Clinical and radiological performance of short implants

A clinical study with two years follow up

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[PICTURE: ©ALICE-PHOTO]

_The aim of this study was to assess the clinical and radiological performance of short (6.5 mm) implants inserted in the premolar and molar regions of the maxillae. Eligible patients had to have a residual bone height of at least 6.5 mm and a bone width of at least 6.0 mm. Restoration was performed as single crowns or fixed large-span bridges and followed for up to two years after insertion.

_Background

The reconstruction of missing teeth in posterior regions is hampered by the limited bone availability and insufficient bone quality typically found in the posterior regions due to post-extraction bone atrophy both apico-occlusally and bucco-palatally, a pneumatised sinus, etc. Significant functional forces in the posterior segments of the maxillae, among other factors, increase the risk of implant failure.[1] Similar anatomical limitations are mentioned in the recent review by Estafanous et al.[2]

Bone quality

Restoration with implants in posterior regions is more complex if, for example, permanent teeth were lost at young age, bone quality is poor (D3 and D4 according to Misch's classification), or enhanced bone resorption due to mucous stimuli is present, and implant placement is complicated by the presence of anatomic structures such as the sinus cavity or inferior alveolar nerve.[3] Particularly in the maxillae, the use of short implants (i.e. the endosseous part is < 7 mm long) is advantageous to avoid sinus floor augmentation (sinus lift).

Several bone augmentation techniques have been developed with the goal of increasing the bone volume before implant placement, thereby allowing the use of longer and wider-diameter implants. The surgical problems and potential failures of such techniques have been clinically extensively documented.[4] The placement of shorter implants has the potential to avoid the need for such techniques. This would be beneficial for patients both in terms of reduced morbidity and financially.

Survival rates

Although early papers on short implants reported higher implant loss rates,[5–8] recent systematic literature reviews have found that initial survival rates were comparable to that of longer implants and thus constitute a viable alternative to additional augmentation procedures. This correlates well with the fact that model calculations by finite element analysis indicate clearly that the distribution of horizontal and vertical loading forces is similar to that of longer implants.[9–12] Other calculations have also demonstrated that bone stress should be almost independent of implant length; a more important role was assigned to implant diameter.[6, 13, 14]

Recent reports indicate that it is possible to achieve highly acceptable implant survival rates with the current short implants.[1, 14] Stellingsma et al. have shown survival rates of 88–100 % in atrophied mandibles.[13] A survival rate of 96 % was reported for short implants in severely atrophic maxillae.[15] Esposito et al. compared the three-year post-loading outcomes of short and long (with guided bone re-

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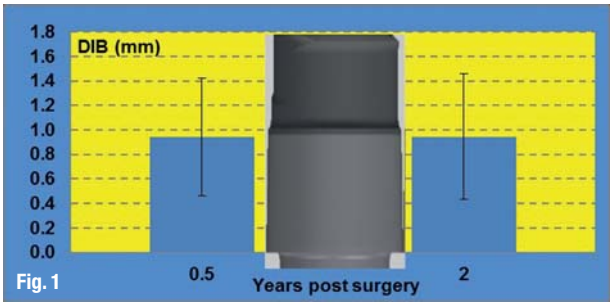


Fig. 1_Peri-implant (mesial and distal) bone level around short implants six months (0.5 years) and two years after implant insertion. The implant shoulder is included to visualise the periapical bone level also in relation to the implant geometry.

generation) implants in a randomised parallel group study.[16] They concluded that in cases with limited residual bone of 7–8 mm over the mandibular canal short implants are a viable alternative to vertical augmentation. The treatment is faster, cheaper and associated with reduced morbidity.

It is to be noted that implant insertion into pristine bone was compared with implants placed after preliminary sinus lift elevation.[17] In this prospective study, which included 393 implants and 155 patients treated in two groups, the implants placed into augmented sinuses had a lower survival rate compared with implants placed into pristine bone.

Crown-implant ratio

Excessive crown–implant ratios have been hypothesised to be detrimental to long-term withdrawal. For obvious reasons, this ratio must be given particular attention when using short implants. Birdi et al. determined the crown–implant ratios of 309 single-tooth implant-supported restorations on short implants.[18] The mean follow-up time was 21 months and the mean crown–implant ratio was 2, that is, rather unfavourable for a tooth. No statistically significant relationship was found between the crown–implant ratio and implant success, or the mesial or distal periapical bone level.

Short implants in posterior regions

De Santis et al. studied short implants (≤ 8.5 mm) placed in edentulous posterior regions, predominantly in the mandible, that were affected by high bone resorption.[3] After one- to three-year follow-up, they found a survival rate of 98.1 % (i.e. only 2 of 107 implants were lost) and a success rate of 96.3 % (i.e. only 4 of 107 implants failed the predefined success criteria). The results of this study therefore also support the use of short implants in posterior regions with highly resorbed bone. In this context, it is important to be aware that the implant length used by Brånemark et al. in their original protocol was established empirically.[19]

The implants at that time had a machined (smooth) endosteal surface. Current implants with microstructured endosteal surfaces are characterised by improved osseointegration and increased bone–implant contacts. Together with optimised geometry, contemporary implants are superior in maintaining implant stability.[3] This in turn should allow the use of shorter implants. Short implants are typically described as < 10 mm long,[20] but Hagi et al. have described short implants as < 7 mm long.[21] A European Association for Osseointegration consensus conference defined short implants as ≤ 8 mm. This is more practicable, as implants > 8 mm had been commonly used for a long time without any particular problem related to their length.[22]

Survival rates in studies reviewed

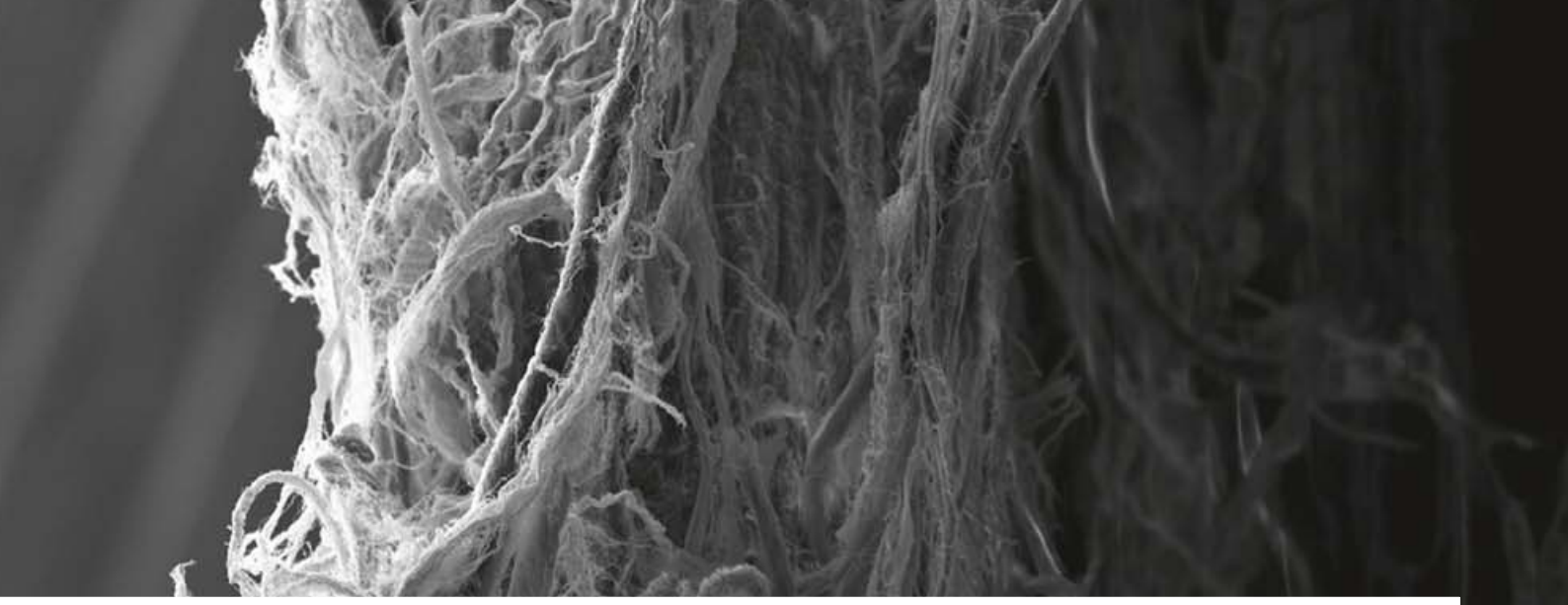
In a recent review on the meta-analysis of short implant survival studies,[20] it was found that the cumulative survival rate in the majority of the studies was similar to that of longer implants (92.5 % and 98.4 % for implants with machined and rough surfaces, respectively) and concluded that rehabilitation using short implants is a reliable treatment.[23] This conclusion is to be understood within the limitations of a meta-analysis and the lack of well-designed randomised trials. A similar conclusion was drawn by Telleman et al. from their systematic literature review of the survival rate of 2,611 short implants that were placed in partially edentulous patients.[24]

Nevertheless, Telleman et al. found an increase in implant survival (from 93.1 to 98.6%) that was associated with increasing implant length (from 5.0 to 9.5 mm).[24] The authors believe that there is fair evidence that short implants can be placed in partially edentulous patients, but with a tendency towards an increasing survival rate according to implant length and a better prognosis in the mandibles of non-smokers. Morand and Irinakis in their earlier literature review also concluded that, even though short implants are commonly used in the areas of the mouth under increased stress (posterior region), the success rate of short implants is similar to that of longer implants when careful case selection criteria have been applied.[25] Annibali et al. too concluded in their systematic review on short implants that prostheses retained by short implants in patients with atrophic alveolar ridges appears to be a successful treatment option in the short term, but recommended further studies to determine its success in the long term.[26]

_Clinical study

Patients

This prospective case series included 56 consecutive patients (35 females and 21 males) referred for dental implantation to three different practices (JNH, JH and DA). Patients were entered into the study consecutively, that is, with no specific selec-



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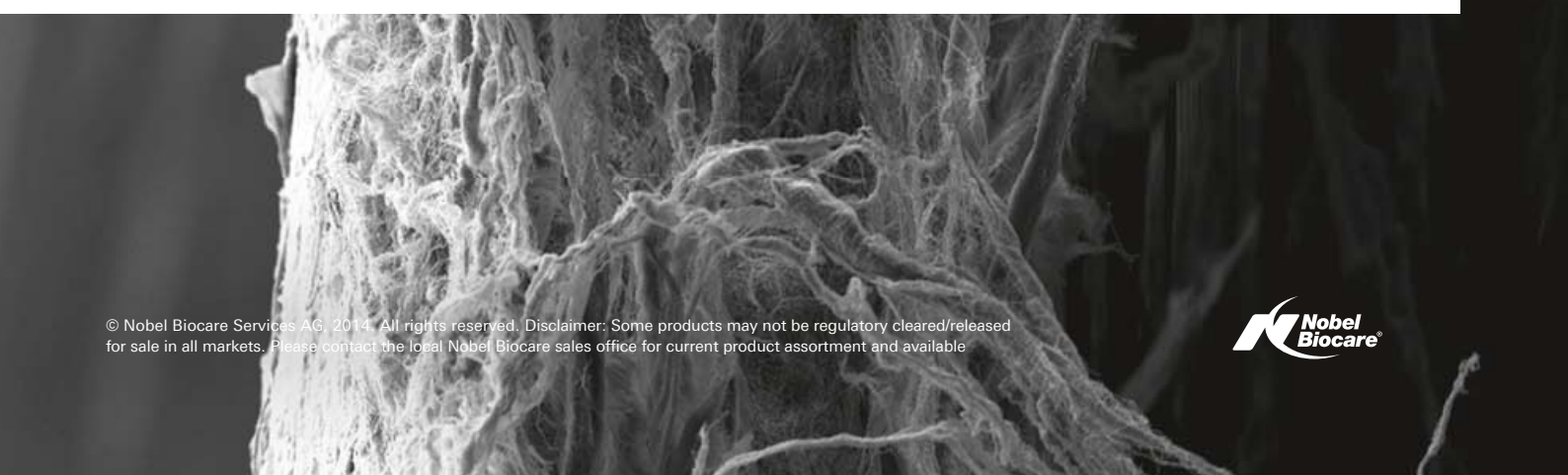

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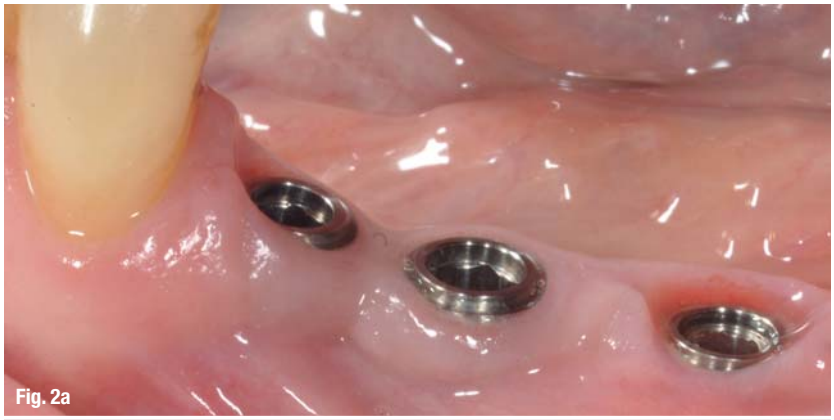
Fig. 2a

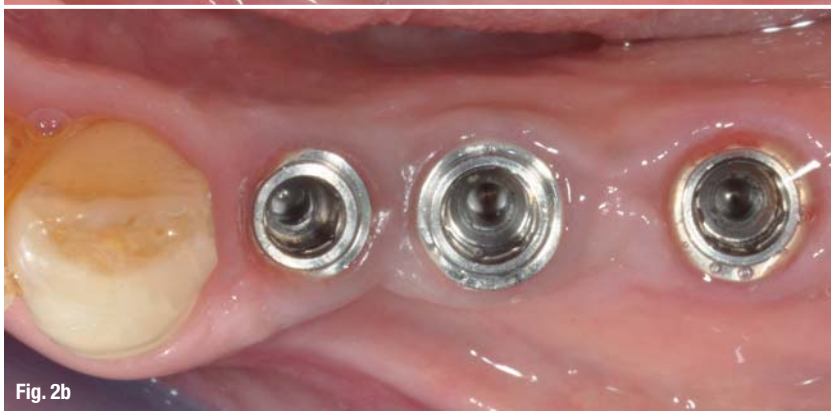
Fig. 2b

Fig. 2_Three implants placed in the right mandible; a) buccal view; b) occlusal view. The healing abutments were removed after two months of transgingival healing.

tion criteria apart from the routine assessment of their suitability to undergo implant surgery, good overall physical status (ASA 1 or 2) and at least one missing tooth in positions 15–17, 25–27, 35–37 or 44–47. At the implant site, they had to have a vertical bone height between 6.5 mm and 8.0 mm, as well as a minimal bone width of 6.0 mm, assessed by virtual implant placement using SIMPLANT software (Materialise Dental). This is based on a native image obtained by cone beam computed tomography (CBCT). Particular attention was given to maintaining a 2 mm safety zone from the mental nerve to avoid any trauma during the surgery due to an initial radiographic error.

Moreover, patients had to present with a normal occlusion (no open bite), including an opposing arch offering adequate occlusal support. Implants were not placed in heavy smokers (more than five cigarettes per day); patients with heavy bruxism, untreated periodontal disease or poor plaque control; or a position where an implant had been lost previously. Implants were inserted into healed bone; that is, implant placement was performed at least three months after tooth extraction. No crestal bone augmentation was performed.

Eligible patients were informed about all of the available alternative therapeutic options. They were included only if they agreed to treatment with short implants. The participating patients were therefore not exposed to any additional risk and this case series was therefore not qualified as research. In compliance with valid ethical requirements (Declaration of Helsinki, October 2013), the patients were instructed about the details of their participation and a written informed consent form was explained to them and signed prior to any intervention.

Surgical procedure

The standard surgical one-stage procedure was performed under local anaesthesia. Patients received antibiotic premedication 1 hour before surgery (2 g amoxicillin or 600 mg clindamycin if allergic to penicillin) and rinsed for 1 minute with a 0.15 % chlorhexidine mouthwash.

The drilling protocol was performed according to the manufacturer's recommendations. The bone quality (D1–D4) was recorded in the patient's chart. The insertion depth of the implant was determined by the anatomy of the surrounding bone. Particular attention was given to avoiding contact between any rough surface and the soft tissue. The implants used were titanium implants of 6.5 mm in length and with a 1.0 mm polished collar, and platform diameters of 4.0, 4.5, 5.0 or 6.0 mm. They had a hydrophilic, moderately rough endosteal surface (ELEMENT implant RC INICELL, Thommen Medical).

At the end of the surgery, patients were instructed to apply standard mouth hygiene procedures, including rising with a chlorhexidine mouthwash immediately after implantation. Paracetamol 1 g every 6 hours was given for 48 hours. No antibiotic or anti-inflammatory medication was prescribed after implant placement. The sutures were removed after one week.

Restoration

The implants were occlusally loaded with resin temporary crowns between eight and 12 weeks after surgery. For permanent prosthetics, patients were referred back to their dentist at least two months later. As a result, some of the restorations were still provisional at the final examination.

Implant stability

The implant stability was assessed by tactile investigation. The implants were considered to be stable in the absence of any signs of mobility, pocketing, bleeding on probing or pain during the investigation.

Follow-up

The patients were followed up two months after loading and follow-up visits were scheduled at least once per year. The routine follow-up programme included oral hygiene reinforcement, scaling and radiographs (when needed).


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Radiographic marginal bone level assessment

Routine periapical radiographs were deemed unnecessary; therefore, in order to check that osseointegration was uneventful, radiographs were taken at six months and two years after surgery. Care was taken to use the parallel–perpendicular technique; that is, the sensor holder was placed parallel to and the radiograph tube perpendicular to the implant axis to ensure optimal projection for each patient. Particular attention was given to obtaining a radiograph that would show the apex of the implant and the occlusal aspect of the crown in order to evaluate the clinical root–crown ratio. Along with the clinical check, the radiographs were used for quantitative bone-level evaluation. This was done by a single evaluator (PZ) using ImageJ (National Institutes of Health, current version). The images were scaled using the known implant thread height.[27]

Results

Fifty-six patients received 77 short implants. The average patient age at implantation was 59 (34–77) years. One patient was on anticoagulant therapy and one had a cardiovascular disease. Two patients underwent simultaneous bone augmentation with deproteinised bovine bone mineral and autogenous bone as filling material. Forty-three (56 %) implants were placed in the maxillae (15–17, 25–27) and 34 (44 %) in the mandible (35–37, 45–47).

Of the 77 implants placed, 16 (21 %) had a platform diameter of 4.0 mm, 37 (48 %) of 4.5 mm, 17 (22 %) of 5.0 mm and seven (9 %) of 6.0 mm. In two of the three participating centres (DA and JH), the maximal insertion torque using the MONO torque ratchet (Thommen Medical) was recorded for 40 implants. Sixteen implants (40 %) were inserted at 20 Ncm, 22 implants (55 %) at 30 Ncm and two implants (5 %) at 35 Ncm, suggesting good bone quality at the inserted sites. This corresponded well with the fact that no implant was lost, that is, an apparent 100% implant survival rate.

The radiographic evaluation of the peri-implant bone height confirmed the remarkably stable bone level achieved with the use of this implant (Fig. 1).[27–29] The peri-implant bone level stabilised at 0.9 ± 0.5 mm (mean ± standard deviation) beneath the microgap, that is, beneath the implant–abutment connection. The implants used have a 1.0 mm machined collar. Therefore, in this patient population, the bone level also stabilised at the interface to the moderately rough endosteal surface.

One patient, a 74-year-old female patient in the cohort reported above, presented with a partially edentulous right posterior mandible. The teeth had been extracted more than three months before and three implants were placed into the healed sites. Owing to the limited distance from the nerve channel, that is, to avoid the risk of its injury, short implants were inserted in replacement of the second premolar and first molar (positions 45 and 46). The implants were covered with healing abutments.

After two months of uneventful transgingival (non-submerged) healing, the healing abutments were removed (Figs. 2a & b) and the soft tissue around the implants was found to be fully conditioned. A periapical radiograph was taken that confirmed the absence of any pathological signs (not shown). An open-tray impression was taken. The framework was screw attached to ensure that a passive fit was achieved, the occlusion checked, and the permanent restoration (Fig. 3) completed and screw attached within two weeks of removal of the healing abutments. An intra-oral photograph taken after two years of function demonstrates the very favourable and predictable outcome (Fig. 4).

Fig. 3_Permanent bridge (porcelain-fused to metal) before insertion.

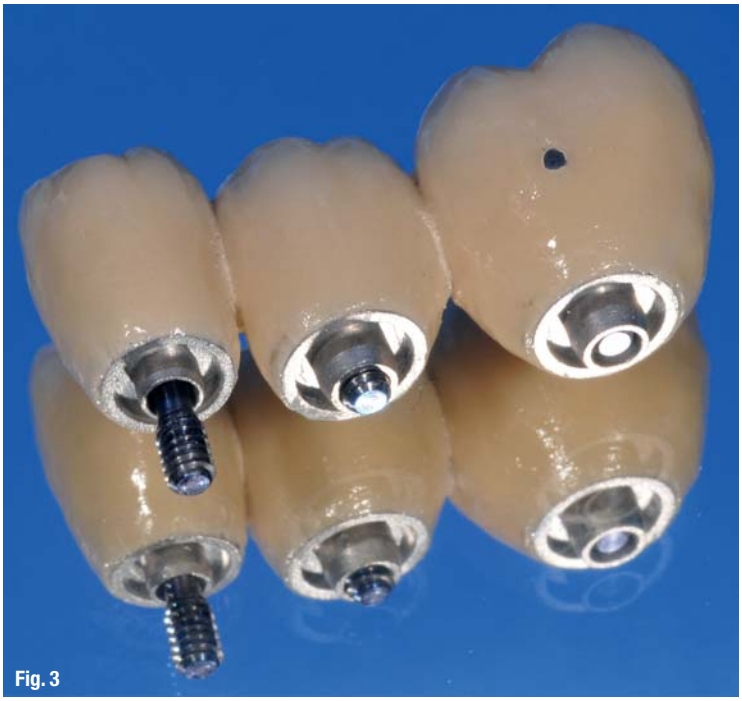

Fig. 3

_Discussion

Recently, short dental implants have proven to be as successful as longer implants. This improvement[30] can be explained by the use of short implants for specific indications and the improved initial diagnosis resulting from the widespread use of CBCT, which has been available since the turn of the century, improved implant design and our ability to identify risk factors for peri-implantitis.[31, 32] The availability of diagnostic tools with improved accuracy that enable more widespread manufacturing of

(precise) surgical guides has contributed to the increased survival and success of short implants. This improvement in hard-tissue management has been accompanied by more precise soft-tissue diagnosis (thin biotype) management, which in turn may have contributed to the improved survival and success rates observed in recent publications.

No mechanical advantage for longer implants

Studies using finite element analysis have generally found that the highest stress is only exerted on the crestal part of the dental implant, whereas little force is transmitted to the apical part. In accordance with this finding, longer implants thus should not show any mechanical advantage if only this aspect is considered. This particular point is supported by the results of the case series presented in this article. We have demonstrated that the success of short implants is similar to that of long implants. Moreover, the crown–implant ratio of < 2 does not appear to be of any importance, leaving open the question of the need to splint short to long implants.

Survival rate of short implants is similar to longer ones

Our findings support the feasibility of treating single missing teeth with short implants. In a recently published clinical investigation of short dental implants restored as single-unit non-splinted crowns, 221 short (L 6.0–9.0 mm; D 3.7–5.6 mm) implants placed and restored in 168 patients were followed for 27 months.[33] The survival rate in the maxillae was 88.6%, whereas it was 96.0% in the mandible. Cigarette smoking, diabetes mellitus and bone augmentation procedures were not associated with an increased (early) implant failure rate. The researchers concluded that the survival rate of short implants restored as single crowns over an average of 37 months was favourable and comparable with that of longer implants.

Less invasive surgical protocol

The case illustrated demonstrates the high predictability of the selected treatment protocol (Figs. 2–4). Were short implants not available, a much more invasive surgical protocol would have been needed. Consequently, a significant clinical risk was avoided and the treatment was more advantageous financially.

Peri-implantitis

The eventual development of peri-implantitis remains a major problem. Two factors are to be considered: the ability to provide optimal plaque control, which may be difficult owing to the posterior location of these implants, and adequate periodontal support. This aspect should be addressed by appropriate hard- and soft-tissue management, that is, ensuring sufficient surrounding bone on the facial and lingual/palatal aspects and optimal soft-tissue biotype.

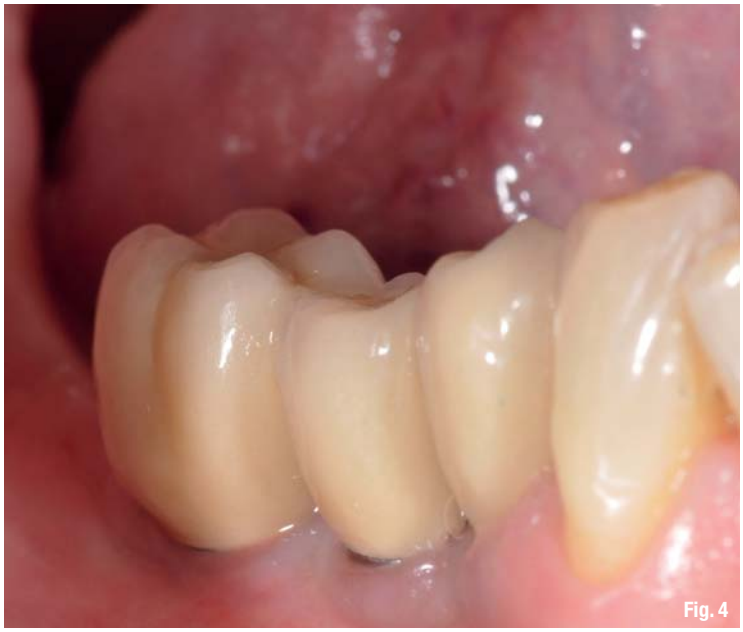

Fig. 4_Buccal view of the permanent bridge two years after implant placement.

_Conclusion

Within the limitations of this case series, the reliable and predictable use of short implants for up to two years was confirmed. The results obtained in a multicentre setting confirmed the positive observations reported by other authors. Minimal periapical bone loss (< 1 mm) was found radiographically. Long-term studies are still needed to establish whether there are any specific risk factors pertinent to the use of short implants._

Editorial note: A list of references is available from the publisher.

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