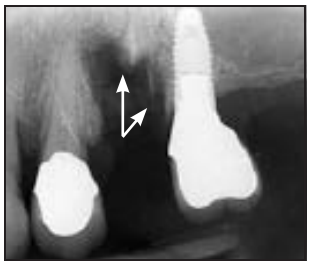


Fig 4a *Two remaining root fragments before their extraction* (arrows).

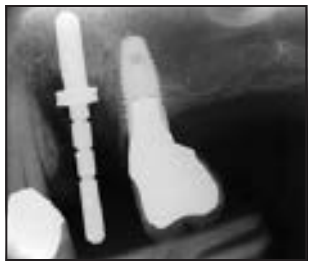


Fig 4b *Direction indicator in place.*

Fig 4c *Immediate implant placement.*

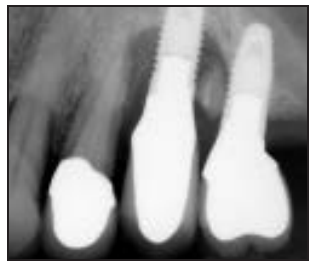


Fig 4d *Radiograph taken at 48 months postloading reveals a large root fragment distal to the maxillary second premolar implant and severe bone loss.*

amoxicillin 875 mg for 10 days and a 0.12% chlorhexidine rinse. After 2 weeks, a mucoperiosteal flap was elevated to expose the area (Fig 3b). Even with the use of 3× magnifying lenses it was very difficult to differentiate the dense cortical bone from the root fragment. The buccal root fragment was carefully removed, along with its contiguous buccal bony plate attachment, which exposed four threads on the implant surface (Fig 3c). Following airborne particle–abrasion cleansing (Prophy-Jet) of the implant and a sterile saline rinse, the area was grafted with DFDBA (Miami Bone Bank). The excised tissue histopathology report confirmed the clinical diagnosis of a portion of residual root with viable bone lining the external surface of the root fragment; there was evidence of cementum and PDL peripherally. The middle portion of the root fragment was filled with viable bone and fibrous connective tissue devoid of any significant inflammatory component (Fig 3d). It was not possible to determine with any degree of certainty from the enhanced digital periapical radiographs, CBCT evaluation, or the histology that the juxtaposition of the root fragment to the implant caused the buccal swelling; however, this patient has been followed up for 4 years without further incidence. Radiographs at 48 months after implant loading reveal stable bone levels mesially and distally on the treated implant (Fig 3e).

Patient 4

A 59-year-old woman was referred for evaluation regarding soft tissue swelling in the area of the maxillary left second premolar implant. The implant had been placed 54 months previously by a surgeon and restored 7 months later. A review of the radiographs retrieved from the time of the extraction and immediate implant placement, 4 years earlier, demonstrated that the apical third of the root of the premolar had been fractured into two pieces (Fig 4a). The radiographs taken during implant placement were not immediately indicative of any root fragments left behind (Figs 4b and 4c). However, the current radiograph revealed the presence of a large root tip fragment on the distal aspect of the implant (Fig 4d), which was not detected earlier because the patient was not compliant with her dental visits. It appears that a root fragment had remained embedded in the walls of the bony socket and had moved distally over the years as the bone resorbed around it. A mucoperiosteal flap was elevated to remove the root fragment (4 × 5 mm). The surgical area was degranulated, the implant was disinfected using an airborne particle–abrasion instrument, and DFDBA was placed into the defect. Six months after treatment the implant remained stable; however, the radiograph showed only minimal improvement, and there was a persistent inflammatory response in the soft tissue. The prognosis for this implant is poor.

Discussion

In this case series, seven implants in six patients had an adverse effect from implant contact with undetected root fragments resulting in coronal bone loss around the implants. This differs from retrograde peri-implantitis, where only the apical area of the implant is affected, and the coronal portion remains integrated.[10] Three different implant systems were represented, demonstrating that this phenomenon is not particular to any specific implant surface configuration. The patients were treated by five different surgeons with extensive experience; therefore, it does not appear to be a single operator-specific oversight. Three out of the seven implants affected were explanted due to severe bone loss. Three implant lesions were surgically treated by root fragment removal, degranulation, decontamination, and bone grafting, and have been stable for a follow-up of 31 to 60 months. One implant (in patient 4) is in the healing phase but most likely will be explanted. A CBCT scan (Imaging Sciences International) was taken after the second implant loss on patient 5 and a small 3-mm root fragment was discovered to be embedded in the buccal bone. It was removed prior to the successful placement of a third implant in that site. All patients except for patient 1 have continued to be monitored at 3-month maintenance visits.

Although there have been some experimental animal studies that have demonstrated promising results toward developing a PDL and/or cementum around dental implants in contact with root tips, they had short-term follow-ups (3 to 12 months), and the implants were not loaded (see Table 1). In addition, none of the monkey, baboon, or dog teeth had endodontic treatment or were symptomatic prior to extraction. In clinical practice, teeth are usually extracted due to nonrestorable caries, vertical or horizontal fracture, periodontal disease, or endodontic failure commonly accompanied by inflammation, bacterial contamination, and bone loss.

In this case series, all teeth had previous endodontic therapy, which may have involved some degree of ankylosis and difficulty in extraction. Since the goal was tooth extraction, mobilization of the root is usually attempted aggressively, and in some cases the roots may have been separated from the bone by a high-speed drill leaving an undetected sliver of root attached to the bone. This may differ from the "socket-shield" technique,[1] whereby the root is intentionally sectioned, not mobilized, and remains attached to the buccal bone with possibly an intact viable attachment apparatus. Similarly, the "root-membrane" technique in which the 45/46 teeth selected were periodontally sound (intact buccal plates) and were diagnosed as nonrestorable due to extensive caries or supracrestal horizontal fractures.[12] However, in other cases, a small, mobilized, nonvital root fragment that could be contaminated with bacteria, endotoxins, or inflammatory cells from incompletely sealed endodontic treatment or periodontal disease might evoke a foreign body inflammatory response when disturbed by osteotomy preparation, implant placement, or loading. Residual root particles or foreign bodies have been proposed to play a possible role in the etiology of retrograde peri-implantitis.[13,14]

In the human cases previously reported and those included in this report, adverse effects became apparent in 6 to 48 months post implant placement. In this report, the retained root fragments, 3 to 5 mm in size, did not appear on the digitally enhanced periapical radiographs immediately in any of the cases, which included both immediate and delayed implant placements. Most studies show that bony lesions in cancellous bone are radiographically undetectable with analog or even digital intraoral radiographs and will only demonstrate a loss in trabecular pattern after the bone loss extends to the junctional area between the cancellous and cortical bone.[15] The lesion becomes a radiographic radiolucency when the bone resorption extends to the cortical bone and is of a critical size defect of 1 mm[15] to 3 mm.[16] The current authors propose this as the rationale as to why small root fragments are initially undetectable radiographically until the bone resorption extends beyond the junctional area. It is considered impractical to take a CBCT scan after every extraction; however, if a tooth was ankylosed and fractured, it may be prudent to take a CBCT scan to try to rule out the presence of any remaining fragments prior to implant placement.

The present authors are currently treating seven more cases of CURIC for which they were not able to get enough pre-incidence information for inclusion in this report. As previous authors have suggested, more cases need to be documented demonstrating long-term, postloading results in humans before intentional implant–tooth/root contact might be considered a reliable clinical option suitable for general use.[1,2,6,11]

Conclusions

Within the limitations of this case series, the detrimental effect of an implant in contact with or in close proximity to a previously undetected human root fragment has been demonstrated along with its clinical management. Careful evaluation of long-term, postloading results in humans where hopeless teeth are extracted due to infection and significant bone loss are required before intentional root fragment retention is considered a safe and reliable clinical option for implant placement.

Acknowledgments

The authors reported no conflicts of interest related to this study.

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