Immediate Implantation of a Pure Titanium Implant Into an Extraction Socket: Report of a Pilot Procedure

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The conventional osseointegration protocol calls for waiting up to 12 months for ossification of an extraction socket to heal before placing an endosseous implant. In this study the possibility of placing a pure titanium implant directly into an extraction socket immediately after extraction was investigated. A pure titanium Nobelpharma 10-mm implant was placed into a central incisor extraction socket of a stump-tailed monkey and allowed to heal for a period of 6 months, followed by functional loading of the implant. The implant was osseointegrated on a clinical and histological level. This pilot study suggests that pure titanium implants have the potential to integrate when placed immediately after extraction of the teeth and warrants further investigation.
(INT J ORAL MAXILLOFAC IMPLANTS 1991;6:277-284.)

Key words: endosseous titanium implant, immediate implantation, osseointegration

The long-term success of osseointegrated implants using principles outlined by Brånemark is well established and has been well documented.[1-3] The Brånemark (Nobelpharma USA, Inc, Chicago, Ill) implant is a pure titanium threaded cylinder that is inserted into the jaw using precise and atraumatic surgical techniques. These implants (fixtures) are then allowed to heal for a period of 4 to 6 months while covered by a mucoperiosteal flap with no oral communication. They are then uncovered and placed in function with a specially designed prosthesis. The system was originally used to rehabilitate the completely edentulous patient, but subsequently has been modified for the partially edentulous patient and craniofacial prosthetic reconstruction.

One of the requisites for successful osseointegration has been to allow ossification of natural tooth extraction sockets before the placement of implants.[4] A patient would then wait up to 12 months for an extraction socket to ossify before the implant was placed.[5] This time interval is considered necessary for proper bone formation and maturation postextraction.[6] Following bone healing, the patient then undergoes two surgical procedures; first, the placement of the fixture, and second, the attachment of the abutment. The delay during socket healing, coupled with the added surgical stage, is inconvenient as well as disconcerting and uncomfortable to the patient, who may already be having difficulty wearing a conventional removable prosthesis.

As there is no applicable method to expedite alveolar ossification, there is clearly a need to determine whether immediate implantation of a titanium implant

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into a fresh extraction socket can succeed when the alveolus is mechanically modified upon removal of the tooth. The modification resembles the preparation made for placement of an implant in an ossified alveolar structure.

Success of this procedure would have the following advantages:

1. The elimination of waiting many months for ossification of the socket
2. Possible maintenance of alveolar bone height and width
3. Fewer surgical procedures
4. Shortened edentulous time period

Literature Review

Investigators have attempted to place implants directly into extraction sockets, but many of these attempts have met with failure.

Sarnachiaro and Gargantini[7] placed four titanium blade-vent implants in four Caraya monkeys immediately after extraction of mandibular second and third premolars and first molars. The implants were evaluated histologically 60 days after placement and were found to be encased in a peri-implant membrane of connective tissue.

Weiss and Rostoker[8] evaluated fiber titanium implants in mongrel dogs. Seventy-eight implants were placed into molar extraction sockets and studied for periods ranging from 1 week to 1 year. This study had 11 failures, and electron probe studies confirmed that there was always an interface of fibrous tissue 5 to 50 μm thick between bone and metal. These implants were allowed to heal while exposed to the oral cavity and were not put into direct function.

Porous vitreous carbon polymethacrylate replica implants were inserted into the extraction sockets of 12 baboons by Hodosh et al.[9] Their histological studies showed a peri-implant membrane composed of collagen fiber bundles and numerous inflammatory cells. The presence of peri-implant connective tissue (fibrous) is considered by many to be a sign of eventual failure.[3,10,11]

Karagianes et al[12] placed 13 porous titanium alloy implants into molar and premolar extraction sockets of *Macaca nemestrina* immediately following tooth extraction. The fixtures were left in place for 6 weeks after insertion and loaded with a functional fixed prosthesis. Of the 13 implants, 8 had failed, with rejection times varying from 3 to 29 months. The investigators suggested that the high failure rate was enhanced by poor animal health, poor bone configuration, and poor surgical technique.

Schulte[13] claimed success over 8 years using the Tübingen implant. This is an intraosseous Al_2O_3 implant that can be used in either immediate postextraction implantation or in the healed bone of an edentulous jaw. The author claims to achieve an integrated fixation, yet the scientific methodology and experimental design used to determine this success are not described.

Anneroth et al[14] placed pure titanium screw-shaped fixtures (Xenodent) into the mandibular incisor extraction sockets of four monkeys immediately after extraction. The procedures followed the surgical protocol proposed by Brånemark, and the implants were evaluated at 7 and 12 weeks postinsertion. The investigators describe a "normal" appearing bone/implant interface with no inflammation. Bone is shown in close apposition to the implant, yet there is still connective tissue present between the bone and the implant surface. The implants appeared healthy at 12 weeks but were not placed in occlusion; therefore, any evaluation of function could not be made.

Todescan et al[15] recently evaluated cobalt-chromium implants in molar extraction sites of mice. This work used a small-animal model, and several materials were employed to expedite bone healing around an implant placed immediately after tooth extraction. Whereas the findings are useful, the small-animal model does not easily lend itself to the evaluation of implants under functional load, which is important for assessment of the functional capability of osseointegrated implants.

Recent publications advocate the use of nonresorbable barrier techniques to aid in the healing of implants placed into extraction sockets.[16,17] These case reports, however, show little histologic data to support claims of bone fill. Becker et al[18] recently reported on the use of Gore-Tex augmentation material (WL Gore & Assoc, Flagstaff, Ariz) around immediate implants in dogs. The study reported on the efficacy of healing dehiscences using a barrier versus not using a barrier. Their study showed that the barrier significantly enhanced bone formation at extraction sites when dehiscences were involved.

Confirmation of immediate implantation as a successful clinical technique cannot be drawn from these studies. In order for an implant to be evaluated for immediate implantation, it should be placed atraumatically, allowed to heal undisturbed, and functionally loaded. In this manner, true clinical conditions are implemented in the experimental design. This paper reports on a preliminary study that evaluated immediate implantation of a pure titanium implant into a fresh extraction socket.

Materials and Methods

One elderly stump-tailed monkey had its mandibular left central incisor and right lateral incisor extracted.

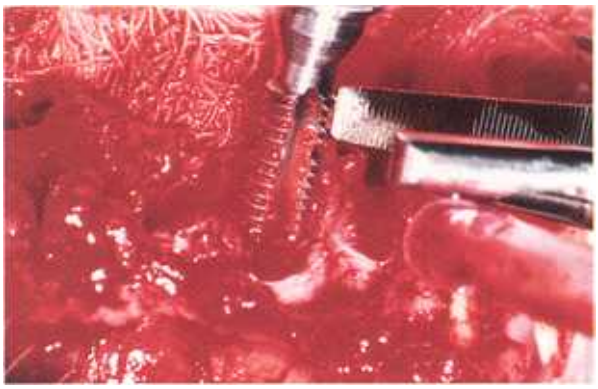

Fig 1 The extraction socket tapped (threaded) with the Nobelpharma titanium screw tap.

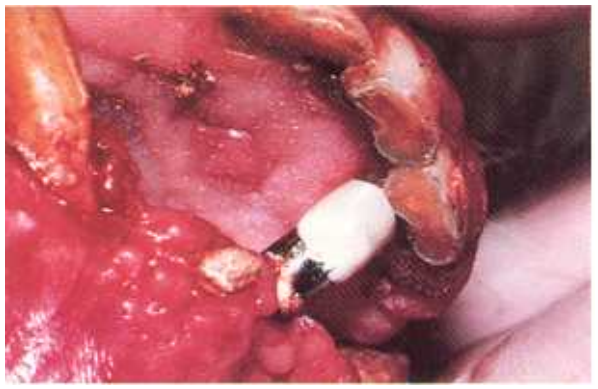

Fig 2 The composite resin gold crown has been secured in position with the conventional gold screw. Occlusion of the crown has been verified.

The alveolar walls were curreted vigorously to remove the residual periodontal ligament. Using the sequence of drills commonly used in the Brånemark procedure,[1] the left central incisor socket was prepared (Fig 1) and a 10-mm pure titanium Brånemark fixture was inserted and appeared to have good stability. Preparation of the socket involved enlarging the socket's diameter as well as deepening to accommodate the implant. At the time of placement, it was noted that the superior 2 to 3 mm of the socket was wider and the inferior 5 to 6 mm was narrower than the implant. The apical 2 to 3 mm of the implant extended beyond the apex of the socket. The socket of the right lateral incisor was allowed to heal without intervention to assess the length of time needed for extraction socket healing. The implant was sealed with a conventional cover screw, and both sites were covered with a wide-banded mucoperiosteal flap mobilized to seal the cover screw and allowed to heal.

After a healing period of 6 months, a transmucosal abutment was connected to the implant. Prosthodontic procedures (impressions, jaw registrations) were completed and a 4 methacryloxyethyl trimellitate anhydride (4-META) light-cured, composite resin gold crown was fabricated and attached to the implant with the conventional prosthodontic components of the Brånemark system (Fig 2). The crown/implant assembly functioned in occlusion for 6 months.

Clinical Assessment. During the 6-month loading period, clinical measurements were made every 2 months. The clinical assessment consisted of the following parameters:

1. Visual signs of inflammation; Meitner et al (modified)[19]
2. Plaque accumulation; Silness and Löe[20]
3. Mobility; Lindhe and Nyman (modified)[21]
4. Pocket bleeding index; Proye et al[22]
5. Sulcus bleeding index; Muhlemann and Son[23]
6. Pocket depth; Ramfjord[24]
7. Gingival margin location; Ramfjord[24]
8. Attachment level; Ramfjord[24]
9. Gingival width; Ramfjord[24]
10. Occlusion and prosthesis condition

Measurements were made with a standard Glickman probe (no. 26 G) at a point midsurface on the buccal, lingual, mesial, and distal surfaces. The precise point was marked by a dimple cut into the gold coping and was visible to the examiner.

Radiographic Assessment. Radiographic examination took place at the time of crown placement and again 6 months postloading. Radiography of the perifixtural structures at crown placement and at the end of the observation period (12 months postimplantation) was performed using the long cone paralleling technique. For the purposes of comparing standardized radiographs, a jig was fabricated so that film placement would be duplicated at these two time points.

A square impression coping was attached to the laboratory analogue on the master cast and luted with autocure resin to a radiographic film holder. The film holder was positioned so that once in place in the mouth, the film and implant were parallel to each other. A 16-inch long cone paralleling technique ring was then attached to the film holder and a radiograph was made (70 Kv, 15 mA, 1/2 sec). A second ring, angulated at 12° in the horizontal direction, was then used to allow the making of a second radiograph with a central ray angulated 12° to the first radiograph. The two-film procedure (stereoroentgenography) is helpful in obtaining the following data:

1. Marginal bone height (mesially and distally), using the fixture threads as an internal dimensional reference
2. Possible presence of radiographically detectable soft tissue at the bone/fixture interface

3. Presence of internal mechanical failure of the fixture[25]

After the functional loading period, the implant, with its surrounding hard and soft tissue, was removed en bloc under local anesthesia and evaluated histologically.

Histological Assessment. Histological assessment made use of four evaluations:

1. Gross evaluation
2. Decalcified section
3. Ground section
4. Ultrastructural evaluation

The implant and its surrounding hard and soft tissue was block-sectioned from the jaw and placed in pitric acid formaldehyde. After fixation, the implant block was sectioned longitudinally using the Bueler Isomet slow-speed sectioning machine. One half of the implant was processed for decalcified section (longitudinal sectioning) and the second half was processed for ground section (horizontal sectioning). A soft-tissue specimen was removed from the periabutment mucosa and processed for ultrastructural evaluation.

Decalcified Section. The implant block was decalcified using formic acid and sodium citrate. Once decalcification was complete, the implant was removed from the block and thin-sectioning procedures were initiated. The crypt surface of the implant was scanned using a scanning electron microscope to ensure that no tissue remnants were present on the surface. The specimen was then prepared in paraffin to a thickness of 0.75 to 1.5 μm. Hematoxylin and eosin, Masson, and Villanueva stains were used in the evaluation of the various sections.

The type of tissue present at the interface was quantified and characterized into three groups using the computerized digital analyses system. The three groups were:

1. Direct bone contact
2. Bone marrow contact
3. Fibrous soft tissue contact

These three types of tissue are important in that they are all present to some degree in implant systems.

Ground Section. The implant block for ground section was embedded in methyl methacrylate and then sectioned horizontally using the Bueler Isomet (Buehler Ltd, Lake Bluff, Ill) slow-sectioning machine. The specimen was then glued to a glass slide with epoxy resin adhesive and petrographically ground to reduce the thickness of the specimen to 30 to 50 μm. The specimen was then stained using a Villanueva stain.

Ultrastructural Assessment. Ultrastructural evaluation using a transmission electron microscope scanned the periabutment mucosa to determine morphologic characteristics and changes within the tissue.

Results

Clinical Assessment. At each clinical examination period, the implant and a neighboring tooth were examined. No difference was found between the measurements recorded on the periabutment tissues of the implant when compared to a neighboring natural tooth. There was no measurable increase in pocket depth and clinical measurements revealed no loss of attachment. Gingival inflammation was present to the same degree on both the implant and the natural tooth. No mobility

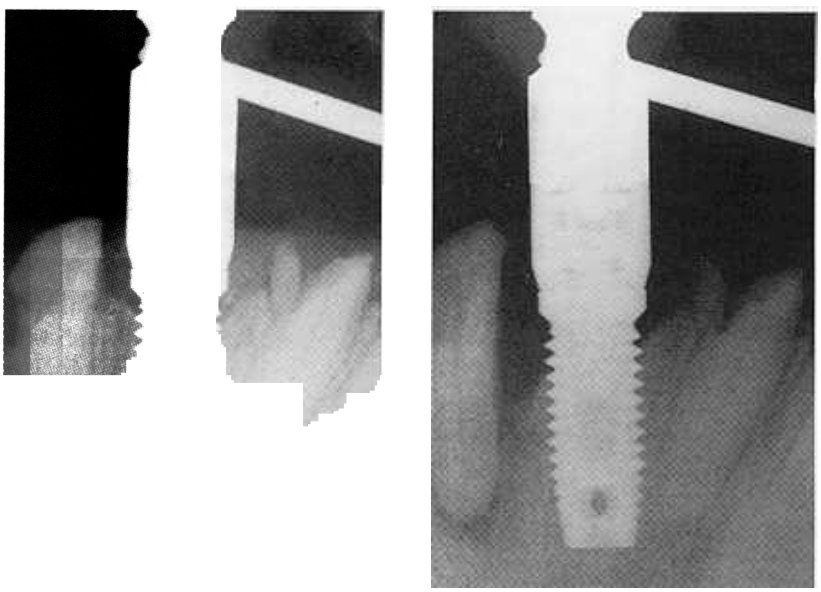

Fig 3 *(Left)* Radiograph made at the time of crown placement. No radiolucent area can be seen around the implant and bone appears to be abutting against the implant surface.

Fig 4 *(Right)* Radiograph made after the functional loading period. Notice the 1.3-mm vertical bone loss present on the mesial surface of the implant. This bone loss may be associated with the neighboring central incisor's periodontal bone loss.

or signs of infection were noted at the implant site at any time during the study.

The composite resin crown was still in functional occlusion at the conclusion of the loading period and held up well over the duration of the study.

Radiographic Assessment. No radiolucent area could be seen surrounding the implant at the two time points. Of interest was the loss of vertical bone height seen on the mesial surface of the implant at the conclusion of the loading period (Figs 3 and 4). This loss was measured at 1.3 mm.

Histological Assessment. *Gross Evaluation.* The gross specimen showed a 2-mm soft-tissue pocket surrounding the superior aspect of the implant. The remainder of the host tissue seemed to be in intimate contact with the surface of the implant.

Decalcified Section. The evaluated specimens demonstrated bone to be in contact with the implant surface along most of its length and no inflammatory cells were seen on the sections evaluated (Fig 5).

Using the computerized digital analysis system, this pilot study found 58.2% of the implant's embedded length was in apparent direct contact with bone (the word "apparent" is used because of the fact that the implant was removed during the thin-sectioning procedure and the implant space was measured rather than the implant surface itself); 24.7% of the implant's embedded length was in contact with bone marrow; and 17.1% of the implant's embedded length was in contact with fibrous soft tissue (Fig 6).

Ground Section. The specimens evaluated showed a close relationship of nutrient canals to the implant surface, indicating a healthy and viable relationship between the implant and the host tissue (Fig 7).

Fig 5 *(Left)* Photomicrograph of a decalcified section of the implant/bone interface demonstrating bone to be in contact with the implant surface along most of its length (hematoxylin and eosin, original magnification ×50).

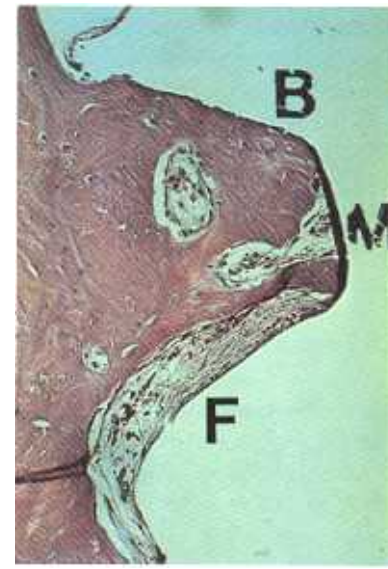

Fig 6 *(Right)* Photomicrograph of a decalcified section of the implant/bone interface showing direct bone contact (B), bone marrow contact (M), and fibrous soft tissue contact (F). The morphological differences are easily seen at this magnification (hematoxylin and eosin, original magnification ×200).

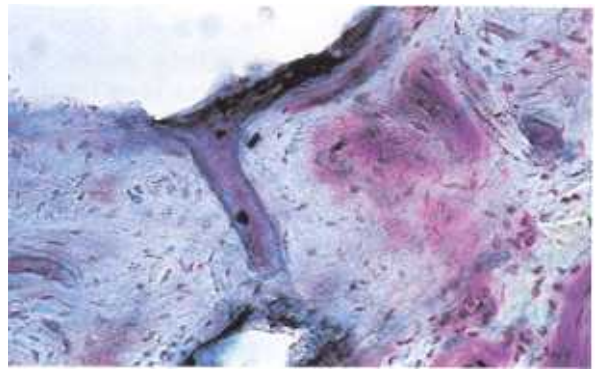

Fig 7 Photomicrograph of a ground section of the implant/bone interface showing a nutrient canal opening into the implant space (Villanueva stain, original magnification ×200).

Fig 8 Transmission electron micrograph of the periabutment mucosa showing an epithelial cell with numerous desmosomes (D) and hemidesmosomes (H) (original magnification ×6500).

Ultrastructural Evaluation. Ultrastructural evaluation using a transmission electron microscope scanned the periabutment mucosa and showed an active basal lamina and normal capillaries. Epithelial cells appeared to be keratinized normally, and desmosomes and hemidesmosomes were evident in the intercellular regions (Fig 8). In examining the deeper crevicular tissues, degenerative changes were noted in the cellular components. The actual abutment/soft-tissue interface could not be delineated in the preparation.

Discussion

Clinical measurements revealed no difference between the implant and a neighboring tooth. The fixed restoration placed on the implant survived well. For a study of this duration, it would seem that this type of restoration would serve the study adequately.

In evaluating the radiographs, a 1.3-mm vertical loss of bone was noted on the mesial surface of the implant. This is within the limit suggested by Adell et al.[1] In evaluating implant bone loss, some of this loss could be caused by the periodontal breakdown of the tooth next to the implant (right central incisor). Should this be factual, special attention must be given implants placed next to natural teeth that are periodontally involved or in patients who are prone to periodontal disease. This bone loss was also not detected using the periodontal probe because the soft tissue present at the gingival cuff was in close apposition to the threads of the implant. This finding casts some doubt on the efficacy of the periodontal probe as a measuring device for peri-implant pockets and is in agreement with the work of other investigators.[3,26–28]

Technical difficulties were encountered during preparation of the specimen for ground section. During preparation, the implant was dislodged. Thus the information given by this technique in this study is of limited value. The ground section specimen has the advantage of implant presence on the slide so that the exact implant position can be evaluated. Its disadvantage is that for this to be accomplished, the prepared section must be thicker and the type of soft tissue present is more difficult to characterize.

The tissue classification devised for this study is important in that a distinction must be made between the two types of soft tissue present at the interface. These tissues are bone-marrow–associated soft tissue, which in fact may become ossified in the future, and fibrous soft tissue, which is a scarlike soft tissue. In reporting data, the soft-tissue component is generally presented as a single tissue and compared to the calcified supporting bone. It is reported in this manner because the dense calcified bone at the interface gives the implant its immediate physical support. Thought must also be given to the role played by the bone marrow soft tissue in providing nutrients and support for the dense supporting bone at the interface. This being the case, there is a need for a more exact classification of the soft tissue type at the implant/host-tissue interface.

There may have been a presumption that osseointegration would imply that the entire surface of the implant is interfaced with bone (calcified matrix).[29] In immediate implantation, a 100% calcified bone/implant interface does not appear to occur, yet there is clinical stability of the implant. In the literature, interface ratios of 50% to 80% have been reported for bone contact with an implant.[30–32] The minimum percentage of integration has yet to be defined for clinical success.

Conclusions

Pure titanium implants placed immediately after extraction of teeth in monkeys have the potential to osseointegrate. One hundred percent osseointegration may not occur and may not be needed along the entire implant/bone interface for successful and predictable function. Osseointegration may not be an all-or-none phenomenon and may rather be a clinical term rather than a histological term. There is a need to make the distinction between the type of soft tissue present at the implant interface.

The results of this pilot study indicate that immediate implant placement into fresh extraction sockets is a potentially viable technique and certainly warrants further investigation. A more in-depth study has been initiated that will evaluate this technique and compare it to the conventional technique of placing implants into healed bone. □

Acknowledgments

The authors would like to thank Dr J. Caton, DDS, MS, for his continued guidance and assistance. The authors also sincerely acknowledge the support of Nobelpharma Inc, Greater New York Academy of Prosthodontics Foundation, Education and Research Foundation of Prosthodontics, Eastman Dental Center Prosthodontic Research Fund, and Biomedical Research Support Grant RR5548.

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Résumé

Implantation immediate d'un implant de titane pur au sein d'un site d'extraction: Rapport d'une technique pilote

Le protocole d'ostéointégration traditionnel requiert d'attendre jusqu'à douze mois l'ossification d'une alvéole après extraction avant de placer un implant endosté. Dans cette étude, on a évalué la possibilité de placer un implant de titane pur directement dans l'alvéole et immédiatement après extraction. Un implant de titane pur de 10 mm fut placé dans l'alvéole d'une incisive centrale de singe et après une période de guérison de six mois, fut placé en charge. L'implant etait ostéointégré d'un point de vue clinique et histologique. Cette étude pilote suggère que les implants de titane pur ont le potentiel de s'intégrer au tissu osseux lorsqu'ils sont placés immediatement après extraction dentaire et cette propriété mérite d'etre étudiée.

Zusammenfassung

Immediatimplantation eines Implantates aus reinem Titan in ein Extraktionszahnfach: Bericht von einem Pilotverfahren

Nach dem konventionellen Osseointegrationsprotokoll soll man bis zu 12 Monaten darauf warten, daß Ossifikation eines Extraktionszahnfaches heilt, bevor man ein enossales Implantat einsetzt. In der vorliegenden Studie wurde die Möglichkeit untersucht, ein Implantat aus reinem Titan direkt in ein Extraktionszahnfach sofort nach Extraktion einzusetzen. Ein Nobelpharma-Implantat, aus reinem Titan und von 10 mm Länge, wurde in das Extraktionszahnfach eines mittleren Schneidezahns eines stummelschwänzigen Affen eingesetzt und hatte eine sechsmonatige Einheilphase; darauf folgte funtionelle Belastung des Implantates. Das Implantat wurde klinisch und histologisch osseointegriert. Die vorliegende Pilotstudie läßt darauf schließen, daß Implantate aus reinem Titan Integrationspotential haben, wenn sie sofort nach Extraktion der Zähne eingesetzt werden. Weitere Untersuchungen über dieses Verfahren sollten gemacht werden.

Resumen

Reporte de un procedimiento piloto sobre la colocación inmediata de un implante de titanio puro en un alvéolo inmediatamente después de la exodoncia

El protocolo convencional de la oseointegración aconseja esperar hasta doce meses para dar paso a la osificación de un alvéolo después de la exodoncia, antes de colocar un implante endóseo. En este estudio se investigó la posibilidad de colocar un implante de titanio puro directamente en el alvéolo, inmediatamente después de la extracción dental. Se colocó un implante de titanio puro, de 10 mm, de la casa Nobelpharma en el alvéolo que correspondía a un incisivo central de un mono de cola corta. Luego de un periodo de cicatrización de seis meses el implante fue puesto en función. El implante se oseointegró de acuerdo al análisis clínico y al histológico. Este estudio piloto indica que los implantes de titanio puro tienen el potencial de integrarse cuando son colocados inmediatamente después de la extracción de los dientes, lo cual justifica la necesidad de efectuar investigaciones adicionales.