Special report

EDITOR'S NOTE: As of the printing date of this publication, the Ankylos SynCone and Cercon abutments were not yet approved for use in the United States. Ankylos implants are approved for single stage surgical placement and immediate loading in the United States, but immediate loading is restricted to the anterior mandible, based on 4 intraforaminal placed implants, and is not indicated for single, unsplinted implants.

PRESENT STATUS OF IMMEDIATE LOADING OF Oral Implants

G. E. Romanos, DDS, PhD

Key Words

Dental implants Osseointegration Immediate loading Implant design Implant survival

G. E. Romanos, DDS, PhD, is an associate professor in the Department of Oral Surgery and Implantology at Johann Wolfgang Goethe University, in Frankfurt, Germany. Address correspondence to Dr Romanos at Dental School Frankfurt (Carolinum), Department of Oral Surgery and Implantology, Theodor Stern Kai 7, D-60590 Frankfurt, Germany (e-mail: Dr.G.E.Romanos@t-online.de). Problem: Several conditions must be present to obtain implant integration and long-term clinical success when using the one-stage implant placement procedure with immediate loading. These conditions include (1) primary stability, (2) sufficient bone quality, and (3) elimination of micromovement of the implant before osseous integration is complete. Purpose: This report presents the results of research on immediate loading using a new and innovative implant design, Ankylos. Methods: The author reviewed clinical studies of immediate loaading or oral implants, including two treatment options, removable overdentures and fixed reconstructions. Results: Animal studies have demonstrated that successful osseointegration of Ankylos implants can occur (Figure 2D) when implants are placed and loaded immediately in the presence of some specific conditions. The histological findings involving implants that were placed in humans and immediately loaded showed no fibrous tissue formation (encapsulation). The bone-to-implant contact (osseointegration) was found to be excellent between the immediately-loaded implants and the surrounding alveolar bone. Conclusions: The Ankylos implant system with its progressive thread design successfully promotes primary, clinical stability at the time of implant placement. Several animal studies have shown that in implant restorations placed in similar areas of poor bone quality (ie, maxilla and the posterior part of the mandible), the concept of immediate loading can result in longterm clinical success, when loading forces are controlled. Immobilization of the implants and soft diet recommendations that reduce micromovement at the bone-to-implant interface will improve longterm clinical success. In summary, the Ankylos implant is well designed for one-stage placement with immediate loading, as well as for two-stage treatment protocols. Both clinical protocols will result in long-term clinical survival.

INTRODUCTION

n 1983, Branemark recommended that endosseous dental implants remain covered and free from loading for a period of 3 months in the mandible and 6 months in the maxilla¹ to allow implant-bone integration (osseointegration). Any micromotion greater than 100 µm during this healing period can have a negative effect on the osseous integration of oral implants.² If micromotions are present and exceed they this level, fibrous tissue may form at the boneimplant interface, and the bone remodeling processes may be disturbed to an extent that would eventually lead to implant loss.³⁻⁴ Following implant placement and a short healing period, immediate loading of implants can have positive social and psychological effects for patients.

Currently, a precise definition for "immediate loading" does not exist, and this has caused considerable confusion in the dental implant literature. In some cases, immediate loading may refer to a period of a few hours, whereas in others, it refers to the first 3 days after implant placement and after the dental restoration has been placed.⁶⁻¹¹ Some clinicians recommend that a restoration be inserted after a period of 3 weeks following implant placement surgery.^{12,13}

In some clinical studies (primary, 2-stage), submerged implants are placed along with nonsubmerged (secondary) implants on the same day. The nonsubmerged implants are used to support a temporary restoration. After healing, the secondary implants are splinted with submerged healed (primary) implants.^{8,12,14} These secondary implants are overloaded and cannot be compared with immediately-loaded implants. There is ongoing discussion whether or not immediately-loaded implants per definition should have occlusal contacts within the same day or a few days after surgery (immediate functional loading), or whether they should remain without occlusal contacts (immediate nonfunctional loading). Under these 2 different definitions of loading concepts, functional or nonfunctional immediate loading is a technique that seems to give satisfactory results in selected cases.15-16

IMMEDIATE LOADING— REQUIREMENTS FOR SUCCESS

Several requirements need to be present to ensure long-term success of immediately-loaded implants. These include: (1) excellent stability of the implant, (2) excellent bone density for the implant bed, and (3) elimination of micromotion in the bone-implant interface during the healing period.

Primary stability

The implant design makes a significant contribution to the initial stability of the implant during placement surgery. An appropriate thread design has a higher retention, and may contribute to a better, long-term clinical prognosis compared to a cylindrical implant forms.¹⁷⁻¹⁸ Moreover, the implant surface microstructure (microinterlock) may also contribute significantly to primary implant stability. Rough implant surfaces, to a greater extent than smooth surfaces, demonstrate a higher attachment of bone cells and accelerate implant integration.¹⁹⁻²² In general, when implants must be loaded immediately, a screw thread implant design with rough surface is

recommended.^{5,8,10} Jaffin et al¹⁰ reported that immediately-loaded implants with machined smooth surfaces had a much lower success rate (83%) compared to implants with titanium plasma sprayed/ sandblasted large-grit acid-etched (TPS/SLA) surfaces (99%).

By increasing the implant surface using a sandblasted microtexture and a progressive thread (Ankylos, geometry Friadent GmbH, Mannheim, Germany), it is possible to use only one implant in order to successfully replace single molars.²³ Studies have also shown that small-diameter implants (3.5 mm in diameter) with a 14-mm length had a total surface similar to multirooted teeth.²⁴ The Ankylos implant has demonstrated excellent stability in the initial stages of healing.²⁵ Its high stability may be explained by the high percentages of bone-to-implant contact present immediately after implant insertion. This bone-implant contact has been documented in different anatomical studies.²⁶ Moreover, the increased stability of the progressive thread design has been demonstrated in a clinical study showing that small size, single-tooth Ankylos implants have an excellent, longterm prognosis. In this study, a total of 357 implants were placed in order to replace missing single (107 anterior and 250 posterior) teeth. The implants were restored after uncovering with single (unsplinted) crowns. After a total loading period of $40.9 (\pm 31.7)$ months, only 8 failures were observed, which represents a success rate of 97.7%.²⁷

The short integration period, which is extremely important for immediate, functional-loading cases, is believed to be associated with the surface roughness of the implant. The surface roughness seems to play an important role in timing,¹⁹ the amount of integration,²² and micromotion tolerance.²⁸⁻³⁰

Bone quality

Another important parameter that influences the long-term success of oral implants is the bone quality of the prepared implant bed. Failure of implants placed with a 2-stage protocol have been reported in areas with compromised bone qualities.³¹ Immediately-loaded implants can also fail when they are placed in areas with poor bone quality; this is often encountered in the posterior part of the mandible.^{8,12,14} Most clinicians recommend implants be placed in the mandibular symphysis, where bone quality is excellent, and to load them immediately.6,7,13,32

Reduction of micromotion

Sufficient immobilization (splinting) immediately after surgery is another requirement in the immediate-loading protocol. The implants should be splinted the same day as surgery using bar-retained overdentures,^{6,7,33} or using a conical, crown-retained implant-supported overdenture as a type of a secondary immobilization.³⁴ Implants may also be splinted with temporary fixed prosthetic restorations^{8-12,14,35} when edentulous ridges are to be restored with fixed prosthetic reconstructions.

Based on the results reported in different orthopedic studies, fractured immobilized bones can be loaded immediately after surgery. This treatment concept is a daily approach to the treatment of fractures when functional, stable osteosynthesis plating systems are used. Early loading can be advantageous to healing in fractured areas.³⁶⁻³⁹ A significant increase in blood vessel formation, as well as active remodeling



FIGURE 1. (A) Splinting of four implants for immediate loading using a bar-retained complete overdenture. (B) A clinical case similar to that shown in (A); SynCone abutments are covered with precision-manufactured copings (telescopic crowns) that will be incorporated in a temporary denture to provide indirect immobilization of the implants immediately following placement. (C–E) Implant placement at the upper jaw for immediate loading. (C) A provisional connection of abutments is necessary to find the correct position. (D) The final abutments were connected and GBR-technique at the crestal part of the implants used before flap closure. (E) The final restorations in the upper and lower jaws present excellent esthetics and (F) no bone loss 2 years after loading.

in fractured zones, has been shown under loading.⁴⁰ Interactive loading, which involves frequent cycling of tension and compression stress, is one of the requirements of healing. Continuous loading, however, is to be avoided. To reduce excessive loading forces during mastication, a soft diet is advised for the first 4–6 weeks of healing.^{11,41-42}

CLINICAL EXPERIENCE WITH IMMEDIATE LOADING

Immediate-loading of oral implants is an innovative and attractive treatment method available in implant dentistry today. This approach requires good knowledge of bone biology and the remodeling processes that occur during healing. There are two ways to treat partially or completely edentulous patients who need prosthetic rehabilitation. These involve either removable, fixed implant-supported or implant-retained restorations, both of which may be used with the immediate loading concept.

Removable overdentures

The first immediate-loading protocols were used to restore the lower jaw using four implants connected with a bar in the mandibular symphysis in the first 3 days after surgery (Figure 1A) to support or retain a removable overdenture. Using this approach, a cumulative implant success rate of more than 88% has been demonstrated in several clinical studies and clinical case reports.^{6,7,32,33}

Recent clinical studies have documented that indirect immobilization of four primary stable Ankylos implants (placed in the anterior region of the mandible) can also be successfully immediately-loaded with an implantsupported overdenture. The implants were not splinted together with a bar, but were connected with prefabricated telescopic conical abutments (Figure 1B) having a 4° angulation (SynCone System, Friadent, Mannheim, Germany). These prefabricated abutments are manufactured with a precise fit to secondary copings that are inserted into the base of the denture. The patient should consume a soft diet, and the denture should not be removed for 10 days.

This treatment protocol has been used in a 204 implants during an observation period of 2 years, and presented a cumulative survival rate of 97.54%.³⁴ The SynCone prefabricated abutments with telescopic copings have many benefits. They significantly reduce the cost associated with the fabrication of customized castings, and they allow better oral hygiene in comparison to the barretained dentures. A similar concept with early-functional loading (the implants were functionally loaded within 5 days after surgery) was recently published using the Branemark implant system. After 2 years of loading, a cumulative survival rate of 96.3% has been observed.⁴³

Fixed reconstructions

The restoration of edentulous jaws with fixed implant-supported reconstruction generally requires a higher number of immediately-loaded implants. This number varies, but 6–12 implants has been suggested by most clinicians.^{8,10,12,14,16,35,44} Glauser et al⁴⁵ reported high success rates (97.1%) after 1 year of loading in areas of low bone density in the maxilla or the mandible. The authors used long implants, and they excluded patients who demonstrated bruxism.

We have successfully restored edentulous upper and lower jaws with only 6 Ankylos implants in each jaw, and have immediately loaded the implants after implant placement surgery using temporary resin restorations (immediate functional loading). The final restorations were placed and cemented with Temp-bond fixation material approximately 6 weeks after placement surgery (Figure 1C–E). No crestal bone loss was evident 2 years after loading using this concept (Figure 1F). The complete treatment protocol for this treatment method has been published recently.44 The present results document a high success rate (97.22%) in 8 patients with 72 implants after a loading period of 15.21 (\pm 7.81) months.⁴⁶ The two implants that failed and were removed were maxillary implants that had been placed in a patient with a history of bruxism. In 5 patients with 6 restoration implants in each lower jaw (30 Ankylos implants), there was no evidence of crestal bone loss, and the implants were 100% successful after a total loading period of 20.50 ± 9.74 months. All implants exhibited healthy peri-implant soft tissues and hard tissues in contact with the implants.47

The Ankylos implant system has resulted in highly successful and predictable osseointegration for immediately-loaded implants placed in the posterior part of the mandible (3 implants connected together) to restore partially edentulous jaws. Two protocols were used in a prospective clinical study involving 12 patients who were bilaterally partially edentulous in the posterior part of the mandible. The first was a standard loading protocol. It was used on one side, and was considered to be the control. The contralateral side involved the immediate functional-loading protocol, and served as the test side. The results produced excellent healing of the soft and hard, peri-implant tissues (Figure 2A-C). After a period of 2 years of follow up, the cumulative success rate was 100% for 3 Ankylos implants connected together and loaded immediately after surgery.42,48

Histological specimens were obtained in a clinical study conducted by Rocci et al⁴⁹ with oxidized implants that were subjected to either early or immediate loading, and followed for a period of 5 to 9 months. All specimens showed normal healing around all implants. In this study, the implants for only 1 patient were subjected to immediate functional loading on the same day of surgery. The implants in 4 other patients involved early loading; 2 months after surgery the implants had occlusal contacts. The investigators performed additional studies to determine the success rate of machined and TiUnite-surfaced implants. Of the implants placed and followed in this study, 14.4% of those with machined surfaces failed compared to 4.7% of oxidized implants in the first year of loading. The higher failures for

the machined-surface implants occurred more frequently in patients who smoked and in those with poor (type IV) bone qualities.⁵⁰

The ability to restore upper and lower jaws using implants placed immediately following natural tooth extraction and by subjecting them to immediate functional loading represents an interesting concept. This treatment protocol would provide many opportunities for patients with advanced periodontal destruction who may not be able to tolerate a full denture.⁴⁴ The excellent primary stability of the Ankylos implant, with its progressive thread design and the root-form design, provides excellent anchorage in the bony socket immediately after extraction. The present clinical data show an impressively high success rate using this treatment protocol after clinical loading of the implant for a period of 2 years.⁴¹

HISTOLOGICAL OBSERVATIONS OF Immediately Loaded Implants

Animal studies have demonstrated that successful osseointegration of Ankylos implants can occur (Figure 2D) when implants are placed and loaded immediately in the presence of some specific conditions. The implant surface roughness and the thread design of these implants are major factors in realizing this success.⁵¹⁻⁵⁶

Comparison of the histological and histomorphometrical findings of the peri-implant hard tissues^{42,55} and soft tissues⁵⁷ on immediately-loaded Ankylos implants and for delay-loaded implants did not show any significant differences in specimens from *Macaca fascicularis* monkeys. The mineralized bone



FIGURE 2. (A, B) Immediate loading of implants in a posterior mandible with a temporary fixed restoration. (C) There is no evidence of crestal bone loss after 2 years of functional loading. (D) Histological specimen from a monkey that demonstrates excellent healing and bone formation following immediate loading. (E) Histological specimen from a human biopsy shows excellent bone-to-implant integration without fibrous tissue formation at the interface 7 months after immediate loading. (F) Higher magnification demonstrates a mature bone with a high number of osteocytes.

tissues at the interface of immediately-loaded implants appeared to exhibit higher density compared to the bone tissue around delay-loaded implants.⁵⁶ Higher bone density has been demonstrated at the interface around both immediate-loaded or delayed-loaded implants compared to unloaded implants in monkeys.⁵⁸ This explains that, in general, loading of implants seems to stimulate the formation of dense bone at the implant-bone interface, as has been reported elsewhere.59

The histological findings involving implants that were placed in humans and immediately loaded showed no fibrous tissue formation (encapsulation). The bone-to-implant contact (osseointegration) was found to be excellent between the immediately-loaded implants and the surrounding alveolar bone. These implants had both blade designs⁶⁰ or screw thread designs,^{53,61} which were removed because of implant fractures. Similar findings (unpublished data) were recorded after a histological examination of en bloc human biopsy specimen from a patient who died from bronchial carcinoma. A total of 12 Ankylos implants (6 in the maxilla and 6 in the mandible) were



FIGURE 3. (A) Radiograph of periodontal disease. (B, C) Teeth were extracted and implants were immediately placed in a maxillary jaw (B) and a mandibular jaw (C). (D) Temporary bridges were used to immediately load implants. (E) Final restorations. (F) Radiograph showing baseline bone levels. (G) Radiograph demonstrates no bone loss.

examined and observed to have implant-bone integration without epithelial proliferation and pocket formation (Figure 2E–F). The histomorphometrical evaluation of bone-to-implant contact within the threads demonstrated a mean of about 51%, and a mean bone volume of about 52% with a tendency toward higher percentages around the implants in the upper jaw 7 months after loading (G. E. R. and C. Johansson, unpublished data, 2004).

FUTURE DEVELOPMENTS AND ASPECTS

For implants placed with immediate loading, primary stability is necessary in order to reduce micromovement and to establish long-term success. To improve primary stability, it is recommended that special surgical techniques be used to increase bone density in the implant bed before implant insertion. Special instruments such as osteotomes (Bone Spreading System, Ustomed Company, Tuttlingen, Germany) may be used in areas with poor bone quality to provide denser bone structure. Advanced augmentation surgical procedures should be used with autogenous bone grafting material from the tuberosities, the chin, or the retromolar areas when implants are inserted in atrophied alveolar ridges. There is no doubt that

guided bone regeneration (GBR) techniques with membranes must be used with considerable care.

When immediate implant placement and immediate functional loading are planned, it is mandatory that a flap be elevated to allow complete removal of infected soft tissues in periodontal pockets. The bone socket remaining following tooth removal must be carefully prepared to receive the implant. The preparation should be made with a minimal amount of surgical trauma and should allow a tight fit between the bone and the implant⁴¹; this will provide the required excellent, primary stability. If these clinical conditions are established, the treatment period can be reduced considerably, and longterm success may be achieved (Figure 3). To date, we have treated 14 patients using this concept using 126 immediate implants placed in 12 maxillae and 6 mandibles, loaded immediately after surgery. After a loading period of 14.07 ± 5.86 months we have demonstrated a 97.61% success rate (3 immediate implants in combination with sinus lift and immediate loading were lost).

Specialized training in advanced periodontal and implant surgery as well as in implant prosthodontics will help dentists realize a high success rate for implants. Additional scientific data for some of these protocols are necessary before these techniques can be used in dental offices on a routine basis. The excellent primary stability of the Ankylos implant system used in these clinical situations is absolutely essential in order to obtain more evidence and scientific data.

SUMMARY AND CONCLUSIONS

The new and innovative Ankylos implant design provides excellent

clinical performance either as a two-stage or one-stage implant with immediate loading. It performs well with either immediate placement and immediate loading following the removal of natural teeth. As reported by Chou et al⁶³ and in our clinical studies, crestal bone loss has not been a problem with this implant. We suggest that clinicians who plan to use immediate loading of the implant carefully follow the treatment protocols described in this paper.

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Note

The results and opinions presented are those of the author and do not necessarily reflect the opinions of the American Academy of Implant Dentistry. This manuscript does not represent an endorsement of the evaluated implant by the American Academy of Implant Dentistry.