Human Histologic Evidence of New Bone Formation and Osseointegration Between Root Dentin (Unplanned Socket-Shield) and Dental Implant: Case Report

Charles Schwimer, DMD, BS1/Gregory A. Pette, DMD, MS2/Howard Gluckman, BDS, MChD (OMP)3/Maurice Salama, DMD4/Jonathan Du Toit, BChD, MSc(Dent)5

The socket-shield technique described 7 years ago has since grown in its reporting in the literature as a valid method of ridge preservation at immediate implant placement. To date, large clinical cohorts with up-to-4-year follow-up have been reported. Additionally, evidence of tissue histology at the dental implant and socket-shield has been demonstrated in the animal model. However, human histologic evidence has not yet been available, and the clinician’s uncertainty regarding the tissues that may form between the socket-shield and dental implant may remain unanswered until now. This case report presents the first human histologic evidence that bone may entirely fill the space between root dentin and an osseointegrated implant surface. INT J ORAL MAXILLOFAC IMPLANTS 2018;33:e19–e23. doi: 10.11607/jomi.6215

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Literature reporting on the retention of the tooth root or part of the tooth root to maintain alveolar ridge volume and offset postextraction collapse has been growing in recent years. The socket-shield technique has been proposed as such a method, sectioning the facial root portion for it to remain submerged in situ with its physiologic attachment to bundle bone intact. The hypothesis asserts that this root portion, when retained, circumvents the destruction of Sharpey’s fibers inserted into bundle bone and “shields” the facial alveolar ridge from collapsing adjacent to the implant. The literature to support this theory is growing. As yet, the technique requires additional data to advocate in everyday practice, especially data ranking higher in the hierarchy of scientific evidence.

Hürzeler and coworkers as well as Bäumer and coworkers have provided valuable histologic evidence of the healed socket-shield and implant sectioned from the alveolar ridge. Yet, these have been presented in the canine model. The clinician may still be uncertain as to what tissue grows between the socket-shield and dental implant in a human. Is it periodontal ligament, new cementum, or partial or full periodontal regeneration? Will the identification of this tissue architecture affect the decision-making when selecting the socket-shield technique to offset resorptive complications at immediate implant placement? The objective of this case report was to present the first human histologic evidence that demonstrates the healing possibility of new bone and osseointegration between root dentin and dental implant.

CASE REPORT

A woman aged 45 years presented to the offices of her periodontist for a routine check-up, and provided a history that included among others discomfort and vague sensation associated with her implant crown at the left maxillary first premolar site. The patient’s medical history was noncontributory. The dental history entailed loss of the premolar tooth 2 years prior and an immediate implant being placed. A period of submerged healing followed, with subsequent implant exposure and definitive restoration with a cement-retained crown. Intraoral examination noted no overt inflammation, peri-implant mucositis, or tissue.
recession. Circumferential probing at the implant crown was warranted to investigate further, and increased probing depths were noted, deepest at the mesiobuccal location: 6 mm (Fig 1). A periapical radiograph was taken, noting crestal peri-implant bone in a “saucerization” presentation, and what appeared to be a foreign object mesial at the implant (Fig 2). The clinical features of crestal loss and bleeding on probing supported the diagnosis of peri-implantitis, yet with a surviving implant. The radiographic diagnosis of a retained root fragment in proximation to the implant, coupled with the peri-implantitis diagnosis, merited presenting the patient with the option of implant removal and rehabilitation of the site. Alternative treatment options, including no additional treatment, were offered to the patient, among which removal and retreatment with an implant-supported restoration was selected by the patient.

Following local anesthesia of the site, a full-thickness mucoperiosteal flap was raised to expose the facial alveolar ridge at the implant (Fig 3). A window was prepared, and the implant with its restoration was torqued and removed laterally via the preparation (Figs 4 and 5). At removal, the longitudinal root section could be noted adherent to the implant surface (Figs 6 and 7). The implant with any attached tissue as is was photographed and then placed into 10% buffered formalin to be sent for histologic examination. The site was debrided, rinsed with saline, and grafted with an allograft particulate bone (Puros, Zimmer Biomet) hydrated in recombinant human platelet-derived growth factor-BB (rhPDGF-BB) (Fig 8). The graft was covered by a layer of nonresorbable, titanium-reinforced dense polytetrafluoroethylene (dPTFE) membrane (Cytoplast, Osteogenics Biomedical) covered by a resorbable collagen membrane (Bio-Gide, Geistlich). The flap was closed (Fig 9) and the site left to heal for a period of 3 months, whereafter a second implant was placed and subsequently restored following osseointegration (Fig 10).

HISTOLOGIC ANALYSIS

The implant with adherent tissue was fixed in 10% neutral buffered formalin, dehydrated, infiltrated,
then slowly embedded in a glycol methacrylate-based polymer resin block, and cut by microtome into undecalcified sections (Exakt Apparatebau). The sections were then polished to within 10 microns and stained with Stevenel's blue and van Gieson picric fuchsin. Viewed at low power (25×) under a light microscope, an adherent root section was observed extending the vertical extent of the implant approximately 3 mm coronally beyond the first thread and polished implant collar (Fig 11a). The fragment was verified as tooth root, displaying dentinal tubules that span the dentin layer that interfaces with an outer cementum layer. At medium power magnification (40×), the dentinal tubules were distinct (Fig 11b). A lateral canal was also observed at about the apical third of the implant. Tissue was present within the implant apical chamber and between the implant threads (Figs 11a to 11d). The tissue contained in the apical chamber and that filled the implant’s interthread spaces was confirmed as bone, displaying a marbled appearance—the resting and creeping reversal lines typical of alveolar bone’s histologic presentation (Fig 11c). This tissue was intimately apposed to the implant surface with continuation to the root section. The bone that filled the thread spaces was confirmed to be vital, displaying osteocytes housed in lacunae, with large atypical vacuolar spaces, which themselves contained bone tissue in areas (Fig 11c). These circular vacuoles were first thought to be vascular lumens of Volkmann canals or Haversian systems. The current hypothesis explaining this presentation is that fragments of dentin dislodged during implant insertion were contained within these in the interthread bone. There appeared to be an absence of fibrovascular tissue at the interfaces between bone and dentin, and bone and implant. The bone that occupied the interthread spaces, when viewed by polarized microscopy, exhibited mineralization with concentric lamellae, evident of mature, remodeled bone (Fig 11d). The space between the implant surface and bone was a separation artifact that likely resulted from the microtome preparation of the sample.

**DISCUSSION**

New treatments not yet supported by strong scientific evidence may be unsound and even controversial. Alas, all health care innovations have their starting point. Typically, in vitro precedes in vivo application, with testing in the animal model before human subjects. The socket-shield technique has progressed to the current stage, where the literature reports on case cohorts as large as 128 patients in a single study, with follow-up at 4 years. Additionally, histologic reports in the canine model have provided insight into the healing of tissues at an implant placed adjacent and in contact with a root fragment. However, the clinician contemplating this technique may still have unanswered questions; paramount among these: What tissues grow between the implant and socket-shield? Since several studies over the last two decades have investigated the probability of forming a periodontal ligament and periodontal tissues onto the implant surface and failed to achieve osseointegration, the clinician would be wary to suspect similar of the socket-shield technique. The distinction, though, is to be made regarding the root section configuration, and the origin of the mesenchymal cells that have osteoblastic differentiation potential. Buser et al had experimented with implantation into retained primate teeth. This novel study demonstrated that a cementum layer...
Fig 11a  Undecalcified section of the implant with the root fragment closely adherent to its surface, spanning from apex well beyond the implant’s polished collar. Tissue is visible filling each thread space, as well as within the apical chamber. Light microscopy, 25×, Stevenel’s blue and Van Gieson’s picro fuchsin.

Fig 11b  The dentinal tubules of the root fragment are prominent (asterisks), as the root fragment interfaces with root cementum (arrows). Note that each thread space is wholly occupied by bone, which intimately interfaces with the root dentin. The interthread bone displays circular, vacuolar structures. Bone tissue obliterates, partly infiltrates, or centrally occupies these vacuoles. Light microscopy, 40×. Stevenel’s blue and Van Gieson’s picro fuchsin.

Fig 11c  High-power magnification verified mature, living bone, organized in concentric lamellae, containing osteocytes within lacunae. Vacuolar structures central to the interthread bone themselves contain bone tissue. Light microscopy, 200×. Stevenel’s blue and Van Gieson’s picro fuchsin.

Fig 11d  Bone filled each thread space intimately interfacing between the root fragment and implant surface. Note the Haversian systems containing vessels. Polarized light microscopy, 40×. Stevenel’s blue and Van Gieson’s picro fuchsin.
formed on the implant surfaces and that a periodontal ligament consistently was present, inserting fibers from implant cementum into adjacent bone. Fifteen years later, Parlar and coworkers similarly aimed to investigate the potential of periodontal tissues to form around dental implants placed into canine teeth. The teeth were hollowed, and implants were inserted wholly inside the teeth. Slits in the teeth were prepared to allow passage to the periodontal ligament. The results of this study also failed to demonstrate successful osseointegration. These root configurations, however, differed vastly from the socket-shield. The socket-shield is prepared as a vertical root portion, facial to the implant, shaped to a concave and thinned slightly, with its physiologic attachment to bundle bone maintained. An implant is inserted palatal/lingual to the socket-shield and derives its primary stability from apical bone, as is routine for immediate implant placement. The socket-shield in its orientation does not obstruct the passage of peri-vascular pleuripotent cells and trabecular bone-lining mesenchymal cells to the implant surface. It may be inferred that the socket-shield does not interfere with adequate osseointegration, and merely serves to support the tissues facial to the implant. After submission of this histologic evidence for peer-review, authors Mitsias and coworkers had reported histology of a similar technique—the root membrane. While differing from the socket-shield by preparing the implant osteotomy through the tooth root, the authors similarly reported the presentation of bone between implant and root dentin. In this case presentation, a vertical root segment that spanned implant apex to collar was observed and living, ordered bone that interfaced between inner dentin and implant threads. It appeared from the radiograph that the root fragment extended beyond the bone crest, and it is now known today from Gluckman and coworkers that that is not a desirable preparation. Had the root fragment in the case presented here been reduced with a diamond bur and high-speed handpiece, the peri-implant tissues may have returned to optimal health. It is debatable whether the root contributed to the peri-implant bone loss, since bone loss can also be noted farthest from the root at the implant’s distal aspect. Literature reporting 5-year follow-up has demonstrated the contrary, that crestal bone is maintained by the socket-shield. Thus, possibly, were this root fragment prepared strictly according to steps described previously, the peri-implant bone level may have been maintained.

CONCLUSIONS

Bone can occupy the space between an implant surface and a socket-shield, as is the desired outcome of an osseointegrated implant.

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REFERENCES