Immediate Implantation of Pure Titanium Implants Into Extraction Sockets of *Macaca fascicularis* Part I: Clinical and Radiographic Assessment

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Immediate implants have the advantages of few surgical exposures, short treatment time, and maintenance of alveolar bone height and width. The purpose of this study was to compare immediate implants with conventional implants (implants placed into ossified extraction sites) in adult monkeys. Forty-eight implants were placed and allowed to heal for a 6-month period. Following a 7-month loading period, the monkeys were sacrificed, and implant sections were evaluated histologically. Clinical and radiographic measurements showed few significant differences between immediate and control implants.
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Key words: animal, clinical parameters, endosseous dental implants, immediate implantation, osseointegration, radiography, titanium, tooth extraction

One of the requisites for successful osseointegration has been to allow ossification of extraction sockets before placement of implants.[1] Therefore, a patient may wait up to 12 months for an extraction socket to ossify before implant placement[2] (Brånemark P-I, personal communication, 1986). The delay during socket healing coupled with an added surgical stage results in greater inconvenience and discomfort to the patient. Complete healing of the socket may also be associated with crestal resorption and reduction of alveolar bone available for implant placement because alveolar atrophy begins soon after extraction.[3–5]

Because there is no scientifically proven method to expedite alveolar ossification prior to placement of an implant, there is clearly a need to determine whether immediate implantation of an implant into a fresh extraction socket can succeed clinically and histologically. If successful, immediate placement of implants would:

1. Eliminate waiting several months for ossification of the socket
2. Possibly maintain alveolar bone dimension
3. Allow for fewer surgical sessions
4. Shorten the edentulous time period
5. Reduce the costs of treatment and improve overall patient acceptance

Several investigators[2,3,6–21] have evaluated immediate implants in extraction sockets of animals. The implants placed vary in design, material, animal model, technique of placement, loading, and duration of evaluation (Table 1). Early literature reports the use of various animals (dogs, monkeys, baboons, mice), and recent literature reports on human clinical

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Table 1 Implant Design and Surface Materials Used by Investigators in Animal Studies of Immediate Implants

	Design	Material
Sarnachiaro and Gargentini, 1979[6]	Endosseous blade	Titanium
Weiss and Rostoker, 1981[7]	Fiber titanium	Titanium
Hodosh et al, 1979[8]	Extracted root replica	Porous vitreous carbon polymethacrylate
de Putter et al, 1986[9] and Denissen and deGroot, 1979[10]	Extracted root replica	Hydroxyapatite
Karagianes et al, 1982[11]	Porous cylinder	Titanium alloy
Block and Kent, 1986[12] and Block et al, 1988[13]	Coated cylinder	Hydroxyapatite-coated titanium
Brose et al, 1987[14]	Smooth surface—elliptic	Aluminum oxide
Brose et al, 1987[15]	Horizontal fin—elliptic	Aluminum oxide
Brose et al, 1987[15]	Horizontal fin—rectangle	Aluminum oxide
Schulte, 1984[16]	Root-form—conical	Aluminum oxide
Stanley et al, 1977[17]	Root-form—conical	Bioglass
Stanley et al, 1981[18]	Root-form—conical	Bioglass
Todescan et al, 1987[19]	Porous coated cylinder	Chrome cobalt
Anneroth et al, 1985[2]	Screw shaped	Titanium
Woolfe et al, 1989[3]	Screw shaped	Titanium
Ettinger et al, 1993[20]	Plasma-sprayed cylinder	Titanium
Gotfrendsen et al, 1993[21]	Hollow screw	Titanium

trials and case report observations.[22–29] The technique of immediate placement has also been reported in combination with guided tissue regeneration procedures,[30–40] as well as with bone healing enhancers.[41,42]

To properly evaluate the immediate implantation technique, the efficacy of the procedure must be established through research in appropriate animals. This includes atraumatic placement of an implant into the remnants of an extraction socket at the time of extraction in an animal that best simulates oral conditions. This should then be followed by an undisturbed healing period, prosthetic loading with an appropriate prosthesis, and evaluation during and after the loading period.

A pilot study published by the authors[43,44] indicated that a conventional implant placed into a prepared socket of a tooth immediately after extraction can become osseointegrated and is able to tolerate masticatory load. The present study is the first in a series comparing immediate implants with conventionally placed implants in the monkey. Part I is concerned with radiographic and clinical findings.

Materials and Methods

Six healthy adult male *Macaca fascicularis* (cynomolgus monkeys) weighing 5 to 5.5 kg were used in this study. All procedures related to the treatment and use of these monkeys were approved by the Institutional Animal Care and Use Committee of the Eastman Dental Center, Rochester, NY.

Preliminary diagnostic procedures included the making of maxillary and mandibular irreversible hydrocolloid impressions as well as occlusal and periapical intraoral radiographs. Maxillary and mandibular teeth were scaled to remove calculus and debris.

Each monkey had selected incisors, premolars, and molars extracted in both the maxilla and the mandible using a local anesthetic agent. The implant sites selected represented the anterior and posterior regions of both the maxilla and the mandible and opposed each other in the dental arch. The extraction sites were allowed to heal normally for 6 months and served as control sites. A 6-month healing period was needed for full ossification of the extraction socket (based on radiographic and clinical observations from the preliminary study).[44]

Implant Placement. *Control Group.* After extraction socket healing (establishment of the control site), the monkeys were given amoxicillin (11 mg/kg subcutaneous injections) 4 hours preoperation and prepared for surgery. After appropriate levels of local and general anesthesia had been determined, full-thickness mucoperiosteal flaps with vertical releasing incisions were initiated, and the implant sites were prepared in accordance with standard procedures for placement of 10 × 3.75-mm Nobelpharma implants (Nobelpharma USA, Chicago).[45] Once secured in position, the rotational tightness of the implants was recorded on a scale of 1 to 4. A measure of 1 indicated little resistance of the implant to rotation as it was secured into final position with the hand wrench. A measure of 4 indicated a heavy resistance to rotation. These measurements were subjective and recorded by the same operator.

Immediate Implants (Experimental Group). After teeth were extracted as atraumatically as possible, the

sockets were prepared using standard Nobelpharma armamentarium for placement of standard 10 × 3.75-mm implants. The countersink drill was not used in preparation of the immediate implant site. At the conclusion of implant fixation, the rotational tightness of the implants was recorded based on a scale of 1 to 4, with 1 indicating little resistance to rotation and 4 indicating significant resistance to rotation.

Experimental implants were placed into lateral incisor root sockets, distal root sockets of mandibular first premolars, mesial root sockets of mandibular first molars, and palatal root sockets of maxillary first premolars and first molars (Figs 1 and 2). After placement of all implants, space-saver cover screws were placed, and following copious irrigation, the sites were closed. To ensure complete tissue coverage, the vestibular periosteum was released where needed, which allowed for the flap to be extended over the implant and sutured primarily.

The monkeys were given intramuscular injections of 2 mg/kg of pentazocine (Talwin, Sanorfi Winthrop, New York) every 8 to 11 hours for three doses for analgesic effect and were maintained on subcutaneous injections of 11 mg/kg of amoxicillin once per day for 5 days postoperatively. The monkeys were maintained on a diet of fresh fruit and softened Purina Monkey Chow for 2 weeks postoperatively and then on a diet of fresh fruit and standard monkey chow for the remainder of the study. No oral hygiene procedures were carried out for the duration of the study.

A total of 48 implants were placed in the six monkeys. Of these, 12 implants were placed into control sites (healed extraction sockets) and 36 were placed into experimental sites (extraction sockets).

Implants were allowed to heal undisturbed for a period of 6 months at which time one monkey was sacrificed before loading of the implants to evaluate the effect of loading on the implant and surrounding tissue. The remaining monkeys were sedated and examined clinically for early exposure of the implants. Using local anesthetic agents, the implants

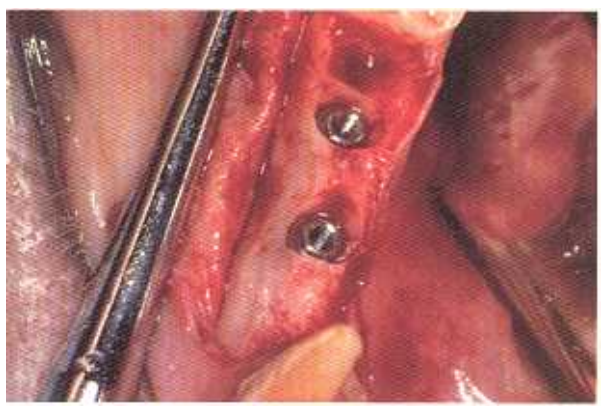

Fig 1 A control implant has been placed in the mandibular first premolar region (anterior implant); an immediate implant (distal implant) has been placed into the mesial root socket of the mandibular first molar.

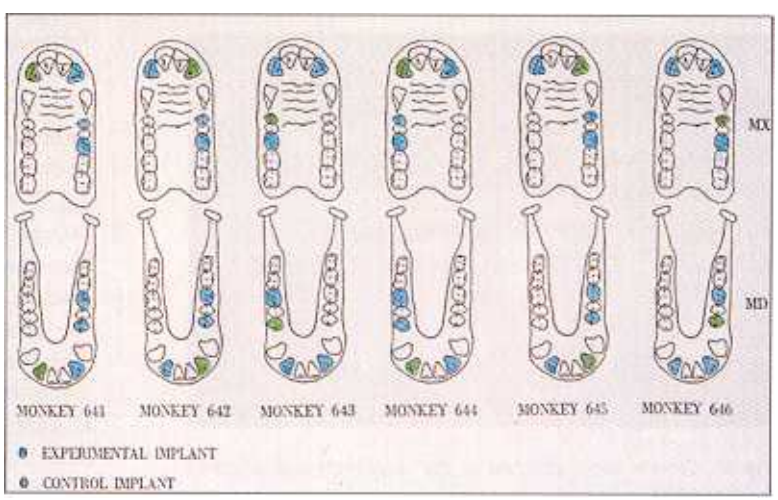

Fig 2 Distribution of control and experimental implants in the six monkeys.

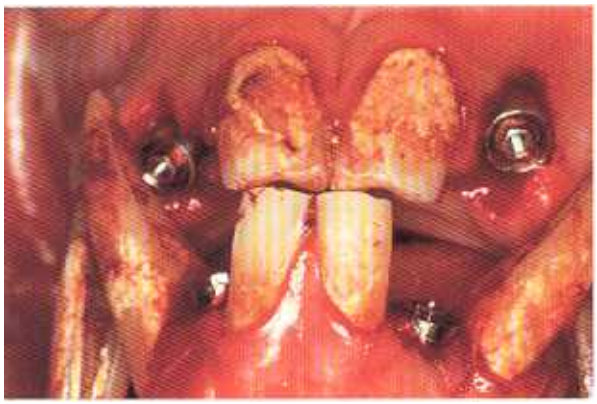

Fig 3 Standard abutments attached to all implants at the time of uncovering.

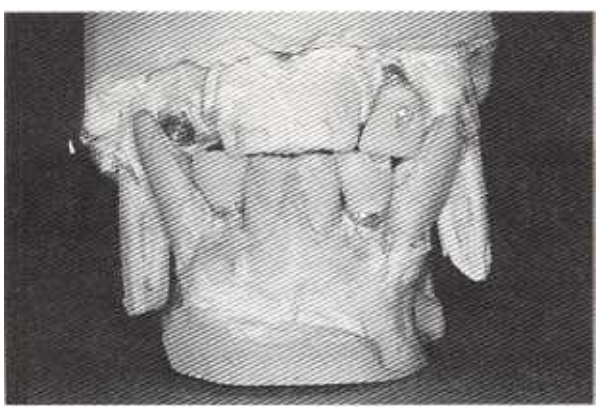

Fig 4 Resin composite bonded to gold crowns were fabricated using standard prosthodontic techniques and components.

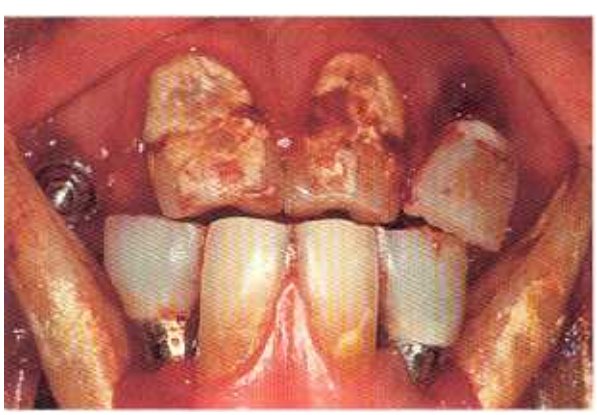

Fig 5 Crowns were attached to the abutments and adjusted for occlusion.

were uncovered, space-saver cover screws were removed, and 3-mm standard Nobelpharma abutments were attached to each implant (Fig 3).

A standard square impression coping (DCB 026) was attached to the abutment, and using the back end of two dental mirrors, the mobility of the implants was evaluated. Using conventional components and prosthodontic materials, a resin composite bonded to gold crown was fabricated for each implant (Fig 4).

Four weeks after implant uncovering, the crown was attached to the abutment with a conventional hexed gold screw (DCA 074) (Fig 5). The presence of a centric occlusal stop was verified using articulation paper, and preliminary measurements were recorded.

Clinical Evaluation. Clinical data were collected at 2-month intervals after initial loading. The measurements collected included:

1. Visual signs of inflammation (compared to natural teeth). A modification of the index by Meitner et al[46] was used. (0 = no inflammation [pale pink color], 1 = equal to natural teeth, 2 = greater than natural teeth.)
2. Plaque accumulation.[47] (0 = no plaque at gingival margin, 1 = plaque present but not visible to the unaided eye, 2 = plaque present and visible to the unaided eye, 3 = gross plaque accumulation.) The presence or absence of calculus was also noted.
3. Mobility. A modified version of the index formulated by Lindhe and Nyman[48] was used. The implant was laterally loaded with the handles of two dental mirrors in a buccolingual direction. The amount of movement, including intrusion, was observed relative to neighboring implants or teeth. (0 = no mobility, 1 = slight mobility—less than 1 mm of movement, 2 = moderate mobility—1 to 2 mm of movement, 3 = severe mobility—greater than 2 mm of movement.) Intrusion was also observed. If the implant proved to intrude, a score of 1 was added to its mobility score. Any mobility (a measurement of 1 or more) indicated implant failure.
4. Pocket Bleeding Index.[49] (0 = no bleeding on probing, 1 = bleeding within 30 seconds on probing.)
5. Sulcus Bleeding Index.[50] (0 = no bleeding, 1 = bleeding present within 30 seconds.)
6. Pocket depth.[51] Measurements were made from the apical end of the probe tip penetration (mm). This number was rounded to the next highest millimeter.
7. Gingival margin location[51] was recorded as the distance between the gingival margin and the junction of the implant crown and abutment.

8. Attachment level[51] is a calculated measurement derived by adding pocket depth and gingival margin location (mm) to give the distance between the fixed reference point and the depth of the probe tip.
9. Gingival width[51] is the distance between the gingival margin and the mucogingival junction (mm) measured on the buccal and lingual surfaces.

Measurements were made with a standard Glickman probe (26 G, Hu-Friedy, Chicago). If measurements fell between the whole millimeter markings, they were rounded off to the next highest millimeter. Measurements were made along the middle of the measured surface (ie, midbuccal) at sites determined by a dimple mark placed on the gold cylinder at the abutment-crown junction.

At each clinical examination period, the maxillary right canine was measured at the same time as the implants. Comparisons in clinical measurements were made between both the control and experimental implants and the neighboring natural teeth. In addition, all the implants and the natural teeth were scaled at each examination appointment.

Radiographic Evaluation. Radiography of the implant and its peri-implant structures was performed using the long cone paralleling technique, standard dental radiographic film (DF-58, Eastman Kodak, Rochester, New York) and custom-fabricated radiographic jigs (Fig 6). Two radiographs were made, one with the central ray perpendicular to the long axis of the film and a second with a central ray angulated 12 degrees in relation to the first radiograph.

Radiographs were made of all the uncovered and loaded implants at the time of crown placement, as well as at the end of the 7-month loading period (Figs 7a and 7b), and were evaluated for:

1. The first point of contact of bone along the implant surface
2. Evidence of peri-implant radiolucency
3. Mechanical failure of the implant

The radiographic evaluation made use of two techniques:

1. Direct grid method
2. Implant anatomy method

Direct Grid Method. Radiographs were viewed in a magnification manner (3.5× Keeler loops) with a superimposed grid. The grid was divided into 1-mm horizontal divisions on either side of an orientation "T." The vertical orientation line was superimposed down the center of the implant, and the horizontal line of the T delineated the superior position of the implant body shoulder (implant-abutment junction)

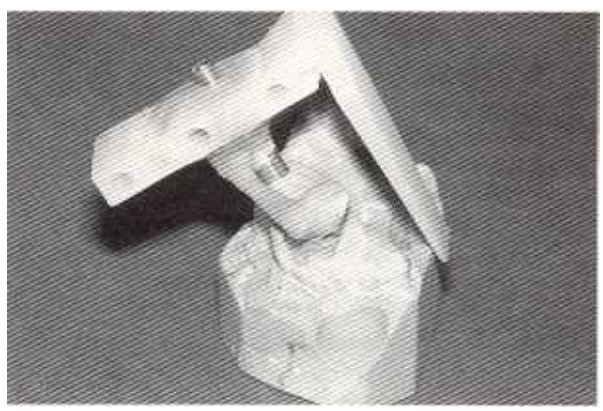

Fig 6 A custom-fabricated radiographic jig was made for each implant region.

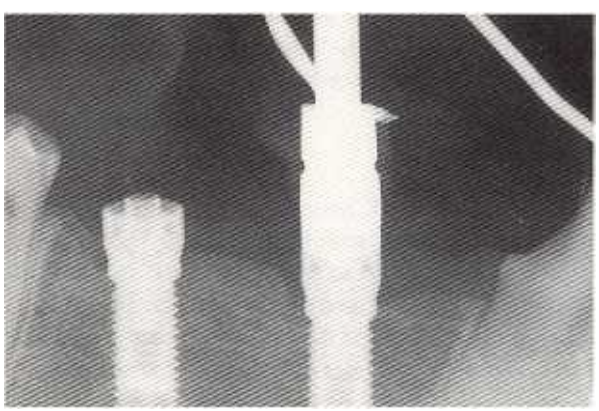

Fig 7a Periapical radiograph of a mandibular posterior site showing two implants in position at the time of initial loading.

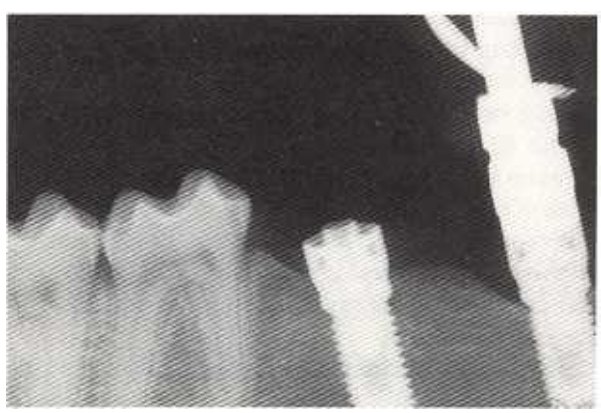

Fig 7b Periapical radiograph of a mandibular posterior site showing two implants in position after the 7-month loading period.

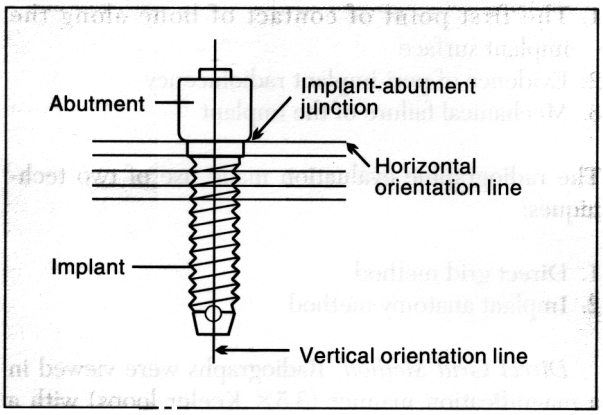

Fig 8 Direct grid method of radiographic analysis.

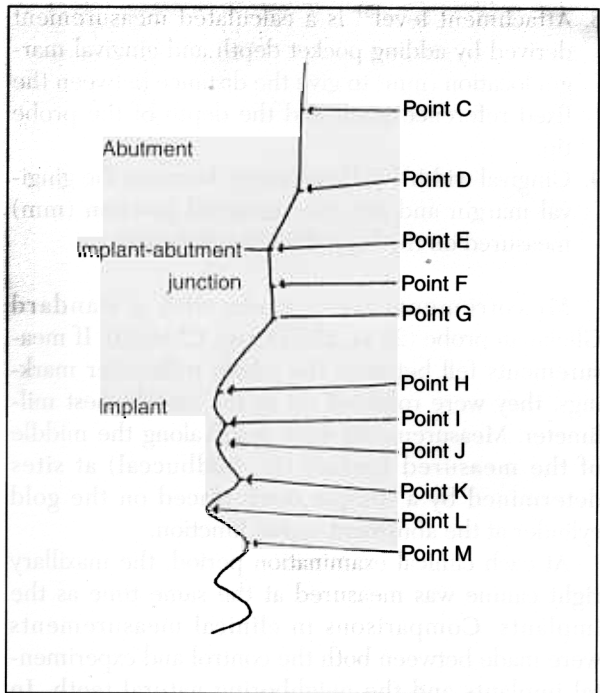

Fig 9 *(Right)* Implant anatomy method of radiographic analysis.

(Fig 8). From this point, the distance to the first point of bony contact was measured along the grid on both preloading and postloading radiographs. In this way, changes during the loading period were evaluated. If the measurement fell between markings, the reading was rounded off to the nearest millimeter.

Implant Anatomy Method. The implant was assigned 11 points along its lateral border. The distance between these points was measured using histomorphometric analysis equipment and was mathematically corrected for magnification. Under 3.5× magnification, the first point of bone contact on the preloading radiograph was noted and assigned the proper letter. This was then compared to the postloading radiograph when another letter was assigned to the first point of bone contact. The distance between these letters was then compared, and measures of bone position were taken (Fig 9).

Error of the Method. The implant anatomy method of radiographic evaluation was duplicated and compared to original readings to evaluate the error of the method.

Histologic Evaluation. Thirteen months postimplantation (7 months postloading) the monkeys were sacrificed with an overdose of sodium pentobarbital IV. The implant segments in the maxilla and the mandible were removed en bloc using a Stryker saw (Stryker Surgical, Kalamazoo, MI) and were submitted for histologic preparation and evaluation.

Statistical Evaluation. Measurements were obtained from the 48 implants in the six monkeys. All comparisons of immediate versus control implants and of implant versus natural tooth were performed using analyses of variance (ANOVA). All statistical analyses were performed using the sitewise data ($P \leq .05$). The generally recognized caveats concerning the use of such an approach were not overlooked; however, it was felt that this would yield the most informative use of the available data resources, particularly in view of the somewhat complex experimental design of this study.

Results

One monkey died 2 hours after implant placement because of an anesthetic complication. The implants from this monkey were not considered in the radiographic and clinical analyses of the data. Information on rotational stability at the time of implant placement was used in the overall evaluation of the distribution of rotational stability sites within the jaw and within the experimental and control implant populations.

In considering the number of clinical failures of uncovered and loaded implants, 100% (24 of 24) of

experimental implants and 87.5% (seven of eight) of control implants were successfully osseointegrated at the conclusion of the loading period. The one failed control implant was mobile at the time of uncovering and was removed.

An evaluation of the implants before they were uncovered showed 19% of the implants to have either observable direct exposure of the implant or a fistula. Once uncovered, an evaluation of the superior surface of the implants showed the following:

1. 21% were completely covered with bone
2. 37% were partially covered with bone
3. 42% were free of bone on the superior surface (Fig 10)

Once the surfaces of the implants were cleared of bone, 13% of the cover screws were missing and many of the screws were partially extruded from the internal channel of the implant. At the time of abutment connection, one implant was evaluated as being mobile and was removed.

Evaluation of Rotational Stability of Implants at Time of Placement. A comparison of the control versus the experimental implants showed that 83% of control implants had a tightness of 3 or 4, while only 57% of experimental implants had tightness of the same range (Table 2).

Once healed and loaded, the implants showed no difference in clinical stability and performance, suggesting that the level of rotational tightness at the time of implant placement did not correlate with the clinical stability and function in either the experimental or control groups.

Clinical Assessment. Preliminary analyses of the data on the clinical assessment of the implant sites indicated no significant differences between measured locations (midbuccal, midlingual, mesial, and distal) or animals. Analyses of variance indicated no statistically significant differences between natural teeth, experimental implants, and control implants with respect to any parameter, with the exception of pocket bleeding at the 4-month point, and sulcus bleeding at the 7-month point. In both instances, the natural teeth exhibited significantly less bleeding than either of the implant types. Both experimental and control implants had similar measurements in relation to each other. Although not statistically significant, deeper pockets were recorded at the beginning of the study, but after the first recording, this was no longer apparent (Table 3).

Implant occlusion was maintained over the loading period (as evidenced with articulating paper). The crowns themselves remained structurally and

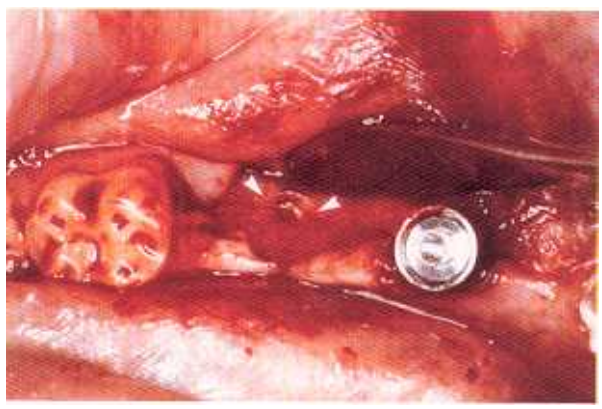

Fig 10 The molar implant shows bone coverage at the time of uncovering (*arrows*). The premolar implant has had the abutment connected.

Table 2 Rotational Tightness at Implant Placement*

	Rotational tightness†			
			3	4
Control (n = 12)	1 (8%)	1 (8%)	6 (50%)	4 (33%)
Experimental (n = 36)	4 (11%)	14 (39%)	6 (19%)	12 (38%)

*No. of implants followed by percentage of the individual population.
†1 indicates low; 4 indicates high.

Table 3 Combined Measurements of Attachment Levels (mm) for Each of the Implant Surfaces

Time	Control	Experimental	Natural
Crown placement	6.29	5.21	2.37
2 months	3.90	4.19	3.19
4 months	4.50	4.45	2.33
7 months (final)	3.50	3.88	2.62

functionally intact. The veneering material (Dentacolor, Kulzer, Wehrheim, Germany) maintained its integrity for the duration of the study.

Radiographic Assessment. The custom-fabricated radiographic jigs made for the implants proved to be very valuable in the production of comparable and reproducible radiographs of the implants and their surrounding structures. The magnification ratio on the radiographs was calculated at 10%. The data presented are in absolute numbers as measured directly on the radiograph.

Direct Grid Method. Radiographic data collected showed that most of the implants had 1 mm or less of bone loss (per mesial or distal side) as measured on the radiograph. Several implants had more than 1 mm of bone loss. In several cases (three surfaces), there was actually an increase in the bone level in a coronal direction (Table 4). The mean bone loss for the total implant population over the time evaluated averaged 0.51 mm of bone (mean of mesial and distal measurements). An evaluation of the two types of implants (control and experimental) showed varying results. Experimental implants had a mean bone loss of 0.45 mm, while control implants showed a mean bone loss of 0.70 mm per implant (control implants made up five of the measured implants, and experimental implants made up 21 of the measured implants) (Table 5). Statistical evaluation using the ANOVA showed no statistically significant differences in implant types (control and experimental implants) and no differences between the mesial and distal surfaces.

Implant Anatomy Method. The summary data gathered in the radiographic assessment using the implant anatomy method are listed in Table 6. The measuring points were selected because they were easily identified on the radiograph. The mean bone loss for all implants measured was 0.47 mm. Control implants showed more bone loss than did experimental implants (1.0 mm versus 0.34 mm). Statistical evaluation using the ANOVA indicated a statistically significant difference ($P < .05$) between the measured bone loss on the experimental and control implants. The experimental implants lost less bone as determined radiographically when compared to control implants.

Error of the Method. An evaluation of the error of the method was made for the radiographic data. The implant anatomy method was repeated for all

Table 4 Radiographic Measurement Distribution With Direct Grid Method (Total Implant Population)*

Bone position†	Mesial	Distal	Combined
		0	1
		2	3
	11	10	21
	11	12	23
2	2	2	4
Total	26	26	52

*Five control implants and 21 experimental implants were used.
†Negative value indicates an increase in bone height, and positive value indicates a decrease in bone height or a loss of bone.

Table 5 Radiographic Measurements (mm) of Bone Loss According to Direct Grid Method*

	Mesial		Distal		Combined	
	Mean	SD	Mean	SD	Mean	SD
Experimental	0.43	0.93	0.48	0.68	0.45	0.80
Control	0.60	0.55	0.80	1.10	0.70	0.82
Combined	0.46	0.86	0.54	0.76	0.50	0.80

*Five control implants and 21 experimental implants were used.

Table 6 Radiographic Measurements (mm) of Bone Loss According to Implant Anatomy*

	Mesial		Distal		Combined	
	Mean	SD	Mean	SD	Mean	SD
Experimental	0.32	0.90	0.36	0.78	0.34	0.83
Control	1.02	0.25	0.97	0.90	1.00	0.62
Combined	0.46	0.85	0.48	0.82	0.47	0.83

*Five control implants and 21 experimental implants were used.

radiographs measured (total implant population), and the results of this second analysis were compared with the results obtained in the first method. The mean bone loss on the mesial surface of the implant was 0.45 mm, and on the distal surface, it was also 0.45 mm. The mean bone loss for the total implant population was 0.45 mm using the error of the method measurements. The mean measure is different by 0.02 mm, or 4.26% of the first mean calculated (0.47 mm).

Discussion

This study compared two implant groups using a nonhuman primate model. Direct extrapolation cannot be made from an animal model to a human population. Any conclusions should be considered speculative.

Clinical parameters used in this study showed a high level of success with immediate implants. No clinical failures were seen in this implant group. One implant in the control group failed (determined by mobility at the uncovering stage). This implant, when placed, perforated the nasal mucosa.

No differences in clinical parameters were noted between the experimental and control implants during this study at any of the time points measured. Visual signs of inflammation, plaque accumulation, mobility, pocket bleeding, sulcus bleeding, pocket depth, gingival margin location, attachment level, and gingival width showed no statistically significant differences between the experimental and control implants.

However, differences were seen between the implants and a natural tooth (maxillary right canine), which was also evaluated. There was increased pocket bleeding with the implants when compared to the natural tooth at the 4-month time point. Sulcus bleeding was more prominent with the implants at the 7-month time point. At these times, the implants (control and experimental) were still similar to each other in the severity of the clinical measures. Perrot et al[52] has shown higher gingival crevicular flow rates around implants compared to those of natural teeth. However, in their study, this increased flow rate was not associated with any observable variation in increased inflammation, bleeding, or bone resorption.

Differences noted between the natural tooth and the implants may be explained by the shape of the implant prostheses. Angulation of the implants at times necessitated fabrication of crowns with severe emergence profiles that may have led to stagnant areas in the vicinity of the implant crown. If this were the only reason, however, it would seem that differences would have been noticed at other time periods during the study.

Attachment levels were reduced (in value) from the first time point to the last time point (7 months later), thus indicating a reduction in the net pocket depth. This may have been related to the possible adherence of gingival tissues to the implant over the evaluation time and would make it more difficult to measure the periodontal pocket. Consequently, there would be a lower value for attachment level.

There is some question as to the validity or relevance of using these periodontal indexes to evaluate the clinical condition of an implant. Periodontal parameters are useful in describing peri-implant epithelial health and predicting active disease processes at this interface. Using these measures to describe the overall peri-implant condition as a measure of success or failure of osseointegrated dental implants seems very limited.[53–55] This may be related to the fact that osseointegrated implants do not have a periodontal ligament. An important indicator of success or failure of an implant is mobility. In this study, as mentioned, only one implant was found to be mobile, and this implant was removed at the time of abutment connection. Although indexes directly related to the gingiva may be valid relative to the inflammatory state of the tissues, extension of the inflammation from the gingiva may not necessarily follow the same course in the implant as it does in the tooth.

Successful osseointegrated implants have been shown to have subgingival microbiota similar to those of healthy teeth.[56,57] Jovanovic et al[58] found that peri-implant disease and periodontal disease appear to have similar etiology. A difference in the susceptibility of implants to microbial effect has been noted. Brandes et al[59] have suggested that osseointegrated implants are less susceptible to alveolar bone loss because of bacterial plaque than are natural teeth. Haanaes[60] suggested that bone resorption around teeth and the fibrous tissue interface of implants is mainly caused by microbial infection, while resorption around osseointegrated implants is primarily the result of excessive loading.

The two-film procedure (stereoroentgenography) used in this study was helpful in obtaining the following data:

1. Marginal bone height (mesially and distally) using the implant threads as an internal dimensional reference point
2. Possible presence of soft tissue at the interface between the implant and its peri-implant bone
3. Presence of internal mechanical failure of the implant[61]

The radiographic bone loss measurements made are within the limits set forth by Adell et al.[45] The method of measurement, however, is quite different.

Adell et al measured bone loss from the lower edge of the implant shoulder (point G in the Implant Anatomy Method of Radiographic Assessment). This study measured bone loss during the first 7 months of loading and did not take into account the possible loss or gain of bone during the actual implant healing time.

The radiographic difference (statistically significant using the implant anatomy method and not statistically significant using the direct grid method) between the experimental and control implants may be the result of the fact that no cortical bone was generally present at the superior region of the implant, and as such, no countersink drill was needed or used. In using the countersink drill, an intimate fit of the implant shoulder to bone may not be obtained, especially on the underside of the shoulder (point H in the Implant Anatomy Method of Radiographic Assessment). With immediate placement of the implant, it is likely that there was better adaptation of the superior portion of the implant to the surrounding bone. It is possible that this may have made a difference in the initial bone loss seen on the radiograph. There is some controversy as to the amount of bone loss at the bone crest partly because of the countersinking itself.[45]

Radiographic analysis of the implants is limited to the superior portion of the implant. If there is minor bone loss in this region at the initiation of treatment and if this bone loss tapers off with time (0.1 mm/year, Adell et al[45]), the loss seems insignificant compared with the amount of bone still present at the interface (as seen histologically).

The soft tissue exposure of the implants noted in this study was probably the result of loss or imminent loss of the space-saver cover screw. Because of the loose fit of the space-saver cover screw, it may be easily dislodged by soft tissue working its way down the inner aspect of the implant, thus causing the cover screw to become exfoliated (Brånemark P-I, personal communication, 1990). This in itself did not seem to cause any difficulty as far as osseointegration was concerned.

The reduced size of the space-saver cover screw and release of the periosteum allows for easier flap closure but does not protect the external hex of the implant from bone overgrowth. Therefore, it was not unusual to find many "implant heads" encased in bone (partially or totally). In preparation for the abutment connection, removal of the bone could lead to damage of the external hex of the implant and subsequent difficulties with abutment placement and prosthesis fabrication and maintenance. Therefore, it is not recommended that this type of cover screw be used under routine implant sites, immediate or conventional.

Rotational stability of an implant at the time of implant placement is affected by the density of the surrounding bone, availability of cortical bone for stabilization, the intimacy, and bone-implant contact. Accepted implant methods[45] require stability when an implant is placed. All the implants in the present study were laterally stable, but rotational stability differed based on anatomic location of the implant and the placement technique.

Conclusions

No statistically significant clinical differences were noted between the experimental and control implants. Short-term radiographic assessment showed more bone loss present with control implants when compared to immediate implants. Based on the conditions of this study, the technique of immediate placement of implants into extraction sockets seems feasible and probably should give similar results when compared to conventionally placed implants.

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