A Step-by-Step Description of PDL-Mediated Ridge Preservation for Immediate Implant Rehabilitation in the Esthetic Region

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The aim of this study was to present in detail the clinical steps of the root-membrane technique. This technique combines the benefits of conventional root submergence via intentional maintenance of a root fragment for ridge preservation with those of immediate implant placement for functional rehabilitation of the treated site. A case study of a tooth diagnosed with a horizontal root fracture is used to illustrate this technique step by step. The clinical application of the root-membrane technique not only allowed for immediate placement in a site with compromised buccal plate but also facilitated excellent clinical stability of soft tissue contours during the 3 years of follow-up. (Int J Periodontics Restorative Dent 2015;35:835–841. doi: 10.11607/prd.2148)

Extraction of a tooth triggers a cascade of events that lead to ridge resorption. Even with the introduction of atraumatic techniques for socket preservation and the advancement of biomaterials used in conjunction with these techniques, ridge resorption can only be partially countered. Partial preservation of the alveolar dimensions may be adequate for implant placement in posterior sites, but esthetic implant placement in the maxillary anterior region remains elusive with conventional treatment approaches.

In an attempt to overcome this challenge, researchers have revisited the approaches used for ridge preservation by maintaining the natural attachment apparatus of the tooth. The application of the root submergence technique ensures hard and consequently soft tissue dimensional stability that provides favorable esthetics but does not yield any functional benefit, as the area can only be used as a pontic site. Recently, a novel approach was introduced whereby only a portion of the root is retained and subsequently submerged in proximity to an immediately placed implant. This approach serves a dual purpose: the retained root fragment aids in the strategic preservation of tissues of the periodontium (root-membrane), while the immediately placed implant allows for the functional...
rehabilitation of the area. The first clinical study reporting successful longitudinal outcomes of the root-membrane technique was recently published, instigating widespread clinical use. Results from Siormpas et al showed excellent medium- and long-term implant survival with no implant failures recorded in a large cohort of patients. The same study showed a clinically insignificant proximal crestal bone loss of approximately 0.2 mm after a median of 40 months. As this study provides the only longitudinal data currently available on the clinical use of the root-membrane technique, it has shaped the indications for its use: adult healthy patients, single maxillary teeth with no signs of moderate or severe periodontal disease (< 3 mm attachment loss), and no signs of acute inflammation.

Preceding this auspicious beginning for the clinical application of the root-membrane technique, several animal studies supported the biological plausibility of osseointegration of implants placed in proximity to retained root fragments. Animal studies have shown that osseo/dentointegration of implants is feasible and that intentional retention of a buccal root fragment prevents osteoclastic remodeling and consequent resorption of the buccal plate. A common pattern seen in these studies is the formation of new cementum on the internal dentinal surfaces of the retained root fragment connected with mineralized tissue on the implant surface. Schwarz et al published histological results of the integration of an implant in the dentin of an unintentionally retained root fragment, a perfect exemplar of seminal yet serendipitous scientific advancement. The elaborate histological and immunohistochemical analysis provided in this study lends some insight into the biological basis of immediate implant techniques, such as the root-membrane technique and the socket-shield technique, that are based on PDL-mediated ridge preservation. The authors found that following trauma during implant site preparation, reparative dentin was formed on the exposed dentinal surface of the retained fragment that bridged the distance between the root fragment and the implant. This mineralized tissue provided what the authors named “dentointegration” on the implant-root interface at a pace equivalent to that of osseointegration noted on the implant-bone interface on the remaining implant surfaces.

Based on the promising published data in favor of the use of this technique, the aim of this article was to demonstrate the technique for PDL-mediated immediate implant placement on a step-by-step basis and to facilitate the application of this novel technique in clinical practice.

**Case study**

A 37-year-old female patient with noncontributory medical history presented for an emergency evaluation in a private clinic with a chief concern of pain following trauma in the maxillary anterior region. The patient was a nonsmoker and had no history of periodontal disease. Clinical assessment revealed a horizontal fracture line in the cervical region of the right maxillary central incisor (Fig 1). Both percussion and cold testing yielded positive responses. The patient’s overall oral hygiene level was very good (plaque control record: 9%) with no sites having probing depths greater than 3 mm. The gingival zenith of both maxillary incisors was at approximately the same level, located 0.5 mm coronally to that of the lateral incisors. A minor degree of supereruption of the involved central incisor was noted. When the patient was asked about this finding she reported having a diastema in adulthood that eventually closed due to shifting of the teeth. The patient requested that recreation of the pre-existing diastema be considered in the final prosthetic restoration.

Radiographic assessment revealed very good bone levels around the neighboring teeth. A continuous radiolucent horizontal
line was visible at the level of the cementoenamel junction of the involved maxillary incisor consistent with the clinical diagnosis of horizontal root fracture (Fig 2). No signs of periapical pathosis were noted. Further radiographic assessment via cone bean computed tomography (CBCT) was pursued to evaluate the condition of the buccal plate of the hopeless tooth. Analysis of the cross-sections revealed a very thin buccal plate with a width ranging from 0.2 to 0.7 mm (Fig 3).

Alternative treatment plan options for the replacement of the hopeless tooth were discussed with the patient. The patient requested to proceed with the least invasive treatment option and rejected the option of bone grafting or adjunctive use of biomaterials to aid in bone regeneration. The patient was also adamant about receiving a fixed interim restoration immediately postsurgery. The proposed treatment plan included preservation of the buccal portion of the root and implant placement with immediate nonfunctional loading. The patient accepted the treatment plan and signed an informed consent.

**Surgical procedure**

**Implant site preparation**

Following administration of local anesthesia and preoperative rinsing with 0.12% chlorhexidine, the fractured crown of the involved tooth was removed with extraction forceps by exploiting the horizontal fracture (Fig 4a). In cases where the crown cannot be extracted without damaging the root of the tooth, a conventional chamfer diamond bur is employed under copious irrigation until the remaining tooth structure is level with the gingival margin (Fig 4b). Care should be given during reduction of the buccal aspect of the root to ensure that it is reduced subgingivally but remains 0.5 to 1 mm supracrestally. The retained supracrestal fragment of the tooth functions as a pillar that supports the midfacial soft tissue via attachment of supracrestal collagen fibers. Subsequently, the implant placement procedure was initiated following the drilling sequence suggested by the implant manufacturer and using the implant drill through the long axis of the remaining root. The drilling was initiated by engaging the palatal aspect of the root so that the buccal aspect would remain intact following preparation of the implant bed (Figs 5a and 5b).

**Partial root extraction**

The goal after enlargement of the dentinotomy/osteotomy was to have an implant housing composed of the mesial, distal, and palatal bony walls while the buccal wall was occupied by the retained buccal aspect of the root composed of a thin layer of dentin followed by cementum, periodontal ligament (PDL), and bundle bone in an orofacial direction. To achieve this goal, a conventional diamond chamfer bur was used to initiate two indentations parallel to the long axis of the root,
one at the mesiobuccal line angle of the hollowed root and one on the distobuccal. This separated the remaining root structure into a buccal fragment and a fragment consisting of the proximal and palatal aspects of the root. The proximal-palatal root fragment was easily retrieved with root tip forceps and removed with care to leave the buccal portion in situ (Figs 6a and 6b).

Root-guided implant placement
Following the selective retention of only the buccal portion of the root, the implant placement procedure was initiated. An important advantage of this technique is the guidance the root fragment provides for the ideal prosthetically driven positioning of the implant. With the exception of cases with pre-existing severe malpositioning of the tooth’s crown, the root fragment successfully serves the purpose of a surgical guide that functions in two distinct planes: the long axis of the root fragment aids in the mesiodistal positioning of the drills, while the volume of the root fragment in the buccal portion facilitates appropriate implant positioning in the palatal two-thirds of the socket.

Implant selection included a tapered implant. The rationale for selecting a tapered implant in conjunction with this technique is that it follows the natural contours of the mid- and apical portion of the root and allows for the retention of a root fragment with enough thickness to ensure resistance to fracture. The path of the osteotomy should be such that the implant threads are in proximity to the dentinal surface but will not cause unintentional dislodgement of the retained root tip due to excessive insertion torque at the time of implant placement. A 4 × 11.5-mm tapered, self-threading implant (AnyRidge, Megagen) was placed in direct contact with the dentin of the retained root fragment. The implant size was such that it would allow for the retention of a root section with approximately 1 mm to 1.5 mm thickness (Figs 7a and 7b). The implant was placed with an implant handpiece at 20 rpm and 40 Ncm torque. The tactile sensation during implant insertion was similar to that of placing an implant in type 2 bone.
Immediate restoration and postoperative regimen

Upon implant seating a titanium temporary abutment was placed and a cement-retained provisional restoration was fabricated using a routine provisionalization protocol. Following adaptation and polishing of the provisional, meticulous occlusal adjustment was performed using an articulating paper to ensure nonfunctional loading of the immediately placed implant (Fig 8). Postsurgical instructions included antibiotics (500 mg amoxicillin every 8 hours for 1 week) and analgesic medication (400 mg ibuprofen per pain) as well as chlorhexidine 0.12% oral rinses. The patient was also instructed to defer from tooth brushing or any mechanical trauma in the area for 2 weeks. Follow-up appointments were scheduled for 2 weeks, 4 weeks, and 3 months.

At the 3-month appointment the provisional prosthesis and abutment were removed and the condition of the root was clinically assessed. The peri-implant mucosa had completely covered the retained root and was attached on the implant (Fig 9). Probing around the implant did not reveal any pockets greater than 4 mm in depth. Palpation of the buccal tissues did not cause any subjective symptoms to the patient or reveal any signs of root displacement. The implant was therefore considered successful and clinically stable, and a definitive all-ceramic restoration was fabricated and cemented on a custom abutment as per routine clinical protocols.¹²

The patient was followed up annually for 3 years postloading. At the 3-year clinical evaluation the tissue stability was remarkable, with the gingival zenith being comparable to that of the neighboring native central incisor and the distal papilla completely filling the interdental embrasure. In the mesial aspect of the crown the midline diastema was reproduced based on the patient’s demand (Fig 10a). In the radiograph, the root fragment remained clearly visible in contact with the implant. Proximal bone levels were stable in comparison to baseline. No abnormal reactions at the bone-implant interface were noted (Fig 10b).
Discussion

The implant rehabilitation of a single anterior maxillary edentulous site presents a unique challenge for the clinician due to the esthetic significance of this region. Various interventions have been recommended for achieving an esthetic soft tissue profile around single implants. These include the use of biomaterials, autogenous tissue grafts, advanced surgical techniques, and combinations of these. The factor that has been shown to contribute most heavily to peri-implant soft tissue esthetics is appropriate palatal positioning of the implant fixture. When implant positioning is ideal, the previously listed interventions for preservation of the mid-facial tissue profile remain equivocal.

The present clinical study demonstrated in detail the rudimentary steps of a novel technique for biologic preservation of the tissue contours around single implants in the esthetic zone. The root-membrane technique dictates the placement of an implant in proximity to a retained portion of the root of a hopeless tooth. The aim of maintaining the root fragment is preservation of the blood and cellular supply that stems from the PDL similar to the root-submergence technique, while the placement of an implant on the palatal aspect of the socket allows for the functional rehabilitation of the site. Thus, the root-membrane technique and similar techniques, such as the socket shield technique, can be better described with the scientific term “PDL-mediated ridge preservation for immediate implant placement.” In addition to the esthetic benefit of maintaining the natural tooth apparatus, it is the authors’ opinion that this technique bears psychological merit. Patients are frequently devastated by the idea of a tooth extraction, especially in the esthetic region. The partial maintenance of the root may prevent the psychological implications of a tooth extraction.

In the case example, a tooth with intact periodontium but poor prognosis due to a horizontal root fracture was successfully treated with PDL-mediated immediate implant placement. The decreased width of the buccal plate that was noted in the preoperative CBCT scan would otherwise prevent immediate implant placement in this site. Not only was immediate

Fig 8 (left) Immediately loaded provisional prosthesis restoring the diastema based on the patient’s preference.

Fig 9 (right) Tissue contours at the final impression appointment. The retained root fragment was fully submerged under the soft tissue.

Fig 10a Patient’s smile at the 3-year follow-up appointment. Note the excellent stability of the gingival zenith point.

Fig 10b Intraoral radiograph of the implant in proximity to the retained root fragment.
placement feasible with the use of the root-membrane technique, but the soft tissue contours demonstrated excellent clinical stability during the 3 years of follow-up.

In general, PDL-mediated immediate implant placement is reserved for cases that fulfill certain criteria. The authors carefully select cases that include healthy adults who maintain a good level of oral hygiene. Teeth with noticeable gingival recession or attachment loss due to a history of periodontal disease are not treated with this technique, as the preoperative tissue level will dictate the final esthetic outcome. Additionally, cases with acute inflammation associated with the root of the hopeless tooth are a clear contraindication for the use of PDL-mediated immediate implant placement. Cases that present with horizontal root fractures that extend subcrestally at the facial aspect of the root also are not routinely treated with this technique, as the benefit of retention of the coronal aspect of the root for attachment of the soft tissue is eliminated in such cases.

Conclusion

The present case study demonstrated the clinical steps of an immediate implant placement technique that is based on a biologic rationale for preservation of tissue contours around the immediate implant. Excellent esthetic results can be achieved under challenging clinical conditions using this technique with partial preservation of the natural tooth apparatus during implant placement. However, the small number of longitudinal studies available to evaluate results of the root-membrane approach and its technique-sensitive nature should lead clinicians to carefully select cases and perform close follow-up.

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References