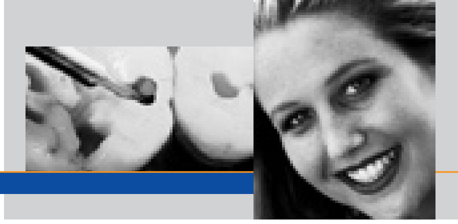


Long-term study on immediate loading of one-piece KOS® implants with fixed complete dentures

Success of 678 one-piece KOS implants up to 9 years after transgingival placement without navigation

The past three decades have seen the treatment concept of dental implantology evolve into a standard treatment regimen. Brånemark developed a two-stage procedure that relied on two-piece implants. Over the past few years, practitioners have followed in the footsteps of the first pioneers of dental implantology by developing a single-stage procedure, complete with immediate placement and immediate loading of the implants used. These treatments are mainly performed with one-piece implants, as these designs offer numerous advantages over two-piece implants in the context of immediate loading.

Dr. Werner Mander, Dr. Dr. (IMF Bukarest) Thomas Fabritius

Two different approaches to immediate loading of dental implants are currently known. Both have in common that splinting/stabilization of several implants is accomplished through the prosthetic superstructure (www.implantfundation.org):

a The first approach relies on the compression screw principle. Screw implants of this type can result in lateral condensation of spongy areas. Implant stability is greatly increased by a mechanism that could be regarded as “corticalization” of the spongy bone.

b The second approach is to establish cortical anchorage of thin screw implants (bicortical screws, BCS) or basal implants. Excellent primary stability can be obtained along the vertical surfaces of these implants with no need for corticalization. Implants of this type are therefore well suited not only for immediate loading but also for immediate placement.

Numerous publications have shown that ideal outcomes can be achieved very easily and predictably with one-piece screw implants (Figures 1 and 2) [Beckmann and Beckmann 2005, Knöfler 2004]. This treatment approach is relatively simple and minimally invasive, causing little surgical trauma, carrying an extremely low risk of infection, and involving very low rates of implant loss. Another strength is the possibility of immediate loading, which is advantageous for obvious reasons and has been shown to yield beneficial effects in maxillary molar areas.

/// MATERIALS AND METHODS

A total of 678 KOS implants were placed to support full-arch restorations in our office between 1997 and 2006. Each of the 89 patients involved was treated with a metal-ceramic fixed complete denture in the maxilla or mandible. Thus, 87 (97.7%) patients were available for follow-up. All treatments were completed by permanent cementation of the definitive one-piece metal-ceramic superstructure within 2 weeks of implant placement. Some of the restorations also included natural abutments.

The 89 full-arch restorations were supported by a mean of 7.6 ± 2.3 implants and 2.0 ± 2.2 natural abutments (Table 1). In the early years, we would allocate more time (in some cases exceeding 2 weeks) for the technicians to fabricate the restorations. Today we deliver the restorations within 2 to 7 days of implant placement. Only in extraction cases do we use a modified protocol, in order to improve esthetic outcomes. Our policy in these cases is to immediately insert a temporary restoration as usual but to keep it as a long-term temporary restoration over several months, until final recontouring of the hard and soft tissue. Rather than placing KOS implants directly into fresh extraction sockets, we rely on healed edentulous sites near the socket. For placement into fresh extraction sockets, we tend to use BCS implants. All screw implants were transgingivally inserted under local anes-

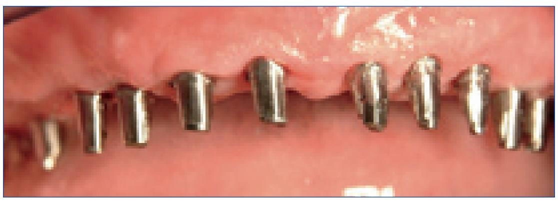


Figure 1 Clinical view immediately after placement of 11 implants.

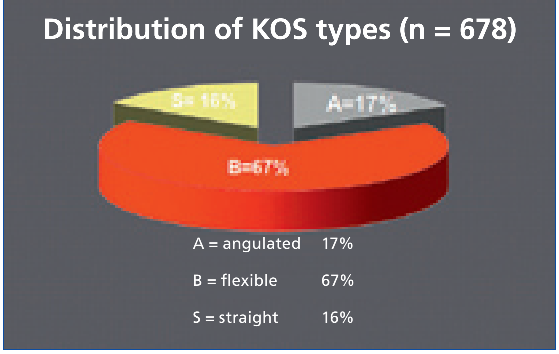
Figure 2 Fixed complete denture 5 days after cementation.

Table 1. Patient data and treatment details

Characteristics	Mean ± SD	Range
Age (years)	58.0 ± 10.1	33 – 82
Follow-up (months)	34.2 ± 33.6	1 – 110
Implants (per jaw)	7.6 ± 2.3	3 – 12
Natural teeth (per jaw)	2.0 ± 2.2	0 – 7
	N	%
Gender (male)	47	52.8
Mixed restorations (teeth/implants)	52	58.4
Follow-up (n = 89)	87*	97.8

*Two patients were lost to follow-up

Table 2. Distribution of implant types



thesia, which was immediately followed by temporary restoration with a fixed complete denture. Surgery was conducted in one session on an outpatient basis. Our sample can be characterized as a single-center consecutive case series. The mean age of patients was 58 ± 10.1 years. The youngest patient was 33 and the oldest patient 82 years old; 74 patients were male and 42 were female. The majority of 79.7% (n = 71) were non-smokers. A mean of 2.0 ± 2.2 natural abutments could be included in the fixed complete dentures, reflecting the presence of usable residual teeth in 52 out of 89 patients/jaws. Strictly edentulous jaws were restored in the remaining 37 patients, meaning that 41.6% of all fixed complete dentures were supported by implants only (Table 1).

The follow-up of the study ranged between 1 month and 110 months (9.2 years) for a mean observation period of 34 months (2.83 years). Two patients (2.3%) were lost to follow-up and could not be evaluated. The 678 compression screws used in the study fell into 67% KOS-B (flexible), 17% KOS-A (angulated) and 16% KOS straight (Table 2, Figure 3). Maxillary implants accounted for 86% and mandibular implants for 14%; 52% (n = 354) were placed in anterior sites, compared to 42% (n = 283) in posterior sites and 6% (n = 41) in tuberosity sites. A technique of either motor-driven or manual implant placement into tuberosity sites was developed relatively late into the study. Before that time, we would normally refrain from placing implants distal to the extended maxillary sinus.

Table 3. Distribution of implant sites

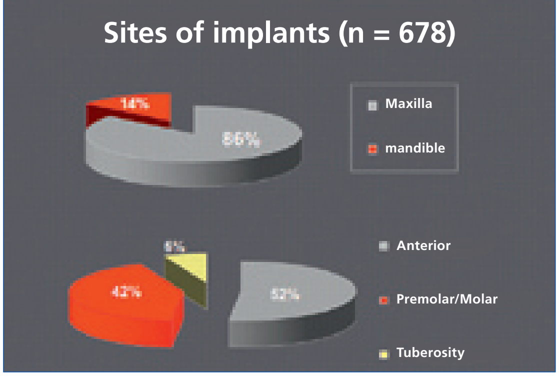


Table 5. Failures broken down by time periods

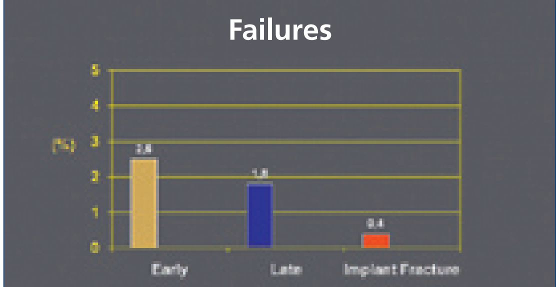
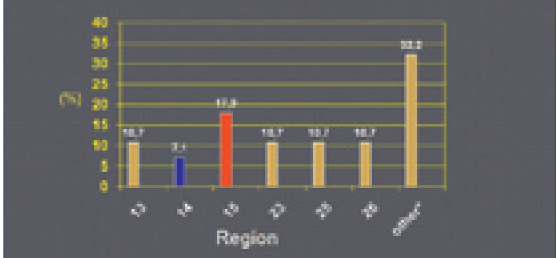
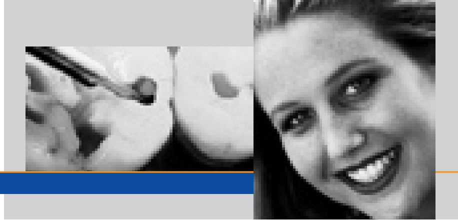


Table 4. Survival rates based on natural abutment status, maxilla/mandible and age

Table 6. Failures broken down by implant sites
(Losses: n = 29 or 4%)





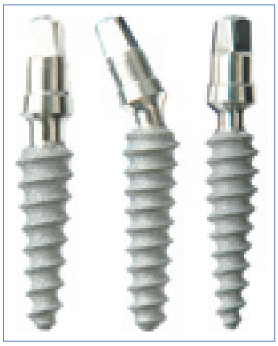


Figure 3 One-piece compression screw implants (left to right: KOS, KOS A, KOS B).

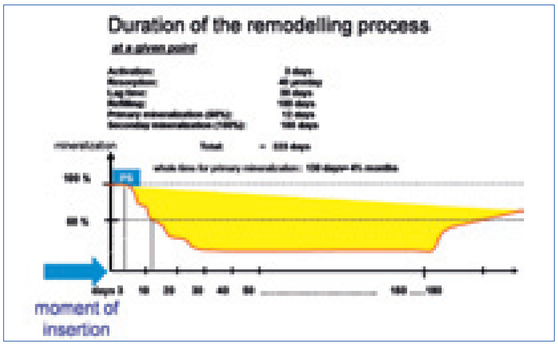


Figure 4 Change of primary stability by osteonal repair remodeling (from: R. Bruce Martin, David B. Bur, Neil A. Shakey: Skeletal Tissue Mechanics; Springer 2004).

Instead, we would preferably use structures with a distal cantilever in the first molar position.

This was possible because we would frequently insert angulated KOS screws in the area of the second premolars in order to avoid the maxillary sinus. At the same time, we would place numerous implants anterior to each maxillary sinus, thereby introducing high stability from the anterior segment to support the distal segments (Table 3).

A panoramic radiograph was obtained for each patient and followed up by clinical examinations. The follow-up examinations and outcome evaluations were conducted in the same office as the initial treatments; they were, however, not performed by the same clinician. The assessments were made by the same dentists who also analyzed the panoramic radiographs to evaluate changes in vertical bone levels.

/// RESULTS

The overall survival rate of all KOS screw implants used in this study was 95.7%. There was no significant difference between the fixed complete dentures supported by implants only (95.9%) and those also including natural abutments (95.6%). Survival was a little, but nevertheless significantly, lower for maxillary (95.5%) than mandibular (97.9%) implants (Table 4). Broken up by age groups, implant survival was 94% among patients 55 years or under, 94% among patients 55 to 65 years old, and 97% among patients older than 65 years (Table 4).

Twenty-nine of the 678 implants failed. The rate of implant failure was 4.3%. This percentage fell into 2.5% (n = 17) early postoperative failures before cementation of the definitive restoration and only 1.8% (n = 12) late failures after definitive cementation (Table 5). Implant fracture accounted for 3 failures (0.44%). One of these events was caused by tooth loss underneath the fixed restoration, while the other two fractures occurred in KOS-B implants during tightening. Table 6 illustrates the distribution of implant sites affected by the 29 failures. Failures were least common at site 14 (7.1% of all implant losses) and most common at site 15 (18% of all implant losses). Sites 13, 23, 25, and 26 demonstrated identical failure rates (10.7% of all implant losses). Nine other sites were affected by 1 implant loss each, thus accounting for roughly one-third of implant failures (32.2%).

Twenty-two implants (3%) were radiographically shown to exhibit horizontal or vertical bone loss > 3 mm after placement. These situations were associated with clinical evidence of peri-implantitis.

/// DISCUSSION

The cases followed up in the present study included roughly the same number of implants in posterior (42% at premolar and 6% at molar sites) an anterior (52%) jaw segments. The vast majority of implants (85%) were placed in the maxilla (Table 3). The study was initially guided by the principles of the First European Consensus Conference [BDIZ 2006]. In accordance with these principles, the distal segment of the maxilla was considered a risk area for implant placement due to its poor bone quality. This view was based on expert opinions and numerous studies [Attard and Zarb 2005, Becker et al. 2003, Bergkvist et al. 2005, Derbabian and Simonian 2005]. It was maintained until the current consensus on immediate loading was published [International Implant Foundation 2008]. However, our results demonstrate that immediate loading is capable of yielding similarly high success rates even at molar and premolar sites of the maxilla if certain principles are observed, including immediate immobilization of the implant abutments and definitive restoration with simultaneous splinting of the implants with fixed cross-arch dentures or at least 3 to 4 stable splinted abutments in the same jaw segment no longer than 3 to 12 days after implant placement. On the subject of indications, it should be noted that our patients' desire for immediate loading is an indication in its own right. Delayed protocols should only be adopted if medical considerations argue against immediate loading. The present study demonstrates that immediate loading is a viable option for dental implants located virtually anywhere in the mandible or maxilla, provided that all relevant principles of immediate loading are heeded and that enough implants have been placed.

Our analysis of errors has revealed two critical phases:

1. Early phase of temporization before delivery of the final restoration (up to 12 days postoperatively)
2. Late phase after permanent cementation of the final restoration (until complete bone healing; up to 6 months or even longer).

Early implant losses were mainly caused by:

- Poor bone quality leading to inadequate primary friction (< 30 Ncm).
- Fracture of temporary fixed denture.
- Premature insertion after tooth extraction (immature bone is not readily identified during transmucosal placement)
- Excessive loading of individual implants still connected to a (temporary or final) restoration that has become mobile upon temporary cementation.

It is essential for the success of immediate loading to consider the time of bone regeneration. A truly safe period is the early postoperative course ending on the third postoperative day. This time window is followed by a phase of highly active bone remodeling, which will carry an increased risk for any prosthetic interventions (Figure 4).

The implants always need to be immobilized as quickly as possible. In fact, we scarcely encountered any problems even in numerous years of using delayed loading (e.g. after 2 to 3 weeks). Presumably, this positive experience can be attributed to corticalization along the compression thread, which would routinely lead to good primary stability. In addition, osteonal structures are probably destroyed as the bone is subjected to heavy local compression. Such bone could no longer be a departure point of bone remodeling but could still be a potential endpoint of bony pervasion. The onset of bone remodeling would be delayed in corticalized areas. The safest path for clinicians, however, is to use temporary loading until the third postoperative day, followed by continued service of the first structure over at least 6 months (i.e. also in cases of simultaneous tooth extractions). The entire secondary structure, whether definitive or temporary, should be very firmly cemented by this ideal point in time (the third day) for proper splinting and immobilization of the recently placed implants, such that osseointegration can progress smoothly. The phase of remodelation for bone repair may take up to 6 months and, if the outlined conditions are met, can proceed without complications. Any mobility of the temporary restoration calls for immediate recementation. To avoid this complication, numerous users will rightly employ strong permanent cements even in the phase of temporization. A minority of patients would present with hopeless conditions even for treatment with thin 3-mm implants. Rather than subjecting these patients to augmentation procedures ourselves, we referred them to specialists for basal implantology or to colleagues with a strong focus on bone augmentation. In our experience, however, referrals of this type have been needed in 15% of patients at the most. In all other 85% of patients for whom major cross-arch fixed dentures were considered, the transgingival KOS technique yielded optimal results even in the absence of any laborious and risky reflection or augmentation techniques. After all, these augmentation techniques are adjunctive surgical procedures and, as such, will carry their own surgical risks. We took care to select a treatment regimen avoiding procedures of this type. Not a single patient in our office had to undergo augmentation to create an implant bed.

We believe that the late implant losses after definitive cementation were mainly caused by the following factors:

1. Inadequate distance between implants (Figures 5 and 6). An enossal distance of 2 mm should be respected with large-diameter KOS implants (4.1 or 5 mm). We have not encountered any problems with thinner KOS implants (even when placed very close to each other).
2. Fracture of an overly delicate metal framework.
3. Lesions of the bony implant bed caused by heat or excessive insertion pressure. These lesions were not immediately evident but only occurred early in the study; improvements in drill geometry and a torque-limiting insertion technique largely eliminated this problem.

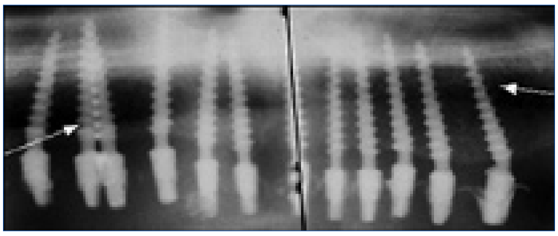


Figure 5 Bone levels after placement of 12 KOS implants in 1999.

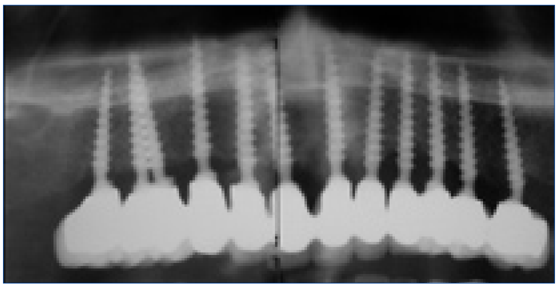


Figure 6 Bone levels after 7 years in 2006 (same case as in Figure 5).

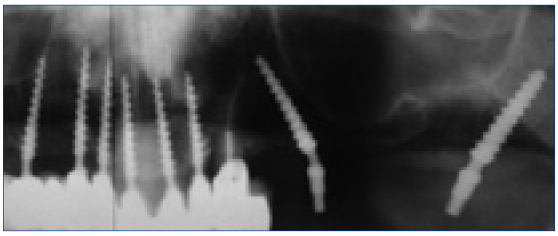


Figure 7 Postoperative view of slanted implants avoiding the maxillary sinus (1999).

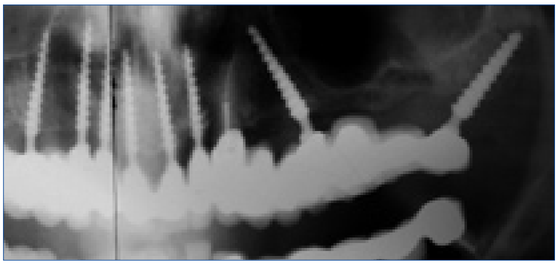
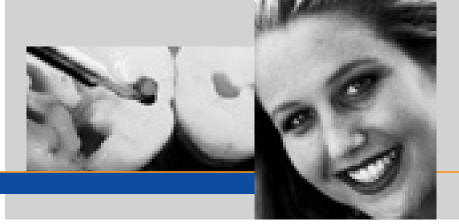


Figure 8 No visible bone loss, despite slanted implant insertion, after 9 years (same case as in Figure 7).



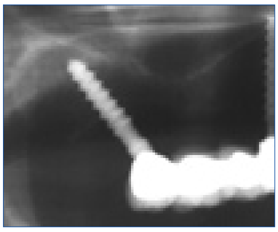


Figure 9 Radiographic detail of tuberosity site 18 in 2000 (same case as Figures 7 and 8).

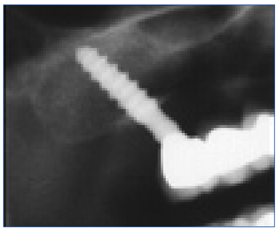


Figure 10 Radiographic detail of tuberosity site 18 (see Figure 9) with evident bone apposition after 6 years.

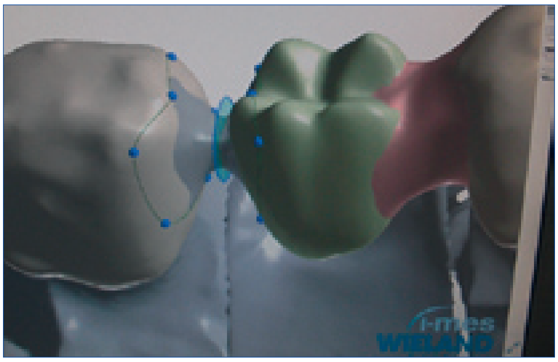


Figure 11 Planning of an overly delicate connector between crown elements.

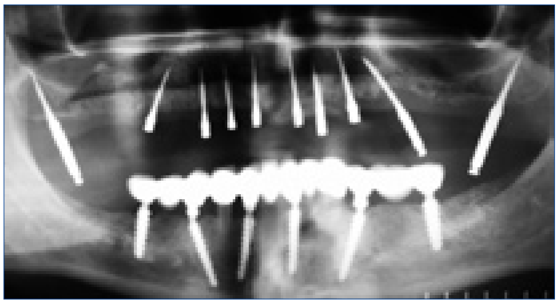


Figure 12 Measuring pins used for verification in the OPG after pilot drilling with BCD1/ DOS1. Implant cavities are checked for their correct position relative to surrounding structures. The mucosal thickness in the insertion area can be evaluated.

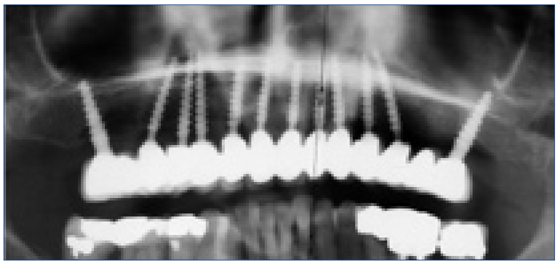


Figure 13 Maxillary restoration after 6 years.

We did not observe any cases of implant failure caused by excessive masticatory loading in the present study. This finding indicates that our approach of splinting the superstructures effectively minimized the pressure (Figures 7 and 8). Patterns of occlusion were usually adjusted to long-centric designs with the possibility of gliding into retral centric occlusion. Most patterns were adjusted to group function rather than canine guidance. The maxillary sinus could generally be avoided by slanted positioning of the implants.

Today we know that slanted insertion of dental implants (relative to either the patient's vertical axis or the bone surface) with or in connection with delayed cross-arch splinting will not create any disadvantages even in the long run. In the presence of a balanced occlusion, slanted insertion can even be associated with bone apposition (Figures 9 and 10). From the very outset, great care must be taken that the structure of the fixed denture will be adequately thick to avoid fracture of the superstructure, which is particularly true of zirconia frameworks (Figure 11). The present study demonstrates that few implants (3%) are likely to show a reduction in vertical bone levels with subsequent peri-implantitis. We believe that the following two reasons account for this low complication rate:

1. Small diameter of the polished implant neck, not exceeding 2.5 mm and even smaller in the flexible KOS-B designs (1.8 mm).
2. One-piece implant design whose shape will preclude any microgaps or micromovements between abutments and implants.

/// SUMMARY

This article reports on a retrospective study of 678 consecutively inserted KOS implants, which are one-piece implants designed in accordance with the compression screw principle. The study covers relatively long observation periods (of 33 months on average) and the great number of restored jaws (n = 89). As a result, some highly predictive conclusions can be drawn notably with regard to immediate loading of these implants with cross-arch structures:

1. High overall and long-term success rate of KOS implants (95.7%) following transgingival insertion without navigation.
2. High success rate in the maxilla (95.4% based on 582 implants, 48% of which were inserted at premolar or molar sites).
3. Even higher success rate in the mandible (97.9 %).
4. Low failure rate irrespective of age.
5. Reduced incidence of vertical bone loss ≤ 3 mm (3%).
6. No prosthetic structures had to be replaced in their entirety because of implant loss.
7. Concerning implant survival, there was no significant difference between fixed dentures supported by implants only and those also including natural abutments.

Our experience with the KOS implant system, reflected in the longitudinal analysis presented in this study, demonstrate that KOS technology and the single-stage clinical procedures developed with these compression implants can offer unmatched long-term outcomes. We do not believe that navigated procedures to insert KOS implants

would hold any true advantages for experienced surgeons, although navigation can be used to support the surgical protocol. Good results have been obtained with reference templates to create bleeding points for implant insertion and to perform minimally invasive pilot drillings, which will permit adjustments in direction and depth through the use of radiographic measuring pins. This is a very inexpensive and yet highly reliable way to verify the success of implant placement (Figure 12). The technique can be used even in smaller offices and will eliminate the need for costly preoperative planning.
In very narrow ridges, KOS implants can also be inserted perfectly well, and without any repercussions on the long-term success, by reflecting a mucoperiosteal flap. There is no need to worry about side effects of flap reflection like the "regional acceleratory phenomenon" (RAP) [Binderman et al., 2001; Yaffe et al., 1994]. After all, close proximity of both cortical walls has already been established in this situation. With very little or no cancellous bone being left, the screw threads will end up bilaterally in cortical bone structures not affected by the RAP. The presented technique has yielded the best results in patients 65 to 82 years of age and therefore should be regarded the method of choice precisely in this target group of patients (Table 4). As a consequence, splint-type fixed complete dentures supported by KOS implants make sense particularly in situations of aged atrophic bone as well as in largely edentulous mandibles and maxillae. Patients under anticoagulation therapy are excellent candidates as well, thanks to the minimally invasive approach. In many cases, anticoagulation does not even have to be reduced after discussing the case with the patient's general practitioner [Mander and Sipos-Jackel 2007].

/// CONCLUSIONS

KOS implants are compression screws designed for single-stage procedures. They are a cost-effective treatment alternative offering strong and lasting benefits in quality of life. Immediate and long-term restorations can be implemented safely and with lasting success in a conveniently short time (Figure 13). Clinicians will find our preferred treatment protocol very simple to perform, notably because the one-part implant design of the KOS system permits the use of abrasive instruments and impression-taking very much like on natural teeth. Costly transfer elements are not mandatorily required. Predictable outcomes can be obtained even in their absence, and the cost-benefit ratio is excellent.

/// EDITORIAL COMMENT

This report is a short version of the findings obtained in the authors' office study. You may wish to contact the authors for an unabridged version with complete references.

AUTHORS
Dr. Werner Mander
Rainerstrasse 36, 5310 Mondsee, Austria
w.mander@t-online.de

Dr. Dr. (IMF Bucharest) Thomas Fabritius
Traunring 96, 83301 Traunreut, Germany
info@zahnheilkunde-bayern.de