

Immediate Loading of Implants Placed Into Fresh Extraction Sockets with Peri-Apical Lesions without Augmentation



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Abstract

The objective of the present study was to evaluate the clinical and radiographic outcomes of immediately placed OsteoCare implants into fresh extraction sockets of maxillary central incisor teeth with periapical lesions, without raising a flap and loaded immediately with the final abutments. All implants were restored immediately with provisional unsplinted acrylic resin crowns above their immediately placed final abutments. The final restorations were placed after 3 to 6 months. The parameters were reported immediately after implant placement and after 3, 6 and 9 months. The described technique included 20 patients of young age, with 3 cases failure. The present results showed promising data for immediate implantation and provisionalization to replace teeth with periapical lesions in the anterior maxilla. The technique applied in this study shortens treatment time and simplifies implant restoration for the dentist, as well as, for the patient. It is evident that the success of this technique requires good case selection, atraumatic tooth extraction, achieving and maintaining primary stability.

Key words: Immediate implantation; marginal bone defect; periapical lesion; immediate loading.

Since Brånemark¹ introduced the osseointegration concept in 1985, a healing period of at least six months has been recommended between tooth extraction and implant placement. In addition, the implant is placed after raising a full-thickness mucoperiosteal flap. It was also assumed that the implant should remain submerged in a load-free environment during the healing period, which is 3-4 months in the mandible and 6 months in the maxilla. After that, a surgical exposure of the implant can be made, the abutment connected and the restoration placed (Adell *et al.*², Brånemark *et al.*¹). This prolonged time after tooth extraction and full-thickness mucoperiosteal flap reflection result in buccal bone resorption and soft tissue loss. Thereby, the final esthetic results may be compromised. In the anterior maxilla, the labial plate of bone is thin and more prone to postextraction resorption.³

Since the maintenance of an existing anatomical structure is easier than its re-construction, immediate total replacement of failing teeth with dental implants was suggested. Immediate implantation has provided the opportunity to achieve better and faster functional and esthetic results. Numerous studies have reported predictable results for immediate implant placement into fresh extraction sockets, with and without bone grafting materials and barrier membranes.⁴⁻¹⁴

Immediate implant placement into fresh extraction sockets with a pathologic lesion is considered a contraindication by many authors including Saadoun³, Block & Kent¹⁵ and Sclar.¹⁶ The authors considered immediate implant placement following tooth extraction is indicated only when the extraction socket is intact and free from any pathologic lesions. Cavacchia & Bravi¹⁷ recommended that the extraction socket should be free from residual infection, but there is a chance of success if there is no active suppuration, pain or swelling. In other words, the granulation tissue associated with chronic infection does not contraindicate immediate implant placement. Nemcovsky *et al.*⁸ however recommended delayed/immediate implant placement; timing of implant placement can be delayed for 4-6 weeks after tooth extraction if there is a periapical infection. Immediate implant placement in the presence of active periapical infection has been reported by Novaes & Novaes¹⁸, Novaes *et al.*¹⁹, Rosenquist & Grenthe.²⁰

Once the idea of immediate implant placement was accepted, the next logical question was whether this dental implant can be immediately restored, at least with a provisional restoration. The idea of immediate implantation, without raising a flap and immediate provisionalization has emerged as an alternate approach that can increase patients' acceptance of implant treatment, shorten treatment time, reduce patient discomfort, and thereby providing patients with a simplified quick restoration.

Recently, clinical studies have demonstrated that implants with rough surfaces can be loaded at earlier times, thus, reducing the period between surgery and restoration. Grit-blasted and acid-etched implants are in this category, and their early loading in patients with good bone quality and quantity has been proven to be successful. OsteoCare implants (OsteoCare™ International, Colnbrook, England)

used in this study, are characterized by grit-blasted and acid etched surface. Implants with rough surfaces achieve faster and better osseointegration, greater bone implant contact (BIC), higher removal torque values and better primary stability than do implants with smooth surfaces. Therefore, they can be loaded at earlier times, thus, reducing the period between surgery and restoration. Grit-blasted and acid-etched implants are in this category and their early loading has been proven to be successful in previous studies^{3,21-26} that recommended using such implants with rough surfaces for immediate placement and provisionalization.

The idea of immediate provisionalization of immediately placed dental implants was introduced and applied in some recent studies. At the beginning, most studies such as those by Balshi & Wolfinger⁷, Cooper *et al.*²⁷, Petropoulos *et al.*²⁸, involved implant placement in the interforamina area of the mandible; where the densest bone is located. Implants in these studies were bilaterally splinted and retained overdentures or fixed bridges. Later, other researchers applied immediate loading of immediately placed dental implants for single-tooth implant restorations. Provisional restorations for single tooth implants can be a modified denture tooth processed into the base of acrylic partial denture²⁹, provisional Maryland bridge³⁰, the crown of the extracted tooth itself if it is sound³¹ or simply a provisional acrylic single crown.^{3,32,33} Garber *et al.*³⁴ reported excellent results with anterior single-tooth implants that were provisionalized after 3 weeks. The provisional restoration was kept nonfunctional out of occlusion for 6 to 8 weeks after which the final restoration was placed. The authors concluded that if woven bone begins to form in a matter of weeks and lamellar bone is preferred for better stress distribution, early loading may be beneficial to bone formation. Thus, immediate total tooth replacement allows maintenance of the bony housing and soft tissue that was present before extraction, while establishing root form anchorage in the bone for esthetic restoration. Locante³⁵ in his study which was conducted on 55 patients, reported a success rate over 98%. In his study, Zimmer Spline Twist MP-1 implants were placed immediately after extraction to replace anterior teeth from the second premolar forward, using a flapless surgery, seating the final angled abutments and placing nonfunctional immediate provisionals for 6 months before the final restorations were placed. Jo *et al.*³⁶ demonstrated a 98.9% success rate for implants placed in fresh extraction sockets and immediately loaded. However, the authors attributed this favorable result to the expandable implant system used. Similar results were documented by Saadoun³ who performed immediate implant placement and temporization in extraction sites, with only a 4.48% failure rate. Similarly, Kan *et al.*³⁷ evaluated immediate implant placement and provisionalization of maxillary anterior single HA-coated threaded implants in 35 patients. The study suggested that favourable implant success rates can be achieved, with good peri-implant tissue responses and aesthetic outcomes. Moreover, Lorenzoni *et al.*³⁸ reported 100% survival rate in a very similar study to the present study. The authors evaluated the clinical outcome of immediate loading of single-tooth implants placed immediately after extraction.³⁸ Stepped-screw type grit-blasted acid etched Frialit-2 Synchro implants were placed into fresh extraction sockets in the incisal maxillary region. After implants were inserted, the angled abutments were seated and immediately restored with unsplinted acrylic provisional crowns. The final

crowns were inserted 4-6 months after implant placement. No implants failed up to 12 months after insertion, resulting in 100% survival rate and all implants maintained excellent peri-implant soft tissue conditions.³⁸ This study however included insertion of the implants with increasing the torque up to 45 N/cm and wearing an occlusal splint for 8 weeks. Similarly, Norton *et al.*³⁹ demonstrated that immediate temporization of Astra Tech ST implants, placed immediately after extraction in the maxilla, can be safe, predictable and yield favourable soft tissue aesthetics. The survival rate in that study was 96.4%. On the other hand, Chaushu *et al.*⁴⁰ in their study, reported that immediate loading of implants placed immediately into fresh extraction sites may carry a risk of failure in 20% of the fixtures. The survival rate was 82.4% for immediately loaded single-tooth implants placed into fresh extraction sockets compared to 100% survival rate for immediately loaded single-tooth implants placed in healed sites. Cavacchia & Bravi¹⁷ recommended that implants placed into fresh extraction sockets should not be loaded immediately. Similarly, Sclar¹⁶ in 2004 considered loading of the fragile buccal plate of bone and encroachment on the interproximal bone causes bone resorption, recession and blunting of the papillae. The rationale for recommending delayed loading is that immediate loading carries a risk for reduced BIC, fibrous encapsulation of the bony defect and apical epithelial migration. In addition, there are several case reports of immediate provisionalization of immediately placed different types of implants by; Kios & Kan²⁹, Touati & Guez³⁰ using Replace Nobel Biocare and Frialit-2 implants, Wöhrle³¹ using Replace Steri-Oss implants, Park *et al.*³² using Osseotite 3i implants, Leary & Hirayama³³ using Bicon implants, Baumgarten *et al.*⁴¹ using Certain Pervail 3i implants.

Primary implant stability is in general a key factor to consider in implant success before attempting immediate loading. It becomes even more crucial in cases of immediate loading of implants immediately placed into fresh extraction sites, as was mentioned by Touati & Guez³⁰ and Lorenzoni *et al.*³⁸ The surgeon should consider that during the first 4-6 weeks after surgery, primary stability actually decreases due to the remodelling phase of necrotic bone, caused by surgical trauma.¹ Therefore, the implant has to be firmly anchored to the bone immediately after its surgical placement, as was assured by Cavacchia & Bravi.¹⁷ Primary stability depends on the surgical technique of implant installation and proper implant selection. The objective of the present study was to evaluate the clinical and radiographic outcomes of immediately placed OsteoCare implants into fresh extraction sockets of maxillary central incisor teeth with periapical lesions, without raising a flap and loaded immediately with the final abutments.

Material & Methods

Twenty patients were selected from the Outpatient Clinic of the Oral Surgery Department, Faculty of Dentistry, Alexandria University. Patients were 17-25 years old and were of both sexes. All patients were free from systemic and local health conditions that can compromise implant success. All patients were nonsmokers, had good oral hygiene, good periodontal status of all teeth, adequate posterior support, adequate inter-arch relationship and interocclusal space that could accommodate the implant abutment and the future crown restoration, had opposing natural teeth, and had no parafunctional habits. All patients signed an informed consent before starting the treatment.

Immediate implantation was performed to replace teeth with periapical lesions, such as; badly decayed teeth that can not be restored, teeth with failed endodontic treatment, fractured teeth after endodontic treatment and teeth with fractured roots after facial trauma. All extracted teeth were maxillary central incisor teeth, had no periodontal disease and no mobility.

Implant System

OsteoCare endosseous root-form implants (OsteoCare™ International, Colnbrook, England), were used in this study. The advanced implant is formed of two-pieces; the implant body and the abutment, with an internal hex connection.

Implant Body

Advanced implants (Fig. 1) are made from Grade II Titanium, with internal hex connection, double-threaded, with grit-blasted and acid-etched surface and have a flared neck characterized by grooving and acid etching. The implant is available in two diameters; 3.75 mm and 4.50 mm, with a wide range of lengths; 8 mm to 18 mm, according to each case requirement.

Implant Abutment

OsteoCare abutments are made of Titanium alloy and can be prepared if needed (Fig. 2). They are available in different angulations from 0 to 45 degrees and in two lengths; 3 mm and 5 mm and in diameters 3.75 mm and 4.5 mm. Implant abument Trial Abutment is tried by engaging the internal hex in the implant fixture with the hex on the bottom of the trial abutment (Fig. 3). A hole also passes through each trial abutment to facilitate rotation with the hex tool situated in the base on the trial abutment stand. The selected abutment is seated and fixed to the implant internal hex by a retaining screw.

Pre-Operative Phase

A- Clinical & Laboratory Procedures

Clinical examination included evaluation of the condition, periodontal status and mobility of the tooth to be extracted and all adjacent and opposing teeth. Inter-arch relationship and interocclusal space that could accommodate the implant abutment and the future crown restoration was evaluated both clinically and by the aid of diagnostic study models. A distance of at least 8-10 mm was required. Alveolar ridge width was determined by direct measurement at 3 different points at the buccal side, using the penetrating bone caliber under local analgesia. Scaling of all teeth was performed and oral hygiene measures were re-enforced and explained to each patient. Then, the shade was selected and the acrylic resin provisional restoration -replacing the to be extracted tooth- was fabricated on the study model with a contour and dimension similar to that of the contralateral tooth. The provisional was free from occlusion in centric and eccentric relations (protrusive contact and lateral excursion) and was designed leaving a 1 mm space mesially and distally to avoid any micromotion caused by the physiologic tooth movement of adjacent teeth. The provisional crown used was either an acrylic denture tooth or an acrylic shell crown of appropriate size, shape and shade. Then, the tooth was removed from the cast, the cast was lubricated and the crown was adjusted by self-cure acrylic resin.

B-Radiographic Evaluation

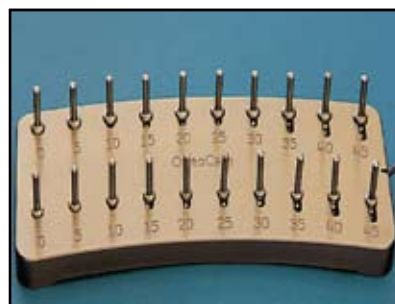
Orthopantomogram (OPG) radiographs were taken to show



◀ (Figure 1)
OsteoCare implant fixture.



◀ (Figure 2)
OsteoCare implant angulated abutments.



◀ (Figure 3)
Trial abutments kit.

an overall view of the maxilla and the mandible, existing teeth, amount of bone beyond the root apex, root length, root angulation, proximity to vital structures, i.e.; nasal floor and presence of any pathological conditions.

Direct digital standardized peri-apical radiographs were taken using an x-ray machine (Heliodont Ds, Siemens Aktiengesellschaft, Germany) to show the bone beyond the root apex, the mesial and distal bone surrounding the tooth to be extracted, root length and angulation, the distance and relation between the root of the tooth to be extracted to the roots of adjacent teeth, the corresponding tooth root in the adjacent quadrant and relation of the root to the nasal floor and presence of any periapical lesion. Direct digital standardized radiographs were taken using XCP (Extension Cone Paralleling technique) to keep a standard distance from the x-ray tube, as well as a fixed direction of the x-ray beam in relation to the implant. The distance was measured from the x-ray tube to the sensor holder to be applied every time. After, the exposure time was adjusted, the Sidexis sensor (Sidexis, Sirona, Germany) was connected to the XCP sensor holder and the angulation of the x-ray tube was adjusted and the tube was connected to the ring of XCP. Then, the sensor was placed into the patient's mouth, parallel to the implant to be exposed to x-rays (Fig. 4).

One day prior to the surgery, each patient was instructed to start the prophylactic broad-spectrum antibiotic therapy in the form of 500 mg of anhydrous Cephalexin tablets (Ceporex™ tablets, GalaxoWellcome, Ireland) three times daily and the non-steroidal anti-inflammatory analgesic drug in the form of 20 mg Piroxicam tablets (Feldene tablets, Pfizer Inc., USA), twice daily.

(Figure 4) ▶
Sensor Connected to the
XCP sensor holder inside the
patient's mouth.



Operative Phase

Surgical Technique

The patients were operated upon under local infiltration anesthesia applied buccally at the surgical site and accompanied by nasopalatine nerve block anesthesia. The anaesthetic solution used was Mepevacaine Hcl 2% with vasoconstrictor as Levonordefrin 1:20,000. Each patient received 2-3 anaesthetic carpules.

A periodontal probe was placed between the tooth root and bone to circumferentially cut the periodontal ligament fibers and facilitate extraction. The tooth was then gently extracted by extraction forceps, with minimum surgical trauma and without any damage to the adjacent soft or hard tissues. The bony socket was then carefully debrided with a sharp curette to remove any granulation or fibrous tissue present and irrigated with sterile saline. Integrity of the socket walls and socket depth from the alveolar crest of bone to the socket apex were checked with the osteotomy probe. Depth of the socket was measured to determine the drilling needed after the root apex.

No incision or flap was performed. The osteotomy was prepared through the socket opening with copious sterile saline irrigation, using the socket walls as a guide. Osteotomy extended for at least 3-4 mm beyond the original root apex. Drills were used according to the manufacturer's recommendations. The last drill was 0.5 mm less than the implant diameter. Drilling extended at least 3-5 mm beyond the root apex and extended 2 mm more than the implant length. Osteotomy probe was used to check the depth of the osteotomy after drilling. Then, the osteotomy was irrigated with tetracycline solution as Tetracycline Hydrochloride 500 mg capsule (Tetracid capsules, CID Co., Egypt) dissolved in saline solution, for detoxification of the osteotomy.

OsteoCare implant was then manually screwed into the osteotomy, until there was resistance. The implant mount was removed and final seating of the implant was achieved by ratchet wrench until the implant shoulder was flushed with the level of alveolar crest of bone buccopalatally. It was placed 3-4 mm beyond the lowest point of adjacent labial gingival margin checked by the periodontal probe, to maintain a shallow sulcus. Then, the torque wrench was used to check the primary stability at 35 N/cm. After using the trial abutments kit (Fig. 3), implant abutment with suitable angulation was selected, adjusted outside the patient's mouth and then seated and tightened to 35 N/cm by the torque wrench. Final preparation of the abutment was completed with carbide bur at high speed with profuse irrigation. The implant was immediately restored with a provisional crown over the implant abutment and kept out of occlusion as verified with an articulating paper. A small piece of cotton was placed into the abutment hole to protect

the screw hole from being blocked with temporary cement. Then, the provisional crown was seated with a thin layer of temporary cement (Provy, Dentsply, Latin America) and the excess was removed with a dental floss.

Post-Operative Phase

Post-operative instructions were given to the patients, which included extra-oral ice packs application for 2 hours on the first day to minimize oedema, oral hygiene instructions including warm 0.2% Chlorhexidine Hcl (Hexitol mouthwash, The Arab Drug Co., Egypt) as an antiseptic mouthwash twice daily from the day of implant placement and continued for the whole treatment period, using soft toothbrush and gentle cleaning with dental floss, to eat soft diet and to avoid biting on the provisional crown, to continue the use of the pre-operative broad-spectrum antibiotic and to take the non-steroidal anti-inflammatory analgesic twice daily for 7-10 days.

Direct digital standardized peri-apical radiograph was taken immediately after implant placement to evaluate the implant position.

After one week, each patient was recalled and examined for the presence of any pain, swelling or mobility. After 3 months, the final impressions were taken directly on the implant abutment, after blocking the abutment screw access hole with a temporary filling. Impressions were made using rubber base impression material (Speedex, Coltene/Whaledent Inc., USA). The shade was selected and the final restoration was cemented with temporary cement, so that it could be removed if necessary.

Follow-up Phase

A-Clinical Evaluation

All patients were examined immediately after surgery and during the first week to check if there was pain, discomfort, swelling, or infection. Then, the following clinical parameters were used to clinically evaluate the cases after 3, 6 and 9 months after insertion of the final restoration. Assessment of the plaque was made according to 1964 Silness & Loe plaque index.⁴² The peri-implant mucosa was evaluated visually and by probing, according to the 1963 Loe & Silness⁴³ classification. The probing pocket depth around the implant was measured at the four aspects of the implant; facial, palatal and proximal surfaces, using the probe graduation in mm, according to the 1978 Harvard conference.⁴⁴ The integrity of the interproximal papillae was assessed by Papilla Index Score (PIS), which is an index evaluating the size of interproximal papillae adjacent to the single-implant restoration according to Jemt in 1997.⁴⁵ Implant mobility was assessed manually according to the criteria by McKinney & Koth in 1982.⁴⁶

B-Radiographic Evaluation

The digital radiography system and technique was as that used pre-operatively and applied immediately after implant placement, after 3, 6 and 9 months. The digital sensor connected to the XCP sensor holder, was placed into the patient's mouth parallel to the implant to be exposed to x-rays (Fig. 4). The image appears on the computer screen immediately (Fig. 5).

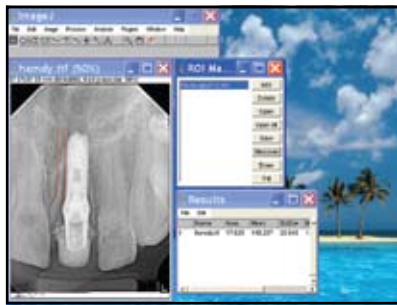
Assessment of bone density

The peri-implant bone density was measured by a computerized

(Figure 5) ▶
Digital image appears immediately on the computer screen.



(Figure 6) ▶
"ROI" selected to measure bone density.



(Figure 7) ▶
Assessment of marginal bone level.

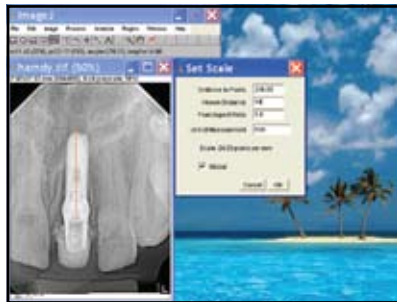


image J program. From "ROI" manager, "Measure" command was selected to give the mean gray value (mean density) of the "ROI" (Fig. 6). The "ROI" was selected mesially, distally and apically to the implant. The mean was calculated immediately postoperatively as the base line and after 3, 6 and 9 months. The Image J program translates the degree of darkness and lightness into a numerical value. The degree of blackening and whitening (radiolucency and radio-opacity) indicates the degree of bone density. In this program, the numerical values range from 0 (darkest) to 255 (lightest). Mean Gray Value (average gray value within the selection) is obtained by the sum of the gray values of all the pixels within the selection, divided by the number of pixels.

Assessment of marginal bone level

The saved image was opened with Image J program. The scale was determined in reference to the known implant fixture length. From "Analyze" command, "Set Scale" command was selected to convert pixels dimension to millimeters. A line was drawn from the implant apex to the implant shoulder. The length of the implant fixture was measured and compared to the real fixture length to determine the magnification factor in the image (Fig. 7). The distance from the implant apex to the first seen point of Bone-Implant Contact was measured. The difference between it and the implant length represents vertical marginal bone defect. The measurements were noted mesially and distally and the mean was calculated in mm according to the magnification factor of the image immediately following implant placement (baseline) and after 3, 6 and 9 months.

Clinical Case Reports

Case No. 1

A 21-year-old male patient was referred to extract a badly decayed non-vital maxillary central incisor tooth with a radiolucent peri-apical lesion (Fig. 8). There was no pain during surgery and there were no post-operative pain nor oedema. During the first week after implant placement, implant mobility grade 2 was detected because the patient had replaced a composite filling in the mandibular incisor that was high. After the composite filling was adjusted and the provisional restoration was splinted to adjacent teeth, there was no mobility of the implant. The final crown was placed three months after surgery. Apart from this, the periapical lesion healed successfully during the follow-up (Fig. 8-N, O, P, Q, R) and it can be observed that bone healing goes apically with a reduction of marginal bone defect. There was no mobility throughout the research; however, there was slight resorption of the buccal plate of bone (Fig. 8-K, L).

Case No. 2

An 18-year-old female patient was referred to extract a maxillary central incisor tooth due to fracture of an endodontic file inside the tooth root during endodontic treatment (Fig. 9). The periapical radiograph revealed that the file has perforated the root apex and there was periapical radiolucency (Fig. 9-O, P). The patient felt very mild pain during surgery and in the first day of surgery. There was mild post-operative oedema on the day after surgery. The periapical lesion healed successfully during the study (Fig. 9-Q, R, S, T) and there was no mobility. After 3 months, healing of soft tissues around the implant abutment and the emergence profile (Fig. 9-M) can be observed due to the provisional restoration.

Results

A-Clinical Results

Of the total number of 20 implants placed, three implants were lost.

Statistical Analysis

The paired t test was used to compare the results pre-operatively, immediately after implant placement, after 3, 6 and 9 months, at 5% level of significance ($P < 0.05$).

Pain & Swelling

All patients felt very minimal to no pain during surgery and on the first day. Post-operative discomfort and post-operative oedema were very minimal and unobserved.

Infection

In only one case the implant became mobile and was removed due to pus from around the implant. In the other cases, the periapical lesions healed successfully during the follow-up.

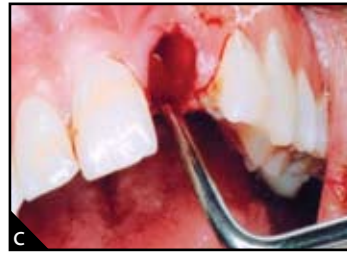
Plaque Index (PI)

The plaque index was reduced by time in all cases. This reduction was significant after 6 months, then, there was a non-significant reduction after 9 months, at 5% level ($P < 0.05$), (Table 1). After 3 months, mean plaque index value was 1.00 ± 0.35 , after 6 months the mean plaque index value was 0.82 ± 0.40 and after 9 months, mean plaque index value was 0.71 ± 0.30 .

Gingival Index (GI)

The GI after 3 months ranged between grade 2 and grade 1.

(Figure 8) Extraction, immediate implantation and provisionalization of case 1



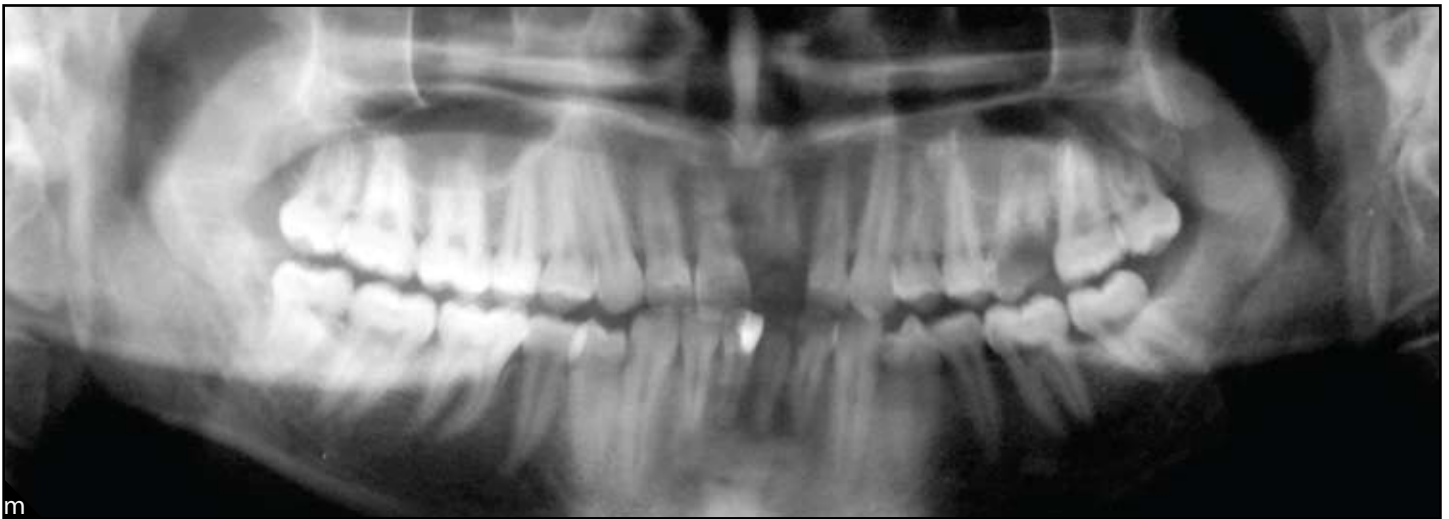
a) Preoperatively; badly decayed root of maxillary left central incisor tooth. **b)** Atraumatic extraction. **c)** Curettage of the extraction socket. **d)** Drilling at least 3-4 mm beyond the original length of the extraction socket.



e) Manual placement of the implant into the osteotomy. **f)** Wrenching after feeling resistance to manual implant placement. **g)** Using the trial abutment to choose the proper angulated abutment. **h)** Placing the final angulated abutment.



i) Angulated abutment seated. **j)** Provisional crown placed. **k)** Final crown placed after 3 months. **l)** Resorption of the buccal bone.



m) Pre-operative OPG.



n) Pre-operative.

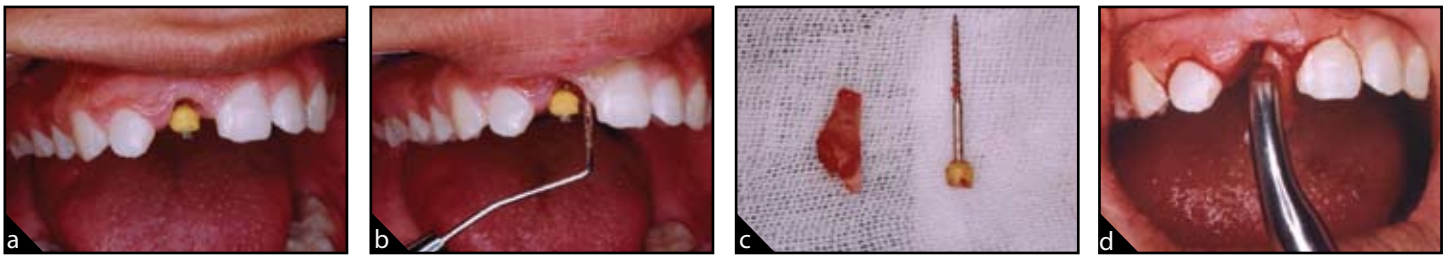
o) Immediate Post-operative x-ray.

p) After 3 months.

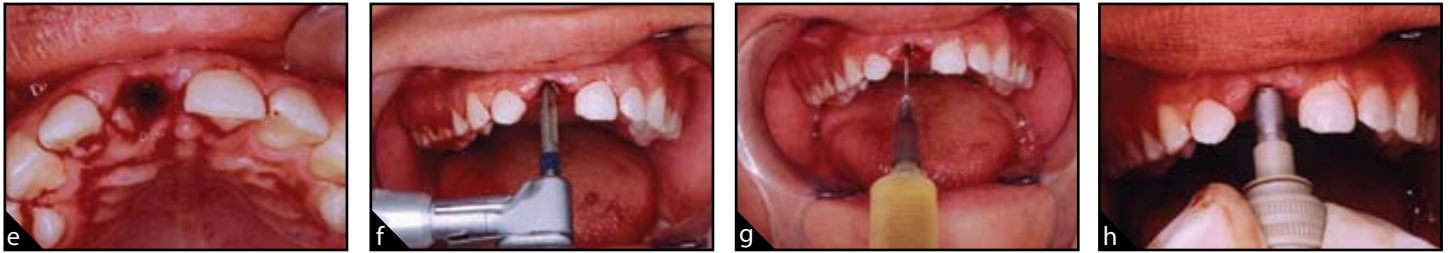
q) After 6 months.

r) After 9 months.

(Figure 9) Extraction, immediate implantation and provisionalization of case 2



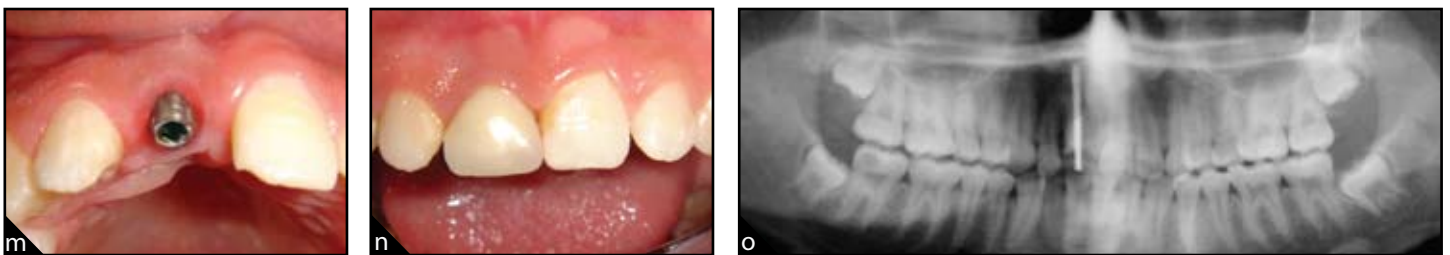
a) Preoperatively; an endodontic file broken inside the root of a maxillary right central incisor tooth. **b)** A periodontal probe is inserted between the root and the bone to cut the periodontal ligament fibers circumferentially around the root to facilitate its extraction. **c)** The file was unscrewed, then the remaining root was removed. **d)** Atraumatic extraction.



e) The socket immediately after extraction. **f)** Drilling at least 3-4 mm beyond the original length of the extraction socket. **g)** Irrigation of the osteotomy with tetracycline solution. **h)** Placing the implant manually into the osteotomy.



i) Seating with over hex driver. **j)** Wrenching. **k)** Placement of the angulated abutment. **l)** Provisional crown placed.



m) After 3 months, healing around the implant abutment with proper emergence profile. **n)** Final crown placed, with maintenance of soft and hard tissues contours. **o)** Pre-operative OPG.



p) Pre-operative. **q)** Immediately Post-operative. **r)** After 3 months. **s)** After 6 months. **t)** After 9 months.

(Table 1): Mean Plaque Index

Case No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
After 3 months	0.75	-	0.75	0.75	1.00	0.75	1.50	1.50	1.75	1.75	2	2.25	2.50	1.00	1.25	1.50	1.50	1.75	0.75	2.25
After 6 months	0.50	-	0.50	0.50	0.75	0.75	1.50	1.25	1.50	1.50	1.75	2	2.25	0.75	0.75	1.25	0.50	1.50	0.50	2
After 9 months	0.50	-	0.50	0.50	0.75	0.50	1.25	1.00	1.50	1.25	1.50	2	2	0.75	0.50	1.25	0.50	1.50	0.50	1.75

(Table 2): Mean Gingival Index

Case No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
After 3 months	1.25	-	0.50	0.50	1.00	0.75	2.25	2.25	2.00	1.75	1.25	0.50	0.75	1.75	1.25	0.50	2.50	2.75	2.00	1.75
After 6 months	1.00	-	0.25	0.50	0.75	0.50	2.25	2.00	1.75	1.50	1.00	0.50	0.50	1.75	1.00	0.50	2.25	2.25	1.50	1.25
After 9 months	0.50	-	0.25	0.25	0.50	0.50	2.00	1.75	1.75	1.50	1.00	0.25	0.25	1.50	0.50	0.50	2.25	2.00	1.25	1.25

(Table 3): Mean Probing Depth

Case No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
After 3 months	2.25	-	2.00	2.00	2.25	2.00	3.00	2.75	2.50	2.50	2.00	1.75	1.75	2.25	3.00	2.00	2.25	2.25	1.75	1.50
After 6 months	2.00	-	1.75	1.75	1.75	1.75	2.75	2.50	2.25	2.25	1.75	1.50	1.75	1.75	2.50	1.75	2.00	1.50	1.25	1.25
After 9 months	1.75	-	1.50	1.75	1.75	1.50	2.50	2.25	2.00	2.25	1.75	1.50	1.50	1.75	2.25	1.50	1.75	1.50	1.25	1.25

(Table 4): Mean Bone Density

Case No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Imm. Post-op.	129	-	127	140	98	126	143	139	109	112	133	143	129	117	153	92	122	136	132	129
After 3 months	131	-	132	143	112	130	146	143	124	129	145	155	138	133	166	114	134	143	142	133
After 6 months	145	-	142	150	126	137	154	149	134	136	149	159	146	145	173	122	139	150	157	149
After 9 months	151	-	146	155	133	148	159	154	141	150	156	164	159	161	178	135	144	158	164	153

(Table 5): Mean Marginal Bone Level

Case No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Imm. Post-op.	5.1	-	2.9	3.9	5.2	4.8	3.4	3.7	2.5	1.9	1.7	3.4	3.3	4.1	3	4.7	1.7	2.9	3.1	2.4
After 3 months	3.5	-	2.3	3.5	4.3	3.2	2.8	3.4	2.2	1.5	1.3	3.1	2.9	3.7	2.5	4.1	1.3	2.4	2.7	2.1
After 6 months	3.4	-	2.2	3.2	4.1	2.6	2.6	3.3	2.1	1.4	1.2	3	2.8	3.5	2.3	3.8	1.2	2.2	2.6	2
After 9 months	3.3	-	2.1	3.1	3.9	2.4	2.5	3.2	2.1	1.3	1.2	2.9	2.8	3.4	2.3	3.7	1.2	2.1	2.5	1.9

Then, it was ranging between grade 1 and grade 0 in all cases. There was a significant reduction in the mean GI, at 5% level ($P<0.05$) after 6 months and after 9 months (Table 2). After 3 months, mean GI value was 1.21 ± 0.76 , after 6 months it was 1.04 ± 0.78 and after 9 months it came down to 0.82 ± 0.73 .

Probing Depth (PD)

The PD started from 2 to 3 mm in labial and palatal sides, and 3 to 4 mm in proximal sides. Then, it was reduced to reach 1 mm in labial and palatal sides, and 2 to 3 mm in proximal sides. There was a significant reduction in the mean PD after 6 months, then, there was a non-significant reduction after 9 months, at 5% level ($P<0.05$) (Table 3). After 3 months, mean PD value was $2.32 \text{ mm} \pm 0.40 \text{ mm}$, after 6 months it was $2.04 \text{ mm} \pm 0.42 \text{ mm}$ and after 9 months it was $1.86 \text{ mm} \pm 0.38 \text{ mm}$.

Papilla Index Score (PIS)

In all cases the interproximal papillae filled the entire interproximal space, and were in good harmony with the adjacent papillae; PIS 3. The interproximal papillae of all cases were intact during implant placement and maintained throughout the study.

Implant Mobility (IM)

In the first case, mobility grade II was detected during the first week because the patient had placed a high composite filling

in the opposing mandibular incisor. After the composite filling was adjusted and the provisional restoration was splinted to adjacent teeth, there was no mobility of the implant. The final crown was placed three months after surgery. In another case, the implant became mobile during the first week and the implant was removed. In another case, mobility grade II occurred during the first month. The final crown was placed six months after surgery. Mobility grade II remained till the end of the follow-up period. No mobility was detected in the other cases throughout the study.

B-Radiographic Results

There was a significant increase in the mean bone density by time in all cases, at 5% level ($P<0.05$) (Table 4).

Discussion

The technique applied in this study included an atraumatic tooth extraction without raising a flap, drilling at least 3-4 mm beyond the root apex, implant insertion, attaching the final abutment and placing a provisional restoration free from occlusion at the same visit. The final restoration was placed after 3-6 months. Such technique simplifies the classical sophisticated implant placement technique, saves a lot of time as well as eliminates the necessity for grafting materials or barrier

membranes around the immediately placed implants. In addition, drilling only 3-4mm beyond the root apex protects the bone from excessive heat generation. The atraumatic extraction preserves the walls of the extraction socket and improves primary stability. In contrast, drilling into healed sites results in more heat generation and more postoperative pain and oedema, because more amount of bone is being prepared. This was assured in the studies done by Saadoun³, Garber *et al.*³⁴, Locante³⁵ and Lorenzoni *et al.*³⁸

The results of the present study indicate that immediately placed dental implants into fresh extraction sockets with periapical lesions, and immediate loading have favorable clinical and radiographic outcomes. All patients felt very mild to no pain during surgery and there was minimal to no postoperative pain or oedema. This is because drilling was performed only beyond the root apex, which minimizes heat generation and reduces the risk of overheating the bone. This was in agreement with the study of Schwartz-Arad & Chaushu⁴⁷ who reported that reducing the surgical trauma at the time of implant placement results in obtaining more vital bone in contact with the implant interface and thereby improving primary implant stability. It should be also notified that flapless implant placement reduces postoperative discomfort, pain and oedema since the periosteum is left intact.

Most patients were very keen to perform oral hygiene instructions after delivery of the final restoration. The plaque index and the gingival index decreased in all cases, revealing improved oral hygiene. The probing depth around the implants in all cases was reduced by time to reach 1mm in labial and palatal sides and 2 to 3 mm in proximal sides. Similar findings were reported by Al-Ansari & Morris⁴⁸ who demonstrated that placing dental implants without flap reflection resulted in probing depths of less than 2 mm around dental implants.

The papilla index score (PIS), described by Jemt⁴⁵, has been utilized in the present study as a simple technique for a more scientific evaluation of the integrity of the interproximal papillae mesial and distal to the single-implant restoration. This index was also used recently by Cardaropoli *et al.*⁴⁹ as one of the parameters to assess clinical alterations of peri-implant mucosa. The interproximal papillae in all cases were preserved and filling the entire interproximal space and in good harmony with the adjacent papillae with a PIS = 3. There was minimal to no recession, which provided good esthetic results. Our explanation is that this occurred as a result of placing the implants without raising a flap and leaving the periosteum intact on the bone, which provides most of the blood supply to the bone. Besides, whenever the papilla is detached from bone, the interproximal bone is denuded from the periosteum. This affects the vascular supply to the papilla in varying amounts, depending on the type of surgery. Thereby, raising a flap eventually leads to gingival recession, papillae destruction and crestal bone resorption as was explained by Campelo & Camara⁵⁰ and Covani *et al.*⁵¹. In addition, flapless implant placement offers other advantages such as, simplifying the procedure, reducing time of treatment, reducing or even eliminating post-operative discomfort, pain and oedema, allowing faster soft tissue healing around the implant, reducing possibility of contamination and infection and gaining excellent final aesthetics. According to Cardaropoli *et al.*⁴⁹, the surgical trauma caused by flap elevation induces

remodeling of the surface layer of alveolar bone that was exposed during flap elevation. The labial bony wall in the anterior maxilla is thin, porous and more prone to resorption; when a flap is raised and the periosteum is detached, buccal resorption becomes very prominent.

There are on the other hand some disadvantages of the flapless surgery. It prevents direct visualization of the bony configuration during drilling. Since flapless implant placement is a blind surgery, working blindly may lead to incorrect implant placement or perforation of the buccal plate of bone. Therefore, Campelo & Camara⁵⁰ considered preoperative CT scan a must before flapless implant surgery. Without raising a flap, it is more difficult to assess any bone defect during implantation. Besides, there is limited ability to augment the implant site, to place a barrier membrane and thus the ability to retain a grafting material is more complicated.

The possibility of incorrect implant placement or perforation of the buccal plate of bone is however more likely to occur in delayed implant placement and less likely to happen during drilling into fresh extraction sockets. When the tooth is extracted due to caries or failure of endodontic treatment, the alveolar bone surrounding the root is usually not resorbed at the buccal side and the walls of the extraction socket guide the surgeon to the osteotomy direction. Besides, bone resorption and presence of bone concavities are much more likely to exist in case of placing implants into healed sites after extraction (late implantation). Preoperative clinical, radiographic evaluation and careful drilling into the extraction socket would definitely prevent such complications.

In the case where implant mobility grade II was detected in this study, the patient had a new composite filling in the opposing incisor and the filling was high. After the composite filling was adjusted, the provisional restoration was splinted to the adjacent teeth with composite during the first month and the final restoration was placed three months after implant placement. Despite the fact that the preoperative periapical lesion healed gradually during the follow-up phase and marginal bone defect was reduced, there was however resorption of the buccal plate of bone that occurred during the first three months after implant placement probably due to excessive occlusal forces caused by the high composite filling placed on the opposing tooth during the healing phase. Therefore, it is recommended that the patient should not undergo any restorative treatment without consulting the treating dentist.

In another case in this study, the implant became mobile during the first week after its placement and was removed. The tooth that was replaced with this implant, was extracted due to the fracture of the post and part of the root canal treated tooth after trauma. Although there was no peri-apical radiolucency in the preoperative peri-apical and panoramic radiographs, there was external resorption of the apical third of the root. The cause of implant failure of this case cannot be related to loading because the provisional restoration was not placed after implant placement. It is most likely because of the poor primary stability after attaching the abutment to the implant fixture and due to the weakness of the buccal plate of bone during extraction. Another possible explanation of failure is the possible presence of peri-apical infection that was not apparent in the preoperative periapical or

panoramic radiographs and was not completely curetted after extraction.

Although immediate implant placement into fresh extraction sockets with pathologic lesion was considered a contraindication^{3,15,17}, Cavacchia & Bravi¹⁷ pointed out that there is a chance of success, if there is no active suppuration and the granulation tissue associated with the chronic infection does not contraindicate immediate implant placement. Presence of peri-apical lesions did not prevent success of the other cases in this research because there was no active infection. As we mentioned, immediate implant placement in the presence of active periapical infection has been reported by Novaes & Novaes¹⁸, Novaes *et al.*¹⁹, Rosenquist & Grenthe.²⁰ It has to be clarified that in the present study precautions were taken such as, good curettage of the socket after extraction, use of an antibacterial irrigant and prescription of a strong antibiotic pre and post operatively as was recommended by Gher *et al.*⁵². In addition, all patients who participated in this study were of young age and accordingly resolution of the periapical lesions with new bone formation is more likely to occur than in old patients who are more liable to infection and slow bone healing. In addition, since excessive occlusal forces would disturb bone healing and new bone formation, the provisional restoration that was free from occlusion gave the chance for the periapical lesion to heal with new bone formation.

The three failed out of twenty implants had no mobility and were successful according to the success criteria mentioned by Albrektsson *et al.*⁵³ The failure in these cases was due to an error in the preoperative evaluation and case selection not due to the technique itself (immediate implant placement and immediate non-functional loading).

Again, primary implant stability is the key factor to consider for immediate loading of implants placed immediately into fresh extraction sites. Therefore, patients with periodontal disease and teeth with clinical mobility were excluded from the study to ensure presence of sufficient bone for primary stability. Primary stability depends on the surgical technique of implant placement, proper implant selection and bone quantity and quality.

Regarding the surgical technique used, an absolute requirement of immediate implantation is that 3-4 mm of the implant fixture must be screwed into the bone. Drilling at least 3-4 mm beyond the root apex is mandatory to gain maximum degree of primary stability of the implant as was reported by many authors including Touati & Guez³⁰, Schwartz-Arad & Chaushu^{54,55}, Rosenquist & Ahmed⁵⁶, Nemcovsky *et al.*⁵⁷, Hämmerle *et al.*⁵⁸ The authors recommended using the longest and widest implant whenever possible to increase the bone-implant interface and primary stability. The wider the implant, the greater is the contact with the alveolar socket wall because of the conical shape of the top of the alveolar socket. The implant surface area screwed into the bone is the most reliable index of primary implant stability. Despite that sometimes a part of the implant surface was not completely covered by bone, the implant was stable because it was screwed into the bone more than 3 mm. Similarly, in this research, although the implant in some cases was not completely surrounded by bone coronally, there was good primary stability and there was no mobility. In addition, vertical marginal defects decreased and although did not heal

with bone completely in some cases, there was no mobility throughout the research. According to Juodzbalys¹¹, 30% is the minimal part of the implant surface area to be fixed in the bone and primary stability depends mainly on the implant length, implant width, as well as the depth of its insertion. It was calculated that the drilling must be more than 30% of the implant surface area taking into consideration that bone resorption occurs in the primary stage of osseointegration.

In the present study, a provisional acrylic single crown, free from occlusion, was placed on the implant abutment immediately after tooth extraction, implant placement and abutment placement. The provisional acrylic single crown was used in the present study because it is more hygienic for the patient. Block *et al.*⁵⁹ recommended that 1-2 mm of interocclusal space should exist between the provisional crown and the opposing teeth or restorations. The provisional restoration left 0.5-1 mm space at the mesial and distal margins to prevent micromotion on the implant due to physiologic movement of the adjacent natural teeth. Saadoun³ recommended using a provisional crown restoration that duplicates the contour of the contralateral tooth or the crown of the extracted tooth, if the crown is present. In the present research, immediate restoration with a provisional crown after tooth extraction had an excellent psychological effect on all patients. The provisional restoration role was not only to increase patients' satisfaction by restoring esthetics and phonetics during the osseointegration period. It also guides soft tissue healing around the implant abutment to develop the emergence profile, supports and maintains the papillary height and gingival contour throughout the healing period, provides ideal gingival architecture and interproximal papillae that blend with the gingiva overlying the adjacent teeth without structural or esthetic defects. Furthermore, placing the provisional restoration on the implant abutment with no occlusal contact is different from the submerged approach, where the implant is not exposed to any occlusal forces. Thus, presence of the abutment and the provisional crown allows progressive loading of the implant. In addition, it maintains the position of adjacent and opposing teeth.

Brunski⁶⁰ considered micromovement amounting to 100 µm as the threshold for smooth machined surface implants. More than 150 microns are sufficient to jeopardize healing and adversely affect osseointegration, resulting in fibrous tissue interface.⁶⁰ Morris *et al.*⁶¹ explained that bone responses to clinical loading may be below, within, or exceeding physiological limits. Loading the bone below physiological limits may result in bone resorption, whereas loading above physiological limits may in addition to bone resorption cause fracture failures and eventual loss of the implant. Thus, loading within acceptable limits serves to stimulate bone surrounding the implant and increase bone density. Thus, progressive loading of the implant by a provisional restoration improves the implant ability to withstand functional stresses. Similarly, Touati & Guez³⁰ explained that it is not early loading that cause fibrous tissue encapsulation, but the micromovement caused by insufficient primary stability or by excessive occlusal forces.

In the present study, there was a decrease in vertical marginal bone defect observed radiographically implying an increase in BIC. This can be explained due to the fact that healing of the extraction socket proceeds in an apicocoronal direction around

the implant as mentioned by Ten Cate *et al.*⁶² However, it has to be pointed out that the periapical radiograph reveals only the mesial and distal vertical marginal bone defects present around the implant. It does not show the depth of marginal defects present buccal and palatal to the implant. Besides, the BIC seen radiographically is not a direct bone-implant contact, because it is not histological data and it is not measured directly by a probe after raising a flap. In other words, radiographic examination displays the level of calcified bone located only mesial and distal to the implant. The marginal bone level at the buccal and palatal sides is not demonstrated radiographically. In the case of immediate implantation after extraction, blood, fibrous tissue or woven bone would be present, but not seen radiographically. In the present research, marginal defects decreased in depth, but did not heal completely with bone in all cases. Clinical examination of cases revealed that probing depth was not increased and there was no mobility. This means that these defects healed with fibrous connective tissue formation, instead of osseointegration. This was confirmed by Paolantonio *et al.*⁵, who reported in their study that when a screw type implant is placed into a fresh extraction socket, without using a barrier membrane or a bone grafting material, the clinical outcome does not differ from implants placed in healed, mature bone. Similar findings were reported by Botticelli *et al.*¹², who demonstrated by direct measurement, at the re-entry after 4 months of healing, that even wide and deep marginal defects exceeding 3 mm around SLA-modified surface implants placed with a non-submerged (one-stage) surgical protocol, may predictably heal, but not completely, with new bone formation and defect resolution.

Finally, proper patient/case selection is a very important factor to achieve success of this technique. The patient has to be in an ideal condition regarding any systemic health conditions that can affect the bone, performing good oral hygiene, has no parafunctional habits and with sufficient bone beyond the root apex of the tooth to be extracted. In addition, patient motivation and cooperation to follow instructions and the regular follow-up visits are crucial to achieve success. The patient has to be very understanding and willing to follow all instructions. Meanwhile, the patient should never undergo any restorative treatment without consulting the treating dentist, because any faulty restoration in the opposing dentition can cause excessive occlusal loads on the implant. The healing period after implant placement into fresh extraction socket is very critical. The bone should be left undisturbed to allow its normal healing. Therefore, any excessive functional or non-functional loading should be avoided.

Conclusion

In conclusion, immediate provisionalization of immediately placed dental implants, without flap reflection, is within acceptable parameters a successful procedure and provides the following benefits:

- Preservation of peri-implant bone and soft tissue contour.
- Reduction of postoperative pain and oedema, which increases patients' comfort.
- Improvement of aesthetics and phonetics during the healing period.
- Elimination of a second-stage surgery, thus shortening the treatment time and simplifying implant treatment.
- Improvement of the aesthetic results of the final restoration and increasing patients' satisfaction.

The present results indicate that immediate loading of immediately placed dental implants replacing single-rooted teeth is a predictable treatment that depends mainly on; good patient/case selection, achieving good primary stability and maintaining primary stability. Hence, from the present study we conclude that the success of this technique depends on:

- Good patient and case selection.
- Presence of sufficient healthy bone beyond the peri-apical lesion.
- Surgical technique used; Atraumatic extraction, good curettage of the extraction socket, and drilling at least 3-4 mm beyond the root apex to gain maximum degree of primary stability.
- Implant selection; The implant has to be in length and diameter greater than that of the extraction socket, implants with a flared neck are better to be placed into fresh extraction sockets to increase bone-implant contact at the coronal part of the implant and implants with rough surface are recommended to be used for immediate loading.
- Patients' motivation, patients' cooperation to follow instructions and the follow-up program.

Finally, it is important to note that the data of the present study do not imply that delayed or delayed-immediate implant placement or submerged approaches are no longer indicated. Additional research can be performed to investigate the possibility of immediate implant placement and provisionalization in the anterior mandible and in patients who are smokers, in old age, diabetics, osteoporotics or bruxers.

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