BIC; explantat, histologie, osseintegration, primary stability, immediate loading IMPLANTS

Follow-up and histological assessment of healing of an immediate loading of implants

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The optimal treatment of the toothless mandible often proves itself to be problematic for older patients because of cost related reasons. A prosthetic restoration is desired as quickly as possible also because of aesthetic reasons. A possibility exists in the form of an immediate loading implant. The requirement for this is that the height and width of the jaw are sufficient and that the gums are free of any inflammation. Apart from that, it is also important to achieve an adequate primary stability of the implant.

Conchran et al. (2004) [5] and Esposito et al. (2007) [10] Osseointegration including the assessment of the defined immediate loading as a direct insertion of the supraconstruction usually on the same day as the treatment or 24 hours later – latest, though, one week later. Immediate loaded implants are used transgingivally and so thus the treatment period is shortened. Clinical observations confirmed the positive success of the immediately loaded implants [3, 4, 7]. Long-term observations showed that there is usually no significant difference regarding the osseointegration of the immediately loaded and the late loaded implants [2, 7, 11, 15].

The toothless jaw can be treated with 4 implants (all-on-4) with equal distances of approximatively 12 mm [14]. These ones get then the ballhead attachments or the bridge constructions. As a more lower priced alternative it is possible to plan a 10-membered bridge with 5 implants, a 12-membered bridge with 6 implants and a 14-membered bridge (ceramic) with 8 implants.

Experiences in practice of Fatori have shown that only a few implants, often only 5, are sufficient for the care of the toothless mandible. However, in individual cases the supply of more implants may be necessary.

A case of a patient is presented, which was supplied with 8 TAG-implants (T.A.G. Dental, Israel, Adrovic, 2015) in order to construct a 12-membered dental bridge. An implant has been additionally inserted for the assessment of the osseointegration and has been evaluated histologically (the patient consent was available, legally clarified).

The histological examination of explanted implants with still adherent periimplanted bone and soft tissues, e.g., with the here used technique of bone grafting according to Donath [8], allows a structural assessment of the interfaces between the implant surface and bone [13, 24] in undecalcified specimens, as well as morphometric investigations, e.g., the measurement of the BIC-index (bone-implant-contact).

Presentation of the case

The report is about a 69-year-old patient with a toothless mandible. Clinically there are no present diseases. The patient is a non-smoker. There was sufficient bone supply, so that there no augmentation was necessary. The anatomical situation and the bone conditions were good. An implantation of 8 implants (TAG) took place, out of which one was later removed in oder to be used for the histological assessment of the healing behavior. The patient gave his consent. The implantation took place here in regio 46.

The course of treatment

The local two-sided anesthesia was performed with Ultracain D-S forte, followed by a mandibular anesthesia with half an ampulla Ultracain D-S forte (Hoechst, Frankfurt). For the incision, a 14C scalpel (Aesculap, Tuttlingen) was used, with optimal preservation of the gingival mucosa. According to Lappenelevation, buccal and lingual bone structures could be clearly seen. Sharp bone structures on the alveolar ridge have been straightened with the help of a bud burr (d = 0,8, Komet, Lemgo). The preparation for the implants started with the pilot drill (1.8 mm), then it continued with the push drill 2.28 mm and finally a drill with 3.2 mm was used. The mechanically-cut implants were inserted with a 40 N. In order to avoid unnecessary pressure in the jaw bone, each implant was rotated to the left for a half turn. In this way an optimal blood flow condition to the implant surface was obtained, which can minimize or avoid bone necrosis. Finally, a periosteal slitting was performed in order to obtain a flap closure without tension. The suture technique was performed with vertical sutures (5.0 suture, Resorba, Nuremberg). A double mix impression technique was used as a model for the temporary plastic dental bridge.

After the insertion of the implants, a temporary bridge was constructed on the same day, so that the immediate loading was given. During the treatment period (10 months) there were no complications. An implant was explanted as planned after 4 months and it was histologically investigated. The explantation was carried out in a standard manner with a standard explantation bur (d = 4.4, comet). The resulting osseous defect was filled with NanoBone (Artoss, Rostock).

After 8 months the final supply of a fully ceramic bridge was undertaken.

Postoperative Aftercare

The careful assessment of the periimplanted soft tissue and of the bone bearing tissue must be carried out by means of established standardized procedures:

The sulcus bleeding index, the plaque index [19], the papilla index, the additional determination of the probing depth, and the quality of the gingiva are important here. Bone quality and bone quantity were assessed according to the scheme proposed by Lekholm and Zarb (1985) [12].

The preservation of the intact alveolar walls was attempted by following the Tarnow classification.

The probing depth PD was determined mesially, distally, buccally and palatally after 4 and 6 months for each implant with the periodontal probe XP23/UNC 15 (Hu-Friedy, Frankfurt), the plaque test by Mühlemann was performed and bleeding was probed.

The periimplant soft tissue around all implants was within normal limits in the present treatment period.

A scanning electron microscopic assessment of the implant surface

An unused TAG titanium implant (Ti 6AL 4V ELI, T.A.G. Dental, Israel) was evaluated with the FEREM ZEISS Gemini 940. The sterile implant was removed from the package and was glued immediately afterwards to a sample plate with LeitCTabs and then directly microscoped.

The scanning electron microscopy showed threads with clean cutting and inhomogeneous, normal surface structure. This architecture favors the healing of the implant. The micro-roughness gave reason to expect a good osseointegration of the implant (Fig. 1).

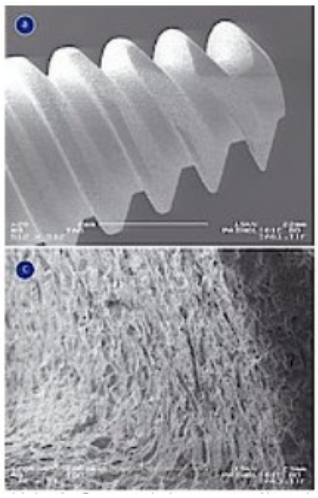

Fig. 1: Scanning electron micrographs of the surface of a sterile TAG implant a) Overview. Clean milled threads. b) Detail shot of the threads. Surface structure of the outer threads, slightly inhomogeneous “frayed”. c) Detail shot of the inner thread. Dark triangular and angular inclusion can be seen. d) Increased surface area. The inhomogeneous structuring of the surface promotes osseointegration.

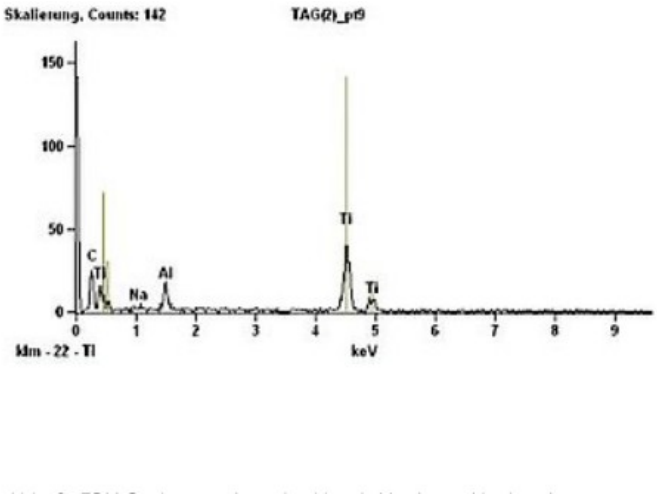

Fig. 2: EDX spectrum of a dark inclusion - detection of aluminum. Ti = Titanium implant.

The elementary analysis (EDX analysis - energy dispersive X-ray microanalysis) revealed few aluminum-containing contaminations on the implant surface (Fig. 2).

Clinical findings

The patient had for 20 years a toothless mandible with adequate bone supply (Fig. 3), so that no augmentation was necessary. The mandible was unstable. According to the patient, an allergy to penicillin was present. The upper jaw is also toothless. The bone quality in the interforaminal region was D1. The palpation of the two peripheral joints revealed no noticeable findings. The mouth opening was normal. The oral mucosa was normal and without any signs of inflammation. The radiography revealed no findings (Fig. 4). The preparation procedures are shown in figures 5 and 6.

Fig. 3: Macroscopic shot of the toothless mandible. There is sufficient bone available. The width of the keratinized gingiva is sufficient. Apical there is an radiant labial frenulum.

Fig. 4: X-ray image of the toothless mandible and maxilla. No pathological abnormalities. The bone quality I is present.

Fig. 5: Preparation of the mandible. Preparation of implant placement.

Fig. 6: Inserted implants (with posts). Preparation for the dental cast.

Histological treatment of the explantat

After 4 months, the implant was removed as planned for the assessment of the healing process (Fig. 9) and processed conventionally with the help of the grinding technique according to Donath. The explantat was introduced to regio 46. Here the bone quality was D2.

Fig. 7: Provisional bridge. Buccal view.

Fig. 8: Provisional bridge. Lingual view.

Fig. 9: Macroscopic image of the explanted implant, which has been osseointegrated for 4 months. Good embedding in the bone block.

Fig. 10: Histological findings. Overview: good osseointegration, toluidine coloring.

After the removal, the explantat was fixated and dehydrated with an ascending alcohol series. Finally, an infiltration was carried out in Technovit 7200 VLC (Kulzer, Friedrichsdorf). The polymerization was carried out over several steps in a light polymerization unit (EXAKT, Kulzer) at 40 ° C. The plastic blocks were polished with a micro-grinder up to the preparation, then an object carrier was fixed on the surface of the cut and the cut was separated with a cut-off grinding machine. As an outline coloring for the 30 µm thick grindings a coloring with toluidine blue and trichrome took place according to Masson-Goldner. The histological findings and the documentation were carried out on a light microscope (Zeiss Axioskop), the determination of the BIC according to the standardized methods [6] took place using a software (Zeiss Axiovision).

Histological findings

In an overall view, the vast majority of the implant surface including threads covered with bones and bones grown almost up to the coronal of the implant shoulder. On one side, a crestally soft overlying soft tissue portion with loose connective tissue with small sections of blood vessels could be detected.

At higher magnifications, connective tissue attachments were found in a few places in the form of loose, vascular and cell-rich tissue. Otherwise, there was a tight bone implant contact with, in some places, an approximately 5 to 10 nm wide, amorphous, bright interface.

Everywhere close to the implant there was mature lamellar cell - rich bone with osteons and cement lines, the peripheral one was made up of coarse, interlinking spongios. In this case we might deal with lager bones. At some distance from the implant surface, channel systems of different diameters as well as larger, connected intertrabecular spaces with fat marks, loose connective tissue as well as focal hematopoietic bone marrow were present. In places, sections of widespread, thin-walled sinusoidal vessels could be seen.

A focal view found at some distance from the implant surface contact osteogenesis. Bone appositions, with the addition of osteoid layers, were present present focally. Osteoblasts and, sporadically, osteocytes were located very close to the implant surface. Clear lacuna of resorption and osteoclasts were not identified. Crestally there were found no signs of resorption processes or necrosis. Infiltrates were not detected (Fig. 11 to 16). The BIC was 83%.

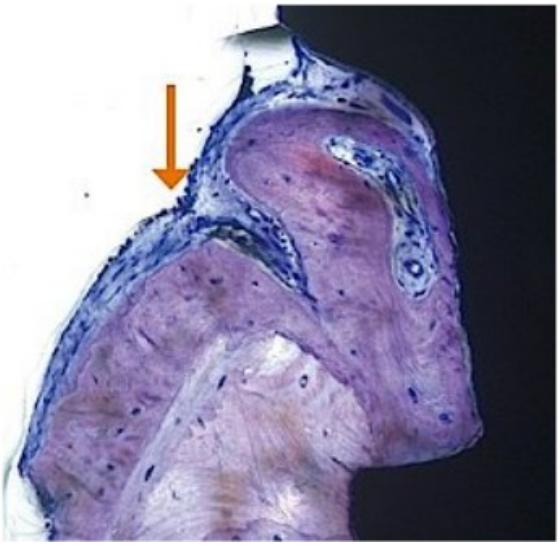

Fig. 11: Section 2: Crestal thin soft tissue support (arrow). Underneath appositional bone deposition. Toluidine coloring.

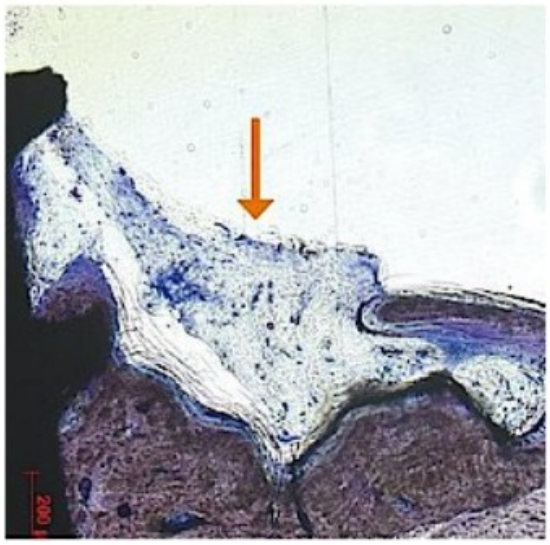

Fig. 12: Crestal gingival soft tissue support without epithelium (arrow) with underlying bone. Toluidine coloring.

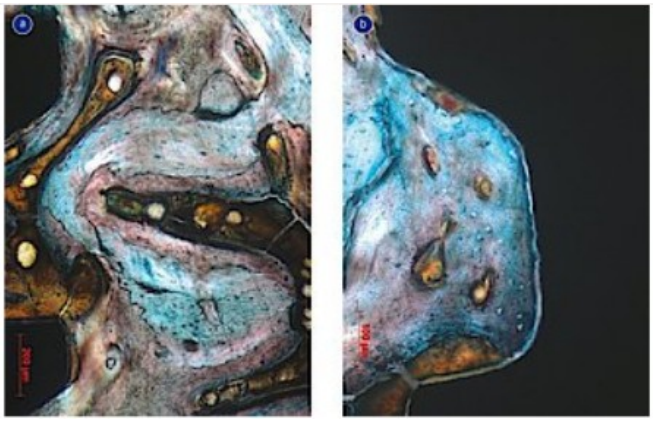

Fig. 13a: Bone is represented greenish. Masson-Goldner coloring. 13b: Detail interface bone implant surface. Masson-Goldner coloring.

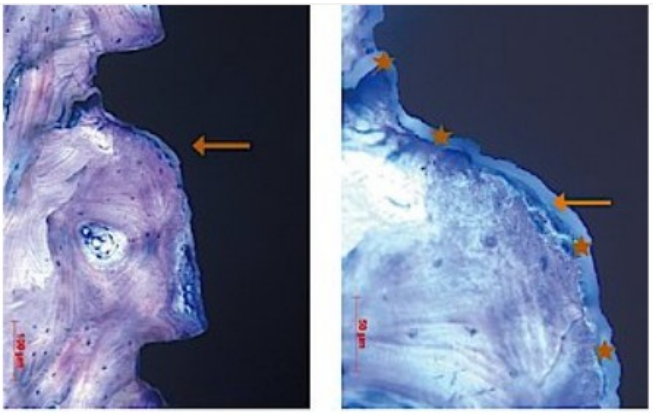

Fig. 14a: Interface of the bone implant surface. Detection of osteocytes near the implant surface (arrow). Toluidine coloring. b: Detail of the amorphous interface (asterisks). Arrow: osteocytes, toluidine coloring.

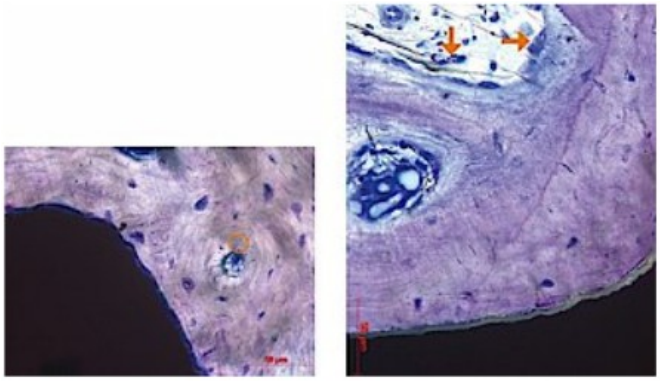

Fig. 15a: Bones near the implant surface. Lamellar bone with osteocytes and osteon (O). Toluidine coloring. b: Evidence of osteogenesis (arrows) near the implant surface. Toluidine coloring.

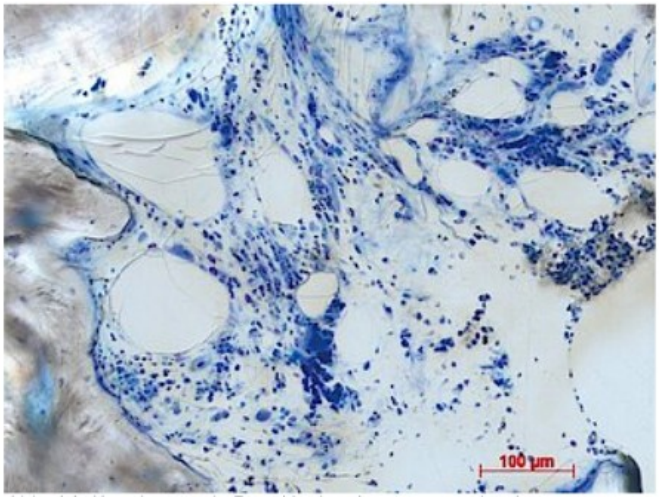

Fig. 16: Bone marrow, fat. Detection of centrally located hematopoietic cells. Toluidine coloring.

Discussion

Dental implants have been used since 1960 as an artificial root substitute in Germany and are currently an established method of care for tooth loss [18]. Brånemark demonstrated a fundamental superiority of osseointegrated implants compared to soft tissue anchored implants. Meanwhile, numerous patients prefer implants to conventional dental prosthesis, independently of their age and the number of tooth roots to be replaced. The trend is to provide the jaw with fixed implants that can be loaded immediately.

By further developing the techniques and designs of modified implants, satisfactory results are being obtained in praxis in the treatment of the jaw with implants. Generally, nowadays well-processed

implants with few surface incorporation are present. Nowadays, the surface character of different implants of different price segments show only a few differences and show a good osseointegration. Implants with a porous surface have a good survival rate regardless of their position and bone quality. Production-related residues on the implant surfaces cannot be prevented, but they shouldn't be too strong. Especially aluminum, which can not be broken down via the usual way of phagocytosis via macrophages, can lead to inflammatory reactions, increased formation of connective tissue, loosening of the implant and loss of implant.

The minimal number of implants required to supply the toothless mandible is a controversial subject. Practical experiences show that there are cost-effective alternatives to the all-on-4 concept. The requirement for success is the existence of a good bone quality.

A good primary stability is always crucial for the integration of an implant and for a good osseointegration, especially in case of immediate loading. Even a micro-mobility of more than 150 µm can lead to an increased formation of connective tissue and to a poor osseointegration [17]. Further important criteria are bone quality and bone quantity. These were good in the case that we presented. 30 years of practice experience with simultaneous follow-up confirmed in the case of a large number of patients the success of supplying the mandible with a minimal number of implants. For the first time Fatori TAG implants (titanium implants) were used in practice. The previous clinical progress and the histological findings give a reason to expect a very good progress.

By means of to the additionally introduced and explanted implant, it was possible to evaluate histologically the extent of the osseointegration. A very good and regular osseointegratio was shown both qualitatively and quantitatively with a BIC-index of 83% after 8 months. A BIC of more than 75% should be achieved with loaded implants in the mandible [1]. Only a few connective tissue gaps were detectable in the course of the interface. The periimplanted bone consisted almost entirely of mature, lamellar bone, which implied an advanced remodeling. A focal view showed directly in the periimplant sites with bone apposition as well as contact osteogenesis at some distance from the implant surface. In the case of TAG implants we speak of titanium implants. An amorphous, approximately 5-10 nm wide interface layer [1], typical for titanium surfaces, was formed. Osteocytes were located sporadically very close to the implant surface, a finding, which was recently used as a sign for a regulation of long-term stability of osseointegration by these cells [12]. Resorption signs - also krestal – were not present.

These findings promise a good treatment of the remaining implants.

Summary

In summary, we had an explantat with a very good osseointegration and very high BIC (bone-implant-contact). Bone conversion was traceable, the osteogenesis was still low. There were no signs of inflammation or necrosis. It is expected to be a good long-term success.

Remarks

There are no conflicts of interest. The consent of the patient for the implant removal and for the publication of the case was given.

Acknowledgement

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