

Histologic and Histomorphometric Report of Three Immediately Loaded Screw Implants Retrieved From Man After A Three-Year Loading Period

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Very high success and survival rates have been reported with the use of immediately loaded dental implants.¹⁻¹⁰ A predictable outcome has been reported in immediately loaded implants.¹¹⁻¹³

Osseointegrated immediately loaded implants have shown a clinical long-term predictability similar to those of conventionally loaded implants.⁸ Immediate loading shortens the total rehabilitation time with increased patient satisfaction and the avoidance of delays in the final rehabilitation with the accompanying difficulty of wearing a conventional denture during the healing phase.^{11,14}

Functional loading placed on an immobile implant is an essential ingredient to achieve osseointegration.¹⁵ When primary stability is achieved and a proper prosthetic treatment plan is followed, immediate loading is a feasible concept.¹⁵ It seems that primary stability, more than the anatomical location, may be the fundamental requirement for immediate loading of dental implants.¹⁵

Histological evidence of osseointegration in clinically successfully osseointegrated implants in man is rather rare in the literature.¹⁶⁻³⁰ Retrieved hu-

Purpose: The aim of the present study, in man, was an histologic and histomorphometric analysis of the peri-implant tissues in 3 immediately loaded screw implants retrieved, because of fracture, after a 3 year loading period.

Results: Mineralized tissue was present at the interface of all implants. The mean bone to implant contact percentage for the 3 implants was $56.3\% \pm 5\%$. The histologic and histomorphometric data showed that mineralized tissues can be obtained in immediately loaded screw implants and that these mineralized tissues are maintained over a period of 3 years. The response of the osseous tissue was

not disturbed by the stresses and strains transmitted at the interface.

Conclusion: A high primary stability, obtained by the large threads of the screw-shaped implant, was probably a key factor in the long-term maintenance of a mineralized bone interface. The primary stability helps to resist micromotion, i.e., the relative movements between the implant surface and surrounding bone during functional loading. (*Implant Dent* 2008;17:192-199)

Key Words: bone-implant interface, implant fracture, immediately loaded implant, retrieved implant, screw-shaped implant

man implants are extremely important for long-term evaluation of implants subjected to functional loading.²⁴

The aim of the present study was a histological evaluation of the peri-implant tissues, in man, in 3 immediately loaded screw implants retrieved, for fracture, after a 3 years loading period.

MATERIALS AND METHODS

A 65-year-old male patient presented a fracture of 3 implants located in the premolar region of the maxilla (Fig. 1). The patient was a heavy bruxer with a high level of parafunctions. These implants had been inserted 3 years previously and had been loaded the same day with a resin

crown in occlusal contact; after 3 months a definitive prosthesis had been inserted. The implants had functioned well for 3 years, were stable, and they had recently fractured in a 4-month period. It was decided to retrieve the implants with a 4-mm trephine bur under abundant saline irrigation. On removal, mineralized tissues seemed to be attached to the surface of all 3 implants.

Processing of Specimens

The implants and the surrounding tissues were stored immediately in 10% buffered formalin and processed to obtain thin ground sections with the Precise 1 Automated System (Assing, Rome, Italy).³¹ The specimens were de-

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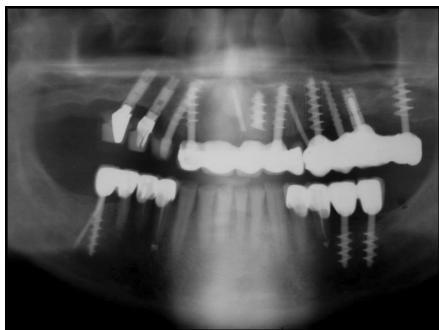


Fig. 1. Panoramic x-ray of the screw-shaped implants.

hydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After polymerization the specimens were sectioned longitudinally along the major axis of the implants with a high-precision diamond disc at about 150 μm and ground down to about 30 μm . Three slides were obtained for each implant. The slides were stained with basic fuchsin and toluidine blue. A double staining was performed with von Kossa and acid fuchsin to evaluate the degree of bone mineralization, and one slide, after polishing, was immersed in AgNO_3 for 30 minutes, and exposed to sunlight; the slides were then washed under tap water, dried, and immersed in basic fuchsin for 5 minutes, and then washed and mounted.

Histomorphometry of bone-implant contact percentage was performed using a light microscope (Laborlux S, Leitz, Wetzlar, Germany) connected to a high resolution video camera (3CCD, JVC KY-F55B) and interfaced to a monitor and PC (Intel Pentium III 1200 MMX). This optical system was associated with a digitizing pad (Matrix Vision GmbH) and a histometry software package with image capturing capabilities (Image-Pro Plus 4.5, Media Cybernetics Inc., Imagingini & Computer Snc, Milano, Italy).

RESULTS

All 3 implants were surrounded by mineralized tissues. At low magnification, it was possible to observe a high percentage of bone-implant contact (Fig. 2). Bone to implant contact percentage was $56.3\% \pm 5\%$. In some areas of the bone interface, bone seemed to have been removed during the trephining process (Fig. 3).

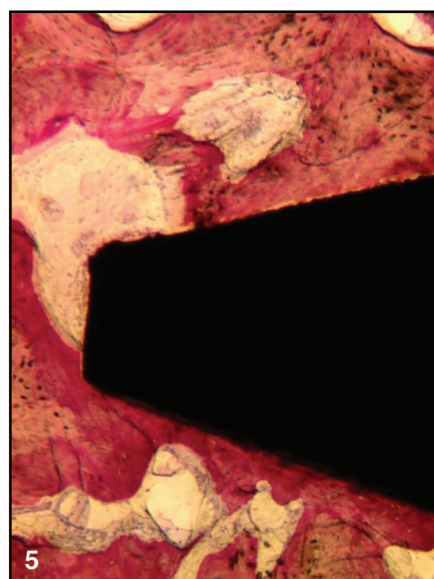
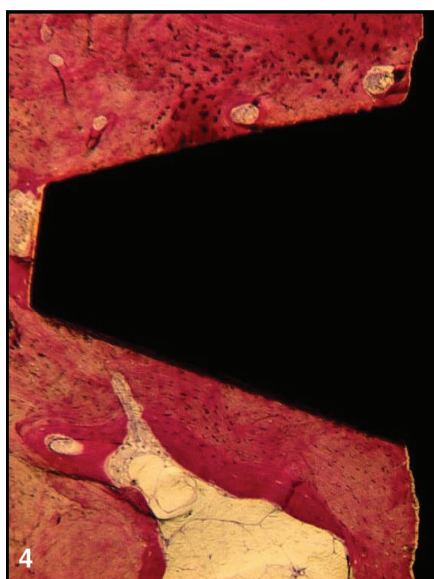
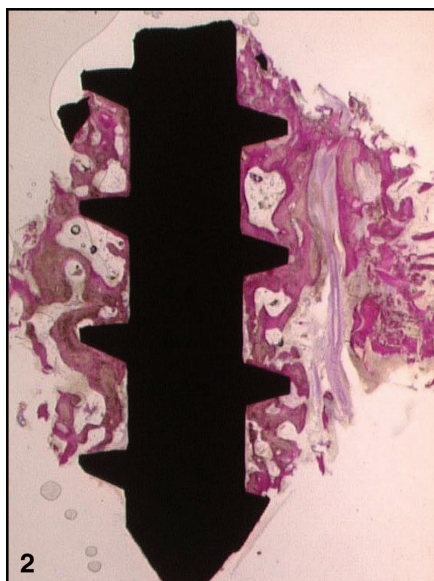


Fig. 2. At low magnification, it is possible to observe an high percentage of bone-implant contact. Acid fuchsin-toluidine blue 6 \times .

Fig. 3. In some areas of the bone-implant interface, bone seems to have been removed during the trephining process. Acid fuchsin-toluidine blue 6 \times .

Fig. 4. The peri-implant bone is compact, mature. Acid fuchsin-toluidine blue 40 \times .

Fig. 5. Small marrow spaces are present in some portions of the interface with the implant surface. Acid fuchsin-toluidine blue 40 \times .

The peri-implant bone was compact, mature (Fig. 4), with the presence of small marrow spaces or small resorption lacunae located at the tips of all the threads (Fig. 5). Haversian systems and remodeling areas were present in direct contact with the implant surface (Fig. 6). In many fields it was possible to observe the presence of many osteoblasts, actively producing osteoid matrix (Figs. 7 and 8). In other areas, it was possible to observe the presence of osteoblasts that were

undergoing transformation to bone lining cells (Fig. 9). The newly formed bone was more strongly stained with acid fuchsin and it was clearly separated from the old, preexisting bone. The bone was in close and tight contact with the implants surface and no gaps or connective fibrous tissues were present at the implant-bone interface (Fig. 10). No inflammatory infiltrate was present. No epithelial downgrowth was present (Fig. 11). In the areas of remodeling bone it was

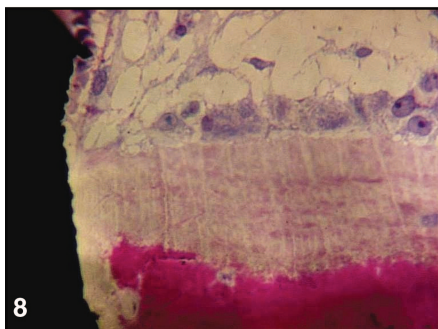
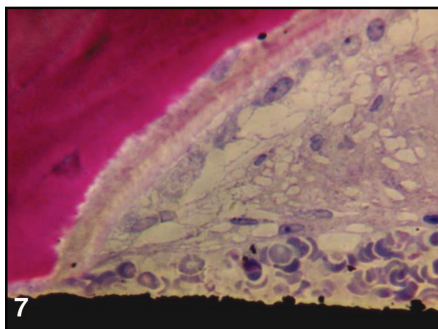
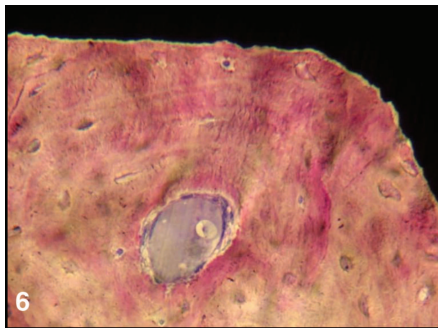


Fig. 6. Haversian systems and remodeling areas are present near the bone-implant interface. Acid fuchsin-toluidine blue 200 \times .

Fig. 7. In many fields it is possible to observe the presence of many osteoblasts. Acid fuchsin-toluidine blue 400 \times .

Fig. 8. The osteoblasts are actively producing osteoid matrix. Acid fuchsin-toluidine blue 400 \times .

possible to observe bone remodeling units with vessels, osteoblasts, and osteoclasts. Lamellar and woven bone were separated by a well-defined irregular cement line. The bone surrounding these lacunae presented a strong affinity for the dyes, wide osteocytic lacunae and it seemed to be undergoing remodeling. In this area, bone lamellae were organized in a concentric way around the point of the thread.

DISCUSSION

Histologic examination provides the best evidence of the type of tissue

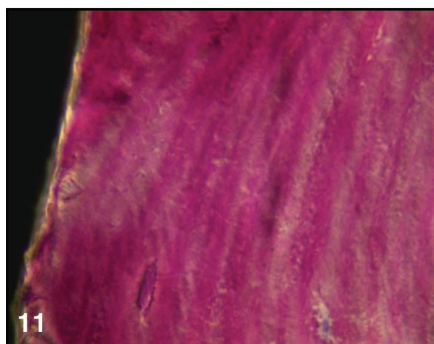
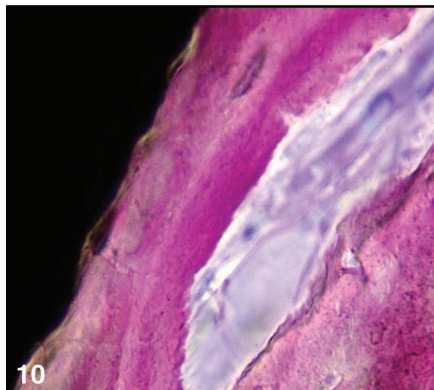
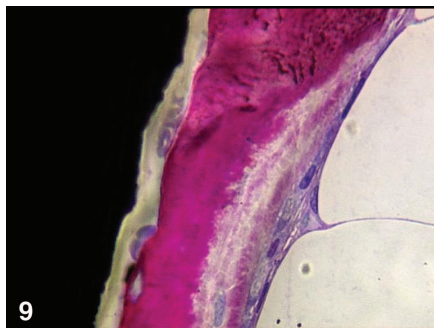


Fig. 9. Osteoblasts undergoing transformation to bone lining cells are present. Acid fuchsin-toluidine blue 400 \times .

Fig. 10. The bone is in close and tight contact with the implant surface and no gaps or connective fibrous tissues are present at the implant-bone interface. Acid fuchsin-toluidine blue 200 \times .

Fig. 11. No inflammatory infiltrate is present. No epithelial downgrowth is present. Acid fuchsin-toluidine blue 400 \times .

at the interface with dental implants. Only rarely the histology of human retrieved immediately loaded implants have been reported in the literature.¹⁶⁻²⁹ Even more rarely it is possible to find histological reports in the literature of immediately loaded implants with a long-term follow-up.²⁴⁻²⁹ In our patient 3 screw-shaped implants fractured over a period of some months. The patient was a heavy bruxer and most probably the para-

functions had caused the fractures. Sometimes, several implants can fracture in the same patient in a limited period of time. The histological data of the present specimens show that mineralized tissues are present at the interface with immediately loaded screw implants and that these tissues are successfully maintained over a long time period (3 years). The response of the bone tissue seemed not to be disturbed by the stresses and strains transmitted at the interface. In blade implants retrieved after 13 and 21 years of function, mature bone in tight contact with the implant surface was seen around most of the implant surface.²⁹ The threshold of critical micromotion seems to be comprised between 50 and 150 μm .¹⁵ An effective way to reduce micromovements could be splinting of the implant, in addition of using an implant with a retentive shape (*i.e.*, a screw-shaped implant).³²⁻³⁵ Rigid splinting and minimal lateral forces are critical factors for success. Implant splinting may certainly be helpful in decreasing the amount of micromotion during the healing period, producing an higher tolerance to deleterious micromovements.³²⁻³⁵ Implants splinted together may decrease the risk of overload to each implant as a result of greater surface and improved biomechanical distribution.³²⁻³⁵ In our implants, the large threads of the screw-shaped implants produced a high primary stability. Threaded implants present considerable advantages compared with press-fit implants for the immediate-loading protocol.³² An appropriate thread design makes a significant contribution to the initial stability of the implant during placement.^{32,34,35} The screws has a higher mechanical retention and greater ability to transfer compressive forces.¹⁵ Screw design not only minimizes micromotion of the implant, but also improves the initial stability.¹⁵ Additionally, the threads increase the surface area of the implant.¹⁵ Another purpose of incorporating thread into the implant design is the transformation of shear forces into more resistant force types at the bone interface.³³ Bone, in fact, responds to different types of loading and is weakest under shear-loading conditions.³³ The bigger the load on the implant, the higher are

the bone stresses that are elicited.³⁶ Threads are also used to maximize the initial contact, improve the initial stability, enlarge the implant surface area, and favor dissipation of interfacial stresses.³³ An important role is played also by the precise fit of the implant in the bone socket and is related to the implant design. Our histological results could also be explained by the fact that functional loading seems to stimulate bone apposition.³⁷⁻⁴¹ Wolff formulated his theory according to which there is a direct link between mechanical loading and bone form; Wolff's law would imply that increased stresses act as a stimulus to new bone formation whereas reduced stress tends to produce bone loss.³⁸⁻⁴¹

CONCLUSION

In a rigidly fixed implant system no significant distortional strains will be produced at the interface and in such a way no fibrous tissue formation will be stimulated. In our implants most probably a high primary stability was a key factor for the very high bone implant contact percentage maintained for 3 years.

Additional human specimens of immediately loaded implants retrieved after long-term periods will help to elucidate more clearly the behavior of the mineralized tissues at the interface.

Disclosure

The authors claim to have no financial interest, directly or indirectly, in any entity that is commercially related to the products mentioned in this article.

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ID Abstract Translations

GERMAN / DEUTSCH

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Histologischer und histomorphometrischer Bericht über 3 unmittelbar belastete Schraubimplantate, die nach einer Belastungszeit von 3 Jahren beim Menschen entnommen wurden

ZUSAMMENFASSUNG: Zielsetzung: Die vorliegende Studie zielte darauf ab, eine histologische sowie histomorphometrische Analyse der das Implantat umlagernden Gewebeteile bei drei unmittelbar belasteten Schraubimplantaten durchzuführen, die nach erfolgtem Bruch nach einem Belastungszeitraum von 3 Jahren beim Menschen entnommen wurden. **Ergebnisse:** An der Schnittstelle zu allen Implantaten was mineralisiertes Gewebe zu verzeichnen. Der durchschnittliche Prozentsatz an Knochen-Implantat-Kontakt für die drei Implantate betrug 56,3% +/- 5%. Die histologischen und histomorphometrischen Daten zeigten, dass unter Verwendung von unmittelbar belasteten Schraubimplantaten mineralisiertes Gewebe gewonnen werden kann und dass diese mineralisierten Gewebeteile für 3 Jahre bestehen bleiben. Die Reaktion des knöchernen Gewebes wurde nicht durch die an der Schnittstelle bestehenden Belastungen und Einflüsse beeinträchtigt. **Schlussfolgerung:** Eine hohe Primärstabilität, die durch die

großen Köpfe der schraubenförmigen Implantate erreicht wurde, kann wahrscheinlich als Schlüsselement für die langfristige Erhaltung der mineralisierten Knochengewebsschnittstelle gesehen werden. Diese primären Stabilitätseigenschaften tragen dazu bei, einer Mikrobewegung entgegen zu wirken, d.h. der relativen Bewegung zwischen der Implantatoberfläche und dem umgebenden Knochengewebe während einer funktionalen Belastung.

SCHLÜSSELWÖRTER: Knochen-Implantat-Schnittstelle, Implantatfraktur, unmittelbar belastetes Implantat, entnommenes Implantat, schraubenförmiges Implantat

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ABSTRACTO: Propósito: El objetivo de este estudio, en un hombre, fue un análisis histológico e histomorfométrico de los tejidos periimplante en 3 implantes con tornillos cargados inmediatamente, debido a una fractura, luego de un período de carga de 3 años. **Resultados:** Se encontró tejido mineralizado en la interfaz de todos los implantes. El porcentaje

medio de contacto entre hueso e implante para los 3 implantes fue de 56,3% \pm 5%. Los datos histológicos e histomorfométricos demostraron que se pueden obtener tejidos mineralizados en implantes con tornillos cargados inmediatamente y que estos tejidos mineralizados se mantienen durante un período de 3 años. La respuesta del tejido óseo no se vio afectada por las tensiones y estreses transmitidos en la interfaz. **Conclusión:** Una alta estabilidad primaria, obtenida por las grandes roscas del implante con forma de tornillo, fue posiblemente un factor clave en el mantenimiento a largo plazo del interfaz de hueso mineralizado. La estabilidad primaria ayuda a resistir el micromovimiento, o sea, los movimientos relativos entre la superficie del implante y el hueso que lo rodea durante la carga funcional.

PALABRAS CLAVES: interfaz implante-hueso, fractura del implante, implante cargado inmediatamente, implante sacado, implante con forma de tornillo

PORTUGUESE / PORTUGUÊS

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Relato Histológico e Histomorfométrico de 3 Implantes com Parafusos Imediatamente Carregados e Recuperados do Homem Após um Período de 3 Anos de Carga

RESUMO: Objetivo: O objetivo do presente estudo, no homem, era uma análise histológica e histomorfométrica dos tecidos de periimplante em 3 implantes com parafusos imediatamente carregados, por causa de fratura, após um período de 3 anos de carga. **Resultados:** Tecido mineralizado estava presente na interface de todos os implantes. O osso médio para a porcentagem de contato do implante para 3 implantes era 56.3% \pm 5%. Os dados histológicos e histomorfométricos mostraram que tecidos mineralizados podem ser obtidos em implantes com parafusos imediatamente carregados e que esses tecidos mineralizados são mantidos por um período de 3 anos. A resposta do tecido óseo não foi perturbada pelos estresses e tensões transmitidos na interface. **Conclusão:** Uma alta estabilidade primária, obtida pelos filetes grandes do implante em forma de parafuso, foi provavelmente um fator-chave na manutenção de longo prazo de uma interface de osso mineralizado. A estabilidade primária ajuda a resistir ao micromovimento, isto é, os movimentos relativos entre a superfície do implante e o osso circundante durante a carga funcional.

PALAVRAS-CHAVE: interface de implante único, fratura do implante, implante imediatamente carregado, implante em forma de parafuso

RUSSIAN / РУССКИЙ

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Отчет о гистологическом и гистоморфометрическом исследовании 3 винтовых имплантатов с немедленной нагрузкой, удаленных у человека после 3-летнего периода нагружения

РЕЗЮМЕ: Цель. Цель данного исследования на человеке – проведение гистологического и гистоморфометрического анализа периимплантатной ткани трех винтовых имплантатов с немедленной нагрузкой, удаленных по причине перелома, после трехлетнего периода нагрузки.

Результаты. На границе имплантат-кость всех имплантатов присутствовала минерализованная ткань. В процентном выражении непосредственный контакт кости с имплантатом для всех трех имплантатов составил 56,3% \pm 5%. Гистологические и гистоморфометрические данные свидетельствуют о том, что минерализации ткани можно достичь при использовании винтовых имплантатов с немедленной нагрузкой, а также о том, что такие минерализованные ткани сохраняются более 3 лет. Ответная реакция костной ткани не была нарушена нагрузкой и напряжением, передаваемыми на границе имплантат-кость. **Вывод.** Высокая первичная стабильность, достигнутая крупными витками винтового имплантата, вероятнее всего, явилась ключевым фактором в сохранении минерализованной костной ткани на границе имплантат-кость в течение длительного времени. Первичная стабильность помогает не допускать микроподвижности, т.е. относительных смещений между поверхностью имплантата и окружающей костной тканью во время функциональной нагрузки.

КЛЮЧЕВЫЕ СЛОВА: граница кость-имплантат, перелом имплантата, немедленная нагрузка имплантата, удаленный имплантат, винтовой имплантат.

TURKISH / TÜRKÇE

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3 Yıllık Yükleme Periyodundan Sonra Bir Erkek Hastadan Çıkarılan 3 Hemen (Yımmediat) Yüklendi Vida İmplantlarının Histolojik ve Histomorfometrik Raporu

ÖZET: Amaç: Bu çalışmanın amacı, 3 yıllık bir yükleme periyodundan sonra bir erkek hastadan kırık nedeniyle çıkarılan 3 hemen yüklenmiş vida implantlarındaki peri-implant dokularının histolojik ve histomorfometrik analizini sunmaktır. **Bulgular:** Tüm implantların arayüzünde mineralize doku mevcuttu. Üç implant için kemiğin implanta ortalama temas yüzdesi 56.3% +/-5% idi. Histolojik ve histomorfometrik veriler, hemen yüklenmiş vida implantlarında miner-

alize doku elde edilebildiğini ve bu mineralize dokuların 3 yıl boyunca muhafaza edildiğini gösterdi. Arayüze iletilen gerilim ve basınç, kemiksel dokudan alınan yanıtı bozmadı. **Sonuç:** Mineralize kemik arayüzünün uzun vadede muhafaza edilmesindeki kritik faktör, muhtemelen vida çeşkindeki implantın geniş yivlerinden sağlanan yüksek birincil stabilite idi. Birincil stabilite, mikro hareketlere—örn., fonksiyonel yükleme sırasında implantın yüzeyi ile etrafındaki kemik arasındaki göreceli harekete—karşı direnç sağlanmasına yardım eder.

ANAHTAR KELİMELELER: kemik-implant arayüzü, implant kırığı, hemen yüklenmiş implant, çıkarılmış implant, vida çeşkinde implant

JAPANESE / 日本語

負荷期間3年後、男性患者から回収した即時負荷スクリューインプラント3本の組織学ならびに組織形態測定学研究報告

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研究概要:

目的: 当研究は3年間の負荷期間後、破損のために男性患者1名から回収した3本の即時負荷スクリューインプラント周辺組織の組織学ならびに組織形態測定学上分析を目的とした。

結果: すべてのインプラント接触面に無機物化組織が認められた。3本のインプラントにおける骨とインプラント平均接触率は56.3% +/-5%を示した。組織学ならびに組織形態測定学上データによると即時負荷スクリューインプラントに無機物化組織が形成すること、さらに3年間にわたり無機物化組織が維持されたことがともに明らかにされた。骨性組織反応は接触面の圧迫や圧力によって障害を受けることはなかった。

結論: スクリュー型インプラントの大型ネジ山部分で得られる高度の初期安定度が、おそらく無機物化骨接触面長期間維持の鍵を握る要因と考えられる。初期安定度はfunctional loadingの際、インプラント表面と周辺骨組織間の相対運動などマイクロモーションに対する抵抗を助長する。

キーワード: 骨-インプラント接触面, インプラント破損, 即時負荷インプラント, 回収インプラント, スクリュー型インプラント

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3 顆立即載入男性患者的螺旋形植體於載入 3 年後取出的組織學與組織形態學報告

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摘要：

目的：本研究的主要目的是以組織學與組織形態學分析 3 顆因為斷裂而在載入 3 年後取出的立即植入螺旋形植體的植體周圍組織。

結果：所有植體介面出現礦物化組織。3 顆植體的平均骨質植體接觸百分比為 56.3% +/-5%。組織學與組織形態學的數據顯示，立即載入螺旋形植體可取得礦物化組織，而且這些礦物化組織維持 3 年的時間。骨組織的反應並未因介面傳送的壓力與張力而受干擾。

結論：螺旋形植體的大螺紋所取得高度初步穩定性，可能是礦物化骨質介面長期保持的主要因素。此初步穩定性有助於抵抗微移動，也就是在功能性載入期間植體表面和周圍骨質之間的相對移動。

關鍵字：骨質植體介面、植體斷裂、立即載入植體、取出的植體、螺旋形植體

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3년 매식 기간 후 인간에서 복구된 3개의 즉시 매입 나사형 임플란트에 대한 조직학 및 조직계측학적 보고서

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초록:

목적: 인간을 대상으로 한 본 시험의 목적은, 골질로 인해 3년의 매식 기간을 마친 후 복구된 3개의 즉시 매식 나사형(screw) 임플란트에서 임플란트 주위에 대한 조직의 조직학적 및 조직계측학적 분석을 하기 위함이다.

결과: 모든 임플란트 접촉면에 광물화된 조직이 있었다. 3개 임플란트에 대해 골과 임플란트의 평균 접촉 비율은 56.3% +/-5% 이었다. 조직학적 및 조직계측학적 자료에서 광물화된 조직은 나사형 임플란트가 즉시 매식되면 얻을 수 있으며, 이 광물화된 조직은 3년 넘게 유지됨을 보여준다. 뼈 조직은 접촉면에 스트레스 및 긴장을 가하여도 상하지 않았다.

결론: 나사 모양의 대형 나사 임플란트에서 확보된 가장 우선시 되는 안정성이 광물화된 골 접촉면을 장기 유지하는 주 요인이었을 것이다. 우선 안정성은 미세운동, 즉, 기능적 매식 시 임플란트 표면과 주위 뼈 사이의 상대적 운동을 견디는데 도움이 된다.

핵심 단어: 골-임플란트 접촉면, 임플란트 골질, 즉시 매식 임플란트, 복구된 임플란트, 나사형태의 임플란트

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