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Table of Contents

New Clinical Methods for Diagnosis and Treatment Planning

Session 1: Computer-Based Diagnostic and Planning Tools for Implant Dentistry

Improving the reliability of computerized reformatted radiological images

WC Scarfe (University of Louisville, KY, USA)

The use of cone-beam computed tomography (CBCT) has led to a complete paradigm shift in implant dentistry – no other technology has been as influential in combining surgery, diagnostics and prosthetics. However, the clinician needs to assume a more dynamic role.

Some kind of cross-sectional imaging is generally required for implant placement. Tomography allowed 3D imaging – images could be cross-combined to give 3D structures. CBCT is the latest technology in this field and allows true 3D imaging acquisition in a 360° arc. The unique characteristics of CBCT allow re-acquisition and display, planning and placement.

CBCT can provide information on bone density from recordings of the scatter radiation; however, these recordings are not necessarily accurate. Software packages can provide numbers from these data, but they do not correlate to Hounsfield units. Contrast resolution can be limited as interfaces can be blended between different surfaces, resulting in a volume artefact. However, contrast can be enhanced using DICOM and/or algebraic reconstruction techniques. Implant assessment can be problematic due to this volume artefact and hardening – bone < 1 mm cannot be detected. A beam hardening artefact may also be observed, due to interaction of photon starvation and scatter radiation. A void can result that can look like pseudo-fractures. Patient movement can also result in minor motion artefacts.

The main goals of imaging are to provide information on the available bone characteristics, the alveolar ridge orientation with respect to anatomy, and the internal anatomy, particularly corticated versus non-corticated areas. Regional anatomy/pathology is important, e.g. the area of proposed implant placement in relation to the size – follow-up imaging may be necessary. Acquisition parameters can have a number of effects, influencing exposure settings, spatial resolution, field of view and sampling.

There are no available data on which are the most important or appropriate slice thicknesses, but image enhancement can be applied to optimize cross-sectional images. The data can also be re-orientated to standardize the imaging display. A 'thick slab' technique can be used to determine the optimal axial reference, so that thick axial images can be produced rather than the default setting. A cross-sectional plan can be produced according to the arch, which has an effect on the height and width of the potential areas. CBCT also allows multiple modes to create a panoramic MPR and viewing in 'line' mode in two planes to allow a view of the full volume.

The software helps translate the planning into surgery, allowing the clinician to view the crestal ridge reduction, minimum platform width and safety zone. 3D imaging can therefore be used for restrictive guide placement. Surgical guides can be restrictive or non-restrictive and are particularly useful in cases of morphological change or edentulousness. Reasonable mean accuracy of surgical guides has been demonstrated.[1]

Has cone beam CT made conventional CT obsolete?

B Koong (University of Western Australia, Perth, WA, Australia and Envision Medical Imaging, Perth, WA, Australia)

There are a number of similarities between CBCT and conventional CT; for example, both are computer-generated imaging techniques, offer multiplanar reformatting and allow data export in DICOM (digital imaging and communications in medicine) as the standard format. CT involves a finely calibrated fan-shaped x-ray beam that can be single, spiral or multislice, whereas CBCT produces a series of 2D images at intervals to produce a 3D picture. It has been difficult to evaluate the validity of the two techniques and compare the literature.

Radiation doses with CBCT can be highly machine-specific (e.g. from 27 – 1073 µSv), while for multislice CT a low-dose protocol of 180 µSv has been recommended by the International Commission on Radiological Protection (ICRP) – CT doses are more radiologist/protocol-dependent. An analysis performed in 2008 suggested that intraoral imaging doses were much higher than those according to the 1990 ICRP guidelines.[2]

CBCT has a much higher image quality, but the scan time is longer and there may be substantial scatter and signal to noise ratio, particularly with larger patients. In addition, there may be significant beam hardening and poor soft tissue contrast, but metal artefact images are generally fewer. Several studies have demonstrated that CBCT is as accurate as conventional CT, and is accurate for taking craniofacial measurements. However, artefacts have been noted adjacent to implants via both methods, which can obviously have an adverse effect on post-implantation imaging. Conventional CT is generally better for viewing the mucosal reaction, but both CBCT and conventional CT are superior to conventional radiographs for identifying periapical lesions. However, neither CT method has been sufficiently proven for caries evaluation.

The interpretation of CBCT in the case of fractures is more difficult, and is not the modality of choice as soft tissues also need to be examined. CBCT and conventional CT are also better than radiographs at locating the mandibular canal and third molars, and panoramic radiographs have been shown to have only limited use in temporomandibular disorders.

There are no published guidelines on the use of CBCT versus conventional CT imaging, but such guidelines may be achievable. Currently, there are risks of significant disease mismanagement, since some conditions can appear very similar to each other. The images should therefore be viewed on a case by case basis – CBCT can let the clinician see where an infection may be coming from, but interpretative skills are required to determine the differences. In addition, MRI scanning may be useful for soft tissue evaluation.

In conclusion, it is important for the clinician to select the correct imaging modality. CBCT is not a replacement for conventional CT, and other modalities need to be considered. Finally, the entire volume of data obtained needs to be examined.

From planning to surgery: a critique of guidance and navigation techniques
R Jung (University of Zürich, Switzerland)
Prof. Jung introduced a typical dentist and technician, with a typical range of patients, and considered how they might evaluate and use computer-guided implant planning and placement techniques.

With computer-guided imaging (either CBCT or conventional CT), 3D tooth position and superposition of prosthetic diagnostics is possible. The conversion of data from CT and CBCT allows 3D planning by means of digital data. Conventional imaging (e.g. conventional 2D radiographs), however, do not allow 3D planning. With computer-guided imaging a stent is used for transfer of data via a stereolithographic or dental laboratory model.

Accuracy has been evaluated in many studies, and systematic reviews of the available data have also been published.[1,3] For example, one review by Jung et al (2009) analyzed 13 clinical and 19 accuracy studies from a total of 2,827 articles and performed a meta-analysis for accuracy on 1,302 implants. The results showed a mean implant deviation of 0.74 mm (max. 4.5 mm) at the entry point and 0.85 mm (max. 7.1 mm) at the apex. The mean deviation in height was 0.32 mm (max. 1.43 mm) and the mean angle deviation was 4.1° (max. 20.43°).[3] Some of the main reasons for inaccuracy include impression taking, CT/CBCT artefacts due to repositioning of the stent, superposition of the prosthetics and rigidity of the stent. The development of computer and software technology may also explain some inaccuracies.

A stent and surgical protocol are always required, but with conventional imaging the positioning and the stents are linked by the dentist rather than automatically, which is more stressful. For computer-assisted surgery with a flapless procedure, pre-operative radiographic diagnostics are necessary, but computer-assisted surgery can be performed with or without a flapless procedure.

In the systematic review by Jung et al (2009) 10 of the 13 clinical studies showed intraoperative complications. There were no contraindications, but some limitations were noted. Computer-assisted surgery may be particularly beneficial in cases of complex anatomy, for minimally invasive surgery, for optimization of implant placement in critical esthetic cases, and for immediate loading. A case of complex anatomy was used to illustrate this, where cross-sectional analysis was performed to evaluate the best possible implant positions. Other cases illustrated the benefits for minimally invasive surgery, for implant placement in esthetic situations and for immediate loading. In general, loading concepts for computer-guided implant placement follow the same principles as for conventional methods, although computerization offers certain advantages.

The systematic review by Jung et al (2009) showed a complication rate of approximately 2.4%[3], while that by Schneider et al (2009) showed prosthetic complications in 13 (12%) of 108 patients, all of which were with a flapless technique with immediate loading[1]. The implant survival rate after 12 months was 96.6%, with acceptable clinical accuracy. Computer-guided placement can therefore have advantages in selected clinical situations.

Implant treatment planning software: an essential tool or gadgetry
D Wismeijer (Academic Center for Dentistry Amsterdam, The Netherlands)
Biomodelling involves the capture and processing of data from a biological structure, and can be patient-specific. Computer-synthesized biomodels need 3D scanning of some kind and should be beneficial in avoiding major mistakes.

Removal or minimization of artefacts is important in both 2D and 3D planning, so the planning software is crucial. Rapid prototyping may be useful, e.g. in the form of stereolithography (resin-based – the thickness of the layer defines the precision), fusion deposition modeling or selection laser sintering.

Systematic reviews have noted inaccuracies in computer-based planning techniques, such as biomodel-guided stereotactic surgery. One of the main reasons for inaccuracies is lack of precision, especially where there is a mixture of digital and analog work flow. Like others, the gonyX system (IVS Solutions AG) is biomodel-based, but has greater precision. The biomodel can be based on previously placed implants to produce an accurate implant-supported drilling guide.

In terms of work flow, a completely virtual environment decreases the risk of inaccuracies, since the total inaccuracy of the procedure is the sum of each of the individual inaccuracies during the process. Impression taking can also be virtual, further reducing inaccuracy.

Data from CT scanning is transferred via DICOM via a specific interface prior to computer-aided manufacturing. This is a closed system, unlike CBCT planning which is an open system. However, there are relatively few open systems, mainly due to differences in environment and concepts, dental laboratory procedures and milling techniques.

Session 2: The Impact of New Technologies on Treatment Planning

Periodontal regenerative procedures in the era of implant dentistry

N Donos (Eastman Dental Institute, London, UK)

The main questions posed by Prof Donos were whether to try to save/regenerate teeth or to extract, and whether implants are always the best alternative. One question is whether implants are more resistant to the patient's susceptibility to periodontal disease, whether they would have a better prognosis and why.

Peri-implant diseases have previously been defined and categorized broadly into peri-implant mucositis and peri-implantitis.[4] Survival rates of implants are merely a measure of the number of implants still in place after a certain time, even if those implants have no clinical value. Implant success, however, focuses on the stability of the peri-implant marginal bone. A review of implant outcomes in treated periodontitis subjects found that there was a significant decrease in implant survival as the follow-up times and numbers of cases increased.[5]

Success from the patient's perspective, however, may be very different and is usually related to overall satisfaction. The cost of dissatisfied patients can be very high, as evidenced by the number of cases of dental malpractice ongoing in the US – implant dentistry and improper implant planning are very common reasons for malpractice lawsuits. Implant survival rates for implants supporting single teeth, conventional bridges or resin-bonded bridges over 5 years are estimated at 95%, 94% and 88%, respectively, but after 10 years the survival rates drop to 89%, 89% and 63%, respectively. The patient situation as a whole therefore needs to be evaluated, not just a particular implant site.

Extraction of teeth with poor prognosis is commonly performed, but Prof Donos asked what poor prognosis actually means. Prognosis is the defined as the prediction of the course of the existing disease, but perhaps the prognosis can be changed in some cases to give predictable long-term results. One way to alter the prognosis may be through the use of regenerative procedures, e.g. the use of bone grafts or bone substitutes, root conditioning and guided tissue regeneration (GBR). Cortellini and Tonetti (2004) analyzed long-term tooth survival in 175 severely compromised patients with intrabony defects treated with guided tissue regeneration (GTR). The mean gain in clinical attachment level (CAL) and reduction in probing depth were 4.6 ± 2.1 mm and 2.8 ± 1 mm, respectively, and the CAL was equal or coronal to the pre-treatment level in 92% of cases after 15 years.[6] Nygaard-Østby et al (2010) also found clinically significant results with GTR and autogenous grafting, with clinically significant results maintained over 10 years.[7] The structure of periodontal tissues after GTR has been examined by Laurell et al (2006) in a preclinical model – the results showed that complete regeneration of the periodontal tissues was possible and could be maintained for 2 years.[8]

Prognostic factors for periodontal regenerative success depend on the patient and the type of defect (e.g. defect morphology and type of radiographic defect). Good oral hygiene and a low plaque score increases the odds of success, while smoking may adversely affect outcomes. Membrane exposure may be challenging and may be an effect of the clinician.

The procedures involved are very technique-sensitive, however, and the flap design can have an effect. There are different flap designs that can be used, but the gingival blood flow is different for each type and some can lead to flap ischemia. Enamel matrix derivative (EMD) has also been evaluated for intrabony defects in a number of studies.[9,10] For example, 5-year results indicated that both EMD and GTR can achieve defect resolution, with equal regeneration that can be maintained over time.[10] Closure of the defect with evidence of new bone and periodontal tissue regeneration has also been shown with GTR and EMD in class III furcation defects.

The investigation of animal models is also important in periodontal regeneration studies. A recent study, as yet unpublished, has demonstrated complete regeneration in acute defects. Studies have also demonstrated the effects on periodontal stem cells. EMD has been shown to stimulate early and

late markers and upregulate osteogenesis, and also stimulates early and late angiogenic marker genes.

In general, periodontal regeneration can change the prognosis at the defect in question, if the right regenerative material is selected. In terms of longevity, survival of periodontally regenerated compromised teeth is in the region of 92-93%, similar to that of implant survival (mean 94% over 10 years).

Choosing the implant design: soft tissue level or bone level?
CHF Hämmerle (University of Zürich, Switzerland)
New possibilities in implant design offer new treatment possibilities and more decisions for the clinician. With one-piece implant designs the transmucosal part is incorporated into the implants, whereas in two-piece designs it is separate. Two-piece designs can offer increased flexibility, with connections possible at bone level. Primary stability may therefore be improved and wound closure can be easier. One-piece systems, however, can be less invasive and can also offer improved primary stability.

The maxillary anterior area is traditionally the main site where users of one-piece systems have had difficulties in placing two-piece implants. Bone resorption with two-piece implants is approximately 1.5 – 2.0 mm, but there may be ways to minimize this, for example by changing the geometry of the implant-abutment interface. A preclinical study by Jung et al (2008) using a new two-piece implant and non-matching (i.e. platform-switched) implant and abutment diameters and crestal, subcrestal or supracrestal placement, either transmucosally or submucosally) showed that the greatest bone resorption was greater with subcrestal placement, but that there was no difference between submucosal or transmucosal placement. No clinical or radiographic problems were noted.[11] Histological analysis from a similar study showed that bone growth occurred over the level of the implant shoulder in some cases and confirmed the radiographic analysis.[12]

A clinical study with this new implant, placed with either transmucosal or submucosal and GBR healing, showed successful tissue integration and a low risk of mucosal recession.[13] A large multicenter study is also ongoing with 128 patients in 12 centers. The tendency was for this implant to be placed deeper (by approximately 1 mm) into the mucosal margin. Of 128 implants placed, only one failure has been noted so far after 12 months. No product-related serious adverse events have been noted, and the clinicians have given very positive feedback on the implant handling characteristics. Bone loss has been minimal, with most of the bone loss noted in the -0.05 to -0.1 mm range. Pleasing esthetic soft tissue contours have been achieved, and the treatment modality and procedures have been considered excellent.

Two-piece implants may be particularly beneficial to avoid severe bone loss, as illustrated by a case where one-piece implants were placed in a patient using computer-guided surgery; problems were noted with these implants, and they were alter removed and replaced with two-piece implants. Another case where multiple implants were necessary was discussed.

Two-piece implants can therefore be useful in cases where soft tissue augmentation and soft tissue correction is necessary and primary closure needs to be obtained. New treatment possibilities may therefore be considered, with predictable bone regeneration and a low risk for complications.

New narrow body implants – expanded treatment opportunities?
PA Stone (Perth Royal Infirmary, Perth, UK)
Factors that influence the choice of implant diameter include surgical considerations, the restorative platform, the physical properties and various biological factors. Wide implants are generally considered to be over 4.5 mm in diameter, standard as 3.5 – 4.5 mm diameter and narrow implants as 2.5 – 3.5 mm diameter. Any implants < 2.5 mm in diameter are considered to be mini-implants, which are generally one-piece and often have the prosthetic component built in. They can create problems

for both the patient and the restorative dentist. Survival rates are generally slightly lower than other implants, e.g. 94.2% over 5 years[14] or 91.7% for up to 8 years[15].

The implant material influences the mechanical properties of the implant as well as the biocompatibility in terms of contact with the bone and soft tissue. The surface chemistry and structure also have an effect on implant success. Currently, four materials are used for dental implants: pure titanium (Ti), which has good osseointegration but slightly less strength than other materials; Ti alloys, which have higher strength but less favorable osseointegration; zirconium (Zr), which has only been evaluated in a few studies; and the recently developed TiZr alloy Roxolid (Institut Straumann AG, Basel, Switzerland).

The tensile strength of TiZr is much higher than that of Ti and is almost as good as that of Ti alloys. A comparison has been performed of Roxolid versus competitor materials under 30° oblique loading conditions. The results indicate that TiZr has higher fatigue strength, and failure only occurred due to abutment fracture, whereas failure was due to implant fracture in the other systems tested. Ti and Zr also show the highest biocompatibility, whereas inflammatory cells were increased with Ti-Al-V (TAV) alloys, the most common type of Ti alloy.[16] Other studies have shown that TiZr alloys have an even lower inflammatory response than Ti.[17]

Another advantage of the new TiZr alloy is that it allows SLActive surface treatment – this is only possible with monophasic structures such as Ti and TiZr, but not with TAV alloys, which do not have a monophasic structure. A biomechanical and histological evaluation of TiZr has been performed. TiZr was found to have a higher removal torque than Ti and showed the same BIC but increased bone ingrowth.

A pilot clinical study is currently ongoing, where narrow diameter (3.3 mm) TiZr implants have been placed in 22 patients according to a standard ITI protocol. After 1 year, 21 patients were available for evaluation. There was one implant failure, most likely due to infection from an adjacent tooth – the tooth was removed and another implant placed. Bone gain was observed in 50% of cases in the first year. A multicenter study has also been initiated in 91 patients who received 182 Ti or TiZr implants. No differences between the groups were found for crestal bone loss, bleeding or plaque. A large non-interventional study (NIS) is also ongoing in 237 patients who received 407 implants. The clinicians were able to avoid using a graft in 57% of cases, and 37% felt that the new implant gave them new treatment options.

The mesio-distal implant position is very important,[18] and the possibility of placing adjacent narrow diameter implants may increase the soft tissue stability in areas where this may be an issue. Improved bone attachment has also been seen with TiZr, increasing the options for the clinician due to greater implant strength and the chance to avoid grafting procedures and increase patient acceptance. Potential disadvantages may be the risk of palatal implant positioning (leading to overcontoured restorations, biofilm formation and esthetic concerns), additional costs and potential abuse of the implant properties.

There are several clinical considerations that need to be borne in mind, including the patient's lip line, soft tissue biotype, screw emergence position, plaque control and the patient's wishes in terms of bone augmentation and esthetic expectations.

The SLActive surface – new promise for compromised sites?

F Schwarz (Heinrich-Heine University, Düsseldorf, Germany)

Surface topography, chemistry and nanotechnology are all interlinked, and a number of recent surface developments, e.g. the hydrophilic chemically modified SLActive, have taken advantage of these properties. For example, in several experimental studies osseointegration has been shown to be consistently faster with SLActive compared to SLA.

Dr Schwarz asked whether current modifications can support bone regeneration in deficient implant sites. For example, BIC was shown to be greater with fluoride-modified (OsseoSpeed) implant versus control (TiOblast) implants in wide marginal defects,[19] and SLActive implants have shown greater bone apposition than SLA implants in circumferential defects[20], while implants with DCD nano-particles (Nanotite) have shown only limited effects compared to control (Osseotite) implants[21].

A pilot study in dogs with SLActive versus SLA implants in three-wall dehiscence defects found that complete defect filling with woven was possible after 12 weeks with SLActive implants,[22] and stabilization of the blood clot at both submerged and non-submerged implants has also been observed.[23] A more recent study in acute defects in 12 dogs using SLactive Bone Level or Nanotite Certain Prevail implants showed woven bone formation equivalent to that seen in previous studies with SLActive implants, with approximately 90% bone fill after 8 weeks. In contrast, the Nanotite implants showed a certain amount of woven bone but a lack of BIC, indicating that SLActive may have a greater potential to support osseointegration. Preliminary data from a similar study also showed a lack of support for new bone formation with OsseoSpeed implants in a non-submerged protocol, but some bone formation was observed with submerged implants. The potential for SLActive implants to support GBR has also been demonstrated;[24] however, defect dimension may also play a role. A greater biological response is observed with increased defect size – investigations have shown that the total augmented/regenerated area is greater with GBR at defect sites, but the vertical bone formation is not increased.

A case series evaluated SLActive tissue level implants in advanced bone defects in 12 patients in combination with natural bone mineral and a collagen membrane. The results indicated that SLActive implants may have the potential to support GBR procedures at advanced defect sites. The recommended clinical procedure involved SLActive Bone Level Implants, GBR, reduced bone filler and submerged healing for 3-4 months, and primary implant stability is required. This is suitable for standard, advanced and critical-sized defects.

Current surface modifications therefore have the potential to support bone formation at deficient sites, but the highest potential is expected from SLActive due to its osseointegration capabilities.

Session 3E: Outcomes

10-year outcome of SLA implants in the edentulous maxilla
K Fischer (Gothenburg University, Sweden)
Ten-year results are available for many implant systems, but there are none for currently available system/surface combinations or for SLA. This study was planned as a long-term evaluation of SLA implants in two different loading protocols. In the edentulous maxilla of 24 patients, five or six implants were placed and loaded either early (within 14 days, 16 patients) or delayed (8 patients). A total of 142 Straumann Standard Plus RN 4.1 mm Ø implants were placed.

The 1-, 3- and 5-year results from this study have already been published.[25,26,27] At 10 years, medical records were available from 23 patients with 132 implants, giving an implant survival rate of 93%. The corresponding prosthesis survival rate was 96%. One patient dropped out before the 10-year evaluation; this patient only had three implants left at the time of the 5-year evaluation due to severe periodontitis. The majority of technical complications were resin-related (39 in the early and 29 in the delayed groups, respectively), while only two were metal-related (both in the early group); these compare well with the results of a 5-year study of implant-supported prostheses in the mandible[28]. Over the 10-year period, the bridges were removed and replaced a total of 31 times.

A total of 18 patients with 102 implants were available for radiographic evaluation at 10 years. In the early group, the bone level changed from -3.46 mm (at baseline) to -4.37 mm at 10-years, while in the delayed group the change was from -2.12 mm (at baseline) to -3.1 mm. Mean bone loss was -0.8 ± 1.2 mm and -1.1 ± 0.9 mm after 5 and 10 years in the early group and was -0.3 ± -1.0 and -0.7 ± 1.3 mm after 5 and 10 years in the delayed group.

Clinical examination was possible for 15 patients with 84 implants. Probing depth > 3 mm was found at 56 implants (10 patients) compared to 18 implants (eight patients) at 5 years. The majority had a sulcus bleeding index of 1 and a plaque index of 1 or 2. The mean ISQ measurements were 57.15 (buccal-palatal) and 67.14 (mesial-distal). In addition, patient satisfaction was reported to be high.

In conclusion, in this 10-year evaluation, there was no significant bone loss between 5 and 10 years, and no signs of peri-implantitis, except for one patient. The reliability of the prosthetic components was shown, and prosthetic problems were mainly resin-related. In addition, patient satisfaction was high.

Reduced diameter implants in the posterior maxilla
J Garcez (private practice, Aracuja, Brazil)
Reduced diameter implants (e.g. < 3.5 mm in diameter) can be used in areas of reduced spaces between teeth and reduced buccolingual dimensions. Such implants can be successful long-term, as indicated by various studies.

Dr Garcez also presented a clinical study over an 8-year period with 152 patients using reduced diameter implants with an edentulous ridge expansion technique. The patients in the study were in good general health and had no local inflammation, with adequate alveolar bone height and reduced bone volume. A total of 756 implants were placed, 194 of which (25.7%) of which were in the posterior maxilla. The cumulative implant survival rate was 98.3%.

A comparative analysis of survival rates from various studies was also performed and presented. For regular diameter implants with sufficient alveolar bone, a mean survival rate of 94.9% was elucidated. For regular diameter implants with onlay bone grafts, however, the mean survival rate was much lower at 78.9%. However, mean survival for reduced diameter implants in insufficient alveolar bone was 94.7%, comparable to regular diameter implants in sufficient alveolar bone.

The use of reduced diameter implants with single crowns or fixed prostheses is an efficient technique, and edentulous ridge expansion is also a useful procedure. The traditional concept that ‘caution

should be used' with reduced diameter implants should therefore be reappraised; however, further clinical studies are required.

Soft tissue stability around immediately placed and restored implants

P Tortamano (University of São Paolo, Brazil)

The question posed by Dr Tortamano was 'when is the best time to place implants?' Placement can be immediate (type I), after soft tissue coverage (type II), after substantial bone healing (type III) or after full healing, i.e. > 16 weeks (type IV). For example, hopeless central incisors may be a suitable situation for type I loading. Most of the advantages and disadvantages relate to time and the available soft tissue.

Immediate implant placement can have many benefits, but some doubts have been raised concerning the success rate, osseointegration and bone remodelling. Consensus statements regarding surgical techniques from the Fourth ITI Consensus Conference have been published.[29]

Bone healing in immediate implant placement with gaps around the implant of ≤ 2 mm has been shown to be similar to that in healed sockets. The main factors for success relate to the peri-implant tissue health. Dr Tortamano presented the results of a study in 12 patients where hopeless central incisors with good periodontal conditions were removed, and impressions and x-rays taken. Peri-implant conditions were evaluated by direct clinical examination or by evaluation of the casts. The distance from the alveolar bone to the gingival margin could not be > 4 mm. Immediate restoration was performed using acrylic resin crowns, with the final restoration placed after 6 weeks. No significant difference was found between either of the evaluation models after 18 months, and immediate placement and restoration was found to be a suitable option in this indication.[30] Another study where CBCT was used to measure the bone thickness at the apex and middle, plus first BIC, was presented; no significant differences were found between the model and the real measurements.

In conclusion, immediate implant placement can save time and avert psychological trauma, but success depends on the extent of the soft tissue and the blood supply of the periosteum.

Esthetic outcomes with bone level implants

C Evans (private practice, Brighton, Australia)

Bone level implants offer the chance of improved esthetic outcomes through reduced crestal bone changes via platform switching and microgap control. Unfortunately, however, there is currently little scientific data available regarding outcomes. Dr Evans' question was 'what is the reason to change from a tissue level implant to a bone level implant?'

Much hype has been made of the concept of platform switching, but there does appear to be mounting support for crestal bone preservation using this technique. Dr Evans presented some data from a retrospective analysis with 27 Straumann Bone Level and 22 Tissue Level implants for single-unit restorations in the esthetic zone. Data in the form of clinical evaluation, radiographs, photographs and casts, were reviewed by a single periodontist. Measurements included the bucco-lingual position, occluso-cervical tooth length pre- and post-treatment, and pink and white esthetic scores (PES/WES) – the maximum scores for the latter are 14 and 10, respectively. Statistical analysis was performed for total scores and individual score variables. Of the 27 patients with Bone Level Implants, 20 had a thin tissue biotype and seven had a thick biotype; the corresponding numbers for the Tissue Level Implant patients were 12 and 10, respectively.

The mean change in tooth length for Bone Level and Tissue Level Implants was 0.1 ± 0.2 mm and 0.5 ± 0.6 mm, respectively. For Bone Level Implants, the mean PES score was 12.7 ± 1, and a score of 11 or greater was observed at 78% of implants. No change in tissue height was observed for 17 cases. Mean WES score was 8.7, with 93% of implants scoring 8 or above. For Tissue Level Implants, mean PES score was 10.5 ±1.3, with only 41% of implants scoring 11 or more. In 16 cases, > 0.5 mm facial tissue was lost. Mean WES score was 8.2, with 81% scoring 8 or above – fewer implants

showed an ideal tooth for or outcome. PES was therefore significantly greater for Bone Level Implants, and facial mucosal level and papilla height were also significantly better.

The crestal remodelling response can be much less with Bone Level Implants, as the papillary volume and buccal contours can be preserved. Emergence profile expansion also allows more prosthetic convenience. Bone Level Implants therefore demonstrate improvements in esthetic outcomes when objective measurements are made. However, Bone Level Implants should not be taken as a substitute for inappropriate 3D positioning. Suitable indications are esthetically sensitive regions when a 4.1 mm profile is desirable.

New and Proven Treatment Procedures
Session 5: Surgical Procedures

Bone grafting for localized defects – simultaneous or staged?
T von Arx (University of Bern, Switzerland)
For bone grafting via a simultaneous approach correct 3D implant positioning and implant stability are required, otherwise a staged approach is necessary. A staged approach is also recommended if the patient has high esthetic demands. A simultaneous approach can be used in esthetic sites provided that the defect morphology allows for predictable bone regeneration.

The goal with either protocol is to re-establish the buccal bone plate, but the question is how much is required. In a systematic review, no studies were found that related buccal bone dimensions to esthetic outcomes.[31] Other articles have found no relationship between buccal bone width and resorption,[32] and more recession has been observed when implants are placed more buccally than lingually[33]. However, recent evidence has suggested that the thickness of the buccal bone wall influences hard tissue alterations – one study showed 43% buccal bone loss until re-entry with thin buccal bone but only 21% loss with thick buccal bone.[34]

Some resorption can take place even in the most stable of horizontal bone grafts. To investigate this, Prof von Arx performed a literature search for studies with horizontal bone augmentation in clinical studies with ≥ 10 patients, examining initial and re-entry widths. In a study with simultaneous augmentation with human bone allograft, 66% resorption was seen when no membrane was used, compared to 48% with collagen membrane and 42% with acellular dermal matrix (ADM).[35]

For the staged approach, three studies were found using particulate grafts, four using block grafts and one study compared particulate versus block. For the particulate graft studies, bone loss in terms of change in graft width ranged from 53% to 69%.[36,37,38] For unprotected block grafts, change in graft width ranged from 23& to 45%[39,40,41] The change in graft width for protected block grafts was much less, ranging from 7% to 12%.[40,41,42] In the particulate versus block study, 40% resorption was found with bone chips and ePTFE membrane compared to 26% with autogenous bone block.[43] The augmentation that can be achieved is approximately 52-58% (1-1.7 mm) with simultaneous particulate graft, 31-60% (1.1-2.7 mm) with staged particulate graft, 55-77% (2.9-5.0 mm) with staged unprotected block graft and 88-93% (3.7-4.8 mm) with protected block graft. The stability and remodeling capacities are different between particulate and block grafts – they have different peripheral nutrition, mechanical load and mucosal pressure properties. This was illustrated in a case of a 41-year old patient treated with horizontal block grafting, using DBBM and a collagen membrane to stabilize the graft. Some resorption was noted at the far ends of the block graft in this case.

There are, therefore, limited data on the stability and grafts in terms of esthetics, but block grafts appear to have better outcomes than particulate grafts, and protected block grafts appear to be superior to unprotected ones. Although simultaneous grafting is still the no. 1 choice for many clinicians, there is very little documentation to support its use.

Sinus floor augmentation
M Chiapasco (University of Milan, Italy)
Implant placement in the posterior maxilla is still a challenging indication for many dentists. Adequate bone quantity is a prerequisite – at least 6 mm is required for the placement of short implants.[44] The two main alternatives for implant treatment in the posterior maxilla is sinus floor elevation combined with standard implants, or the use of tilted implants.

Sinus floor elevation is mainly via a lateral approach, and the technique has been evaluated in systematic literature reviews, including that by Pjetursson et al (2008), which evaluated 48 articles with a total of 12,020 implants,[44] and by Chiapasco et al (2009), which evaluated 59 articles with a total of 13,889 implants[45]. Membrane perforations observed were 19.5% and 10% for the Pjetursson

and Chiapasco analyses, respectively, and the implant loss rate was 5.6% in both cases. The mean implant survival rates found were 90.1% and 95%, respectively.

Autogenous bone and bone substitute combinations were found to have lower implant failure rates, but higher failure rates were found with autogenous particulate and block grafts. However, rough surface implants showed similar failure rates in all materials, and superior survival to machined surface implants.[44] When lack of bone is related to sinus expansion, autogenous or non-autogenous grafting can be used with an equally high implant survival rate.[45]

A recent study evaluated Bio-Oss versus Straumann BoneCeramic for sinus grafting in patients with residual bone height between 3 and 8 mm and width at least 6 mm. All patients were treated with the same technique, and Straumann SLActive implants were placed in 48 sinuses in 37 patients. Similar amounts of soft tissue and mineralized bone were found between the two materials, and bone augmentation was also found to be similar between the two materials. Both materials therefore appeared to be equally suitable for maxillary sinus augmentation.[46]

In the reviews, one-stage implant placement gave slightly higher implant failure rates, but the difference was not significant.[44] However, if primary stability is required, then it may be better to wait.[45] In the Pjetursson et al (2008) review, residual bone height was not reported in many of the studies, and there was a lack of randomized controlled trials with sufficient statistical power.[44]

Local contraindications can be managed, but there are prerequisites, such as efficient sinus clearing of secretions and no sinus pathologies, which should be removed prior to sinus augmentation.

Short implants – what is short and what is not?

F Renouard (private practice, Paris, France)

The EAO 2006 Consensus Conference defined short implants as those with an intrabony length of ≤ 8 mm. The clinical experience of short implants is often counter-intuitive – for example, Dr Renouard showed a case of short implants and bridge which was not expected to be still in place after 15 years but was still in function. Other cases included short implants in the sinus with over 7 years success, implants in infected sites in place for over 15 years, and patients treated with Branemark implants that were still functional after 30-40 years.

Dr Renouard cited data from a finite element analysis using cylindrical implants 11 mm in length under 0°, 15° or 30° loading. The stress load was found to be concentrated in the first 2-3 mm, not at the apex, and almost no stress was found after approximately 7 mm. The stress distribution for both short and long implants is therefore the same, and this has been confirmed by many publications.[47,48,49] These analyses show that implant length does not significantly affect the stresses around the bone.

A systematic review on short implants, which included 13 articles with data from 2,072 patients with 3,173 implants, showed a mean survival rate of 95.9%. Three of these studies were on single crowns, and differences were noted between implant surfaces – better survival was shown with textured surface implants, e.g. 97.6% with TiUnite implants compared to 92.5% with machined surface implants.

Only 1.2% of the longer implants were placed in poor quality bone; the use of short implants therefore reflects the jaw bone characteristics. Short implants in poor bone should not be compared with longer implants in good quality bone, but can be compared with longer implants in grafted bone – the overall survival rates are comparable in this situation. However, morbidity associated with bone augmentation procedures must be considered.

Evidence from the available literature suggests that approximately 6 mm of bone is required in the sinus for implant success, but similar survival rates have been found for short implants as for longer implants in > 5 mm bone. Dr Renouard suggested that the use of short implants in the future could provide the best treatment for the patients in some situations currently treated with longer implants.

Long-term provisional restorations can also be used in such patients. With survival rates > 96% for short implants ≥ 5 mm in length, the use of short implants can therefore be recommended.

Flapless surgery

S Chen (University of Melbourne, Australia)

The definition of flapless surgery is that performed without raising the periosteal flap for either extraction or healed sites. Flapless surgery first began to be reported in the literature in the early 1990s and seemed to be an attractive treatment approach for both the patient and clinician.

Advantages of the technique include increased patient comfort and reduced morbidity – pain and discomfort is minimal and most patients have given positive feedback. The extent of post-operative pain, duration of pain and need for analgesics are all significantly reduced, leading to a significant reduction in patient comfort. Intra-operative bleeding is also reduced, which may be an advantage in anticoagulated patients. The surgical time is reduced, but the disadvantage is that the clinician is working 'blind', so time needs to be spent correlating visual and radiographic measurements. Recent evidence suggests no significant difference in the duration or technical difficulty of the procedure.[50]

There is minimal disruption of blood supply to the site with flapless surgery, which may lead to faster healing and preservation of the hard and soft tissues, therefore potentially enhancing the esthetic outcomes. Some of these potential advantages due to the blood supply can be substantiated; for example, a study of flap and flapless procedures in canine mandibles showed a significantly greater area occupied by blood vessels and a greater total number of blood vessels, with flapless surgery, therefore indicating a greater vascular supply.[51] Mucosal dimensions have been shown to be reduced with flapless surgery, indicating less gingival inflammation, etc.[52] In a clinical study, flapless surgery showed a higher rate of bone loss in the first year, but there was no difference after 4 years.[53] High short-term implant survival rates have also been reported.

Although resorption has been reported with both approaches, it appears to be greater with thin facial bone.[54] Dr Chen presented the results of a retrospective case series, where there was a wide variation in recession – a frequency analysis gave more useful information in this case. The risk appeared to be greater with thin mucosal biotypes, and the results indicated that flapless surgery does not prevent resorption of the facial bone.

Because it is a 'blind' technique, flapless surgery presents a potential risk to anatomical structures and may lead to dehiscences and/or fenestrations. More long-term studies are therefore required. Flapless surgery prevents visualization and management of peri-implant bone defects, and radiography only give limited information. Peri-implant defects are more accessible in extraction sites, where there is also more variability in healing.

Flapless surgery is a technically demanding procedure that should only be undertaken by experienced clinicians. It should be performed only in fully healed bone of adequate dimensions, with proper assessment and planning.

Session 6: Treatment Procedures – Prosthetic and Technical

Bone and tissue level implants – prosthetic complications
W Martin (private practice, Gainesville, FL, USA)
Dr Martin discussed the indications and limitations for tissue level and bone level implants and the modern restorative approaches for both.

Tissue Level Implants have a 45° bevelled shoulder, vertical offset microgap, a single-stage healing option and a trumpet-shaped collar. A number of different restorative components exist for a variety of indications, including extended edentulous spaces, full arch and single tooth; similarly, there is a range of different restorations.

Different options exist for extended edentulous spans as alternatives to adjacent implant placement, including transverse screw retention to have control over mesial cantilevers. For edentulous cases Locator abutments can often be used. The implant brings the polished collar to the tissue surface, offering a higher restoration rate and minimum space requirements. Definitive restorations can be created.

There are limitations for Tissue Level Implants, however, such as reduced intra-arch space, reduced inter-occlusal space and extended edentulous spaces in the esthetic zone. Thin tissue biotype and long-span fixed prostheses can also be challenging.

Bone Level Implants have a 15° internal conical connection, giving a bacterial seal, high stability and prosthetic flexibility. Four grooves give clear feedback on the abutment seating and precision against rotation and re-positioning of abutments. They may be especially suitable for patients with a high esthetic risk, e.g. thin biotype and/or high lip line, or where there is reduced intra-arch space, e.g. adjacent premolar restorations where the available space is ≤ 14 mm – Tissue Level Implants may have problems in these situations, but Bone level Implants may offer advantages.

Bone Level Implants and abutments can offer more space in reduced inter-occlusal spaces – approximately 1 mm compared to Tissue Level Implants. For extended edentulous spaces in the esthetic zone, implants in central sites can control the symmetry and emergence profile – two Bone Level Implants may provide better soft tissue support and management of the interproximal bone.

With long-span fixed dental prostheses it is difficult to get true passivity, but Bone Level Implants may be easier to deliver and restore. In addition, advances in CAD/CAM and materials have allowed frameworks to be created with greater accuracy and strength, which is particularly useful for Bone Level Implants as the frameworks often need to be taller but with maintained strength. Much success has been observed with CAD/CAM screw-retained ZrO_2 prostheses.

Tissue Level Implants can therefore be used in a variety of indications, but Bone Level Implants have added to the prosthetic portfolio, especially in cases of thin biotype, limited intra-arch and inter-occlusal spaces and certain long-span restorations. CAD/CAM technology has also improved esthetics through expanded treatment options.

From casting to CAD/CAM: navigating the technologic advances affecting clinicians today
B Hildebrand (Baylor College of Dentistry, Dallas, TX, USA)
Traditional restorations, e.g. metal-alloy crowns, show success in terms of function and esthetics, but there can be loss of light transference, variations in the quality of the copings and frameworks, time-consuming individual manufacturing and rising costs of materials. CAD/CAM restoration can avoid some of these issues.

CAD/CAM workflow involves either digital impression or master cast/scanning, CAD, CAM, finishing and completion. Depending on the system, the CAD/CAM procedures can be performed in the dental office, dental laboratory or in dedicated milling centers. In-office procedures offer convenient on-site

fabrication, but quality control is more difficult. The capital costs of the systems are quite high, and changes in technology can be expensive and time-consuming. Laboratory-based systems offer lab-based on-site fabrication, but maintenance and support can be more difficult. Again, the capital costs can be very high as rapid large-scale production is necessary. For systems based in milling centers, the casts can be sent – the CAM unit offers outsourcing services. Quality control in this case is taken care of by dedicated, on-site professionals.

Accuracy is dependent on a number of factors. For example, in the scanning process, accuracy depends on tactile, optical and laser factors, while a number of on-office, lab-specific or site-specific factors may influence accuracy in the milling machines. For milling machines, clinically acceptable gaps are from 50-119 µm, while acceptable gaps for in-office systems and lab-based systems are 50-200 µm and 50-100 µm, respectively.

Industry-specific milling centers are becoming more prevalent, with the intention of creating better-fitting abutments for the respective implant systems – there may be differences between in-house and third party abutments in terms of fit.

Titanium offers biocompatibility and radiopacity with low weight and high tensile strength. The price of titanium also remains fairly stable. Of the modern ceramics available, zirconia offers the highest flexural strength and toughness. ZrO_2 is good at stopping crack propagation, which is an important consideration in the laboratory. CAD/CAM options and material issues must be weighed against esthetics and cost.

It has been shown that there is no difference on marginal peri-implant soft tissue colour between all-ceramic and porcelain-fused-to-metal restorations in thick tissue biotypes, but there is a clear difference with thin tissue biotypes. CAD/CAM abutment shading may therefore be important.

Restorations and abutments on natural teeth can work well in many different treatment options, and veneers and more conservative restorations may be important. Removable treatment options and the ability to create bars and frameworks can also offer a significant reduction in cost and time. Other opportunities for CAD/CAM planning are in the implant planning phase and the creation of templates.

CAD/CAM procedures have therefore enhanced dentistry in terms of expanded capabilities, a greater range of solutions, possibilities for new materials, lower potential costs and high quality, tight-fitting restorations.

Evolution in loading protocols in oral implantology

G Gallucci (Harvard School of Dental Medicine, Boston, MA, USA)

In the 1960s, implants were commonly loaded at placement. In the 1970s, however, with the concept of functional ankylosis/osseointegration and biocompatibility of materials, there was a trend towards a more conservative approach. This involved atraumatic preparation of the site with either a submerged approach with smooth surface implants and loading after 3-6 months,[55] or a non-submerged approach with rough surface implants and loading after 3 months[56].

Loading protocols have not always been defined the same way, e.g. immediate loading has been defined as anything from < 24 hours to < 1 week. This was rectified by a recent ITI Consensus Conference, which defined immediate loading as < 1 week subsequent to placement, early loading as > 1 week to < 2 months, and conventional loading as > 2 months; a category of ‘delayed loading’, previously defined as > 3-6 months, was no longer considered necessary.

There are a number of factors that can influence treatment success, including diabetes, bisphophonates and smoking – such patients should be treated using a conventional approach, which allows for monitoring during the healing phase. The implant surface may also play a role. For example, Morton et al (2009) demonstrated a 2-year success rate of 97.7% with early loaded

chemically modified SLA implants.[57] Another important factor is the initial implant stability, i.e. the moment when suitability for immediate, early or convention loading is decided.

Implant number and distribution may also be important, particularly in terms of the prosthodontic survival rate.[58] It has been noted that the more implants that are used, the greater the temptation for a more aggressive treatment approach.

Conventional and early approaches have both been validated in the anterior maxilla and mandible, but validation is still required for immediate loading. Data from systematic reviews has also confirmed validation for all approaches in partially edentulous patients, except for immediate loading in the posterior mandible[59] and maxilla[60]. Another systematic review analyzed 295 full text papers from an initial total of 2,371; a total of 60 met the inclusion criteria for review. The data were analyzed according to removable and fixed prostheses in the maxilla and mandible, and the various procedures classified as scientifically and clinically validated, clinically well documented, clinically documented or clinically insufficiently documented.[61]

From the available evidence, general guidelines for selecting loading protocols are as follows: for partially edentulous patients in anterior regions, there is generally no contraindication for more aggressive loading protocols; in posterior it is better to wait until around 4 weeks after placement; overdentures in the edentulous maxilla should be on 4-6 splinted implants with conventional loading; in the mandible conventional or early loading can be used for overdentures; for fixed prostheses in the edentulous maxilla or mandible, immediate or conventional loading can be used.

In conclusion, selection of the appropriate loading protocol should be evidence-based, and can also be determined by treatment regulators and clinical indications, and the final design should not be modified to a specific loading protocol.

The technicians' viewpoint – material and technical evolution in implant dentistry.
M Magne (901, Marina Del Rey, CA, USA)
For implant rehabilitation, it is necessary to consider all the factors in the patient's mouth, not just the teeth, e.g. translucency. Less invasive restorations are increasingly being requested by patients, who want their restoration to mimic nature – the esthetic expectations are therefore very high. However, the tools that are available to the clinician now in implantology were not previously available.

Metal abutments can be prefabricated or customized and have good biocompatibility and mechanical properties. However, many patients would rather not have metal abutments for fear of shadowing on the gums – a translucent material is therefore preferable. Thin gingival biotypes are less common overall (around 15% of the population), but are more common in women and older patients, particularly in the maxilla. Ceramic abutments can be an advantage in such patients, but different ceramics have different light and shadow properties. Zirconia customized abutments are translucent and tooth-coloured, are cost-effective and can be easily fabricated. They also demonstrate good biocompatibility and strength. A case was demonstrated where the screw access channel was at the incisal border, creating a restorative problem. Exhaustive fabrication was necessary to have the same colour and translucency as the adjacent teeth. Zirconia can also be customized and stratified and bonded to metal – fabrication can take some time but there are fewer abutment failures.

The light source also affects the esthetics – reduced light intensity increases the shadow generated by the metal underneath. In natural teeth, dentin is more fluorescent than enamel – the zirconia abutment can therefore be stratified to mimic nature as zirconia is not naturally fluorescent. The most esthetic approach may be an all-ceramic restoration bonded to a PFM or zirconia abutment that is customized and stratified. These can therefore be recommended in areas of esthetic priority.

Session 7: ITI Research Competition

Bone regeneration with an in-situ formed bioresorbable membrane and hyperbaric oxygen
B Brkovic (University of Belgrade, Serbia)
Critical-sized defects can undergo spontaneous regeneration, and this was evaluated in a rabbit calvarial model. Autogenous bone has certain disadvantages, such as donor site morbidity; therefore biphasic calcium phosphate (BCP), previously demonstrated to be successful, was used in this investigation. Other data suggest that hyperbaric oxygen may improve bone healing in combination with a barrier membrane, so this was also investigated.

A total of 30 animals were split into three groups to receive autogenous bone (10 animals), BCP (10 animals) or no graft material (10 animals); half of each group also received hyperbaric oxygen. Histomorphometry, immunohistochemistry and μCT analysis were performed after 6 weeks. The occlusal properties of the membrane was shown in all groups, but rigidity was not apparent in unsupported defects. There was a significant increase in new bone in the autogenous group, and islands of new bone formation were observed in the BCP group – cellular activity and remodelling were evident. The results indicated that hyperbaric oxygen can increase the ingrowth of new blood vessels, but there was no evidence that expression of VEGF, which promotes vascularisation and stimulates endothelial cells, was significantly altered by the hydrogel membrane.

Osseointegration of zirconia implants in a mini-pig model
M Gahlert (private practice, Munich, Germany)
Titanium implants are the current standard in implantology, but ceramic implants have recently attracted more interest, although the clinical application and evidence is poor. Previous ceramic implants, such as the Tubingen implant, were of Al_2O_3 and had large geometric dimensions; the indications of these implants were very limited.

ZrO_2 may be the material of choice for ceramic implants due to its high biocompatibility and fracture strength. This investigation evaluated the osseointegration of Zr implants with an SLA topography versus Ti implants with the same topography. A total of 96 implants (48 of each type) were placed in 16 minipigs and the removal torque and histology analyzed, including bone-to-implant contact (BIC). The region of interest was the first to last thread of the implant. Direct osseointegration was observed for both materials and the peri-implant bone density was similar for both. There were no significant differences in BIC between the groups, and removal torque values were also very similar (60.4 Ncm and 60.3 Ncm for Zr and Ti implants, respectively). No significant differences were therefore found between the groups at any time point, indicating that the osseointegration of ZrO_2 implants was at least as good as that of Ti implants.

The role of RANK/RANKL in the pathogenesis of peri-implantitis
W Goetz (Rheinische Friedrich-Wilhelm-Universität, Bonn, Germany)
Peri-implantitis is a plaque-induced chronic inflammation with a similar pathogenesis to periodontitis. It involves an early inflammation response (innate and adaptive) that can switch to bone resorption that is dependent on RANK/L, where osteoprotegerin is an inhibitory factor. In this investigation, histopathology, characterization of inflammatory process patterns and triggering of components of the RANK/L system were evaluated. Biopsies were taken from the healthy gingival and peri-implant tissues of a total of 21 patients with implants in function from 1 month to 20 years and bone loss up to 12 mm. A broad spectrum of findings were noted, including different amounts of inflammatory infiltrate – the inflammation stage did not correspond with the clinical parameters.

IL-1β and TNF-α were increased, as were leukocytes, plasma cells, T cells and macrophages, all of which suggest chronic inflammation. In addition, dendritic cells were decreased. Bone fragments showed ectopic calcification and necrotic bone, with TRAP +ve cells that roughly correlated with bone loss. RANK was increased in the epithelium and extracellular matrix, while RANKL was increased in inflammatory cells and the epithelium.

In conclusion, histopathology did not correlate with clinical parameters, and chronic inflammation was observed, indicating innate and adaptive immune system activation. The high frequency of macrophages was an indicator of osteoclast differentiation.

Relationship of various clinical parameters and biochemical markers of bone metabolism in osteoporosis

D Shafer (University of Connecticut School of Dental Medicine, Farmington, CT, USA)

Radiographic and chemical assessment are commonly used, but little is known about how these correlate with implant stability and success. In addition, the effect of osteoporosis is relatively unknown. The aim of this study, therefore, was to evaluate the relationships between various factors and stability.

A total of 30 female post-menopausal patients were assessed, who were part of a best practice study. Each patient received one SLActive implant (21 in mandibles, nine in maxillae) after a minimum of 3 months healing – no implants were placed in recent extraction sites. Bone augmentation was performed at each site in the form of dehiscence graft with particulate material, ridge expansion or block graft. Bone density was assessed radiographically and clinical bone quality assessment was performed. Implant stability, markers of bone health and bone mineral density were also evaluated.

All implants were osseointegrated after 8 weeks, but no significant relationship was detected between ISQ and bone density. There was a significant correlation between localized bone density and CTX at baseline and 1 week, but there was no relationship between bone density and mineral formation. No significant differences were found for any bone density variables.

ISQ was therefore not related to bone density or bone quality measurements. CBCT analysis appeared to correlate with markers of bone metabolism. However, an increased number of patients may alter these results.

Pre-compressed vs. non pre-compressed iliac crest for sinus floor grafting

S Zijderveld (Free University Hospital, Amsterdam, The Netherlands)

Autogenous bone is still considered the gold standard for bone grafting, but the graft architecture may affect the mean bone quantity after grafting. Success with compaction has been reported in orthopedics and has been successfully utilized in craniofacial surgery. The aim of this investigation was to assess pre-compressed versus non pre-compressed bone in sinus floor elevation.

Sinus floor elevation was performed in 10 patients using a split-mouth procedure. Cancellous bone chips from the iliac crest were used; in one sinus in each patient the bone chips were used as normal, while in the other sinus the bone was compressed with forceps, reducing the volume to approximately 50%, before insertion. Histomorphometric analysis was performed, and a total of 48 implants were placed after 4 months.

There was one implant failure. Histology showed vital and vascular bone and 90% lamellar bone, with no significant differences between the groups. Compression therefore did not affect bone vitality. Although the bone volume was reduced for the pre-compressed bone, there was no difference in mean bone quantity between the groups. The osteoid volume was noted to be high, and was higher than in native bone. Compression therefore does not influence mean bone volume after 4 months. This may mean that healing and implant placement could occur earlier, and there was no positive or negative influence on bone volume percentage at the time of implant placement.

Radiographic evaluation of crestal bone loss with different implant interfaces in a canine model

S Caram (private practice, Mendoza, Argentina)

The null hypothesis for this investigation was that there would be no significant differences in bone level changes for different implant-abutment combinations. Six different implant and abutment combinations were used in six dogs, a total of 72 implants were placed. The implants had either

matching or non-matching abutment diameters or were one-piece. The implant-abutment junctions had either a straight or concave profile in each case. The implants were placed 3 months after tooth extraction and titanium screw-retained crowns were placed after a further 3 months.

All implants healed uneventfully and osseointegration was successful. In the straight profile group, significant differences were noted between one-piece and matching and between one-piece and non-matching systems, but no significant differences were noted between the different types in the concave group. No significant differences were noted between matching and non-matching implant-abutment diameters. The concave profile group appeared to maintain bone level, but histological analysis may help to explain the situation more fully.

Decontamination of dental implant surfaces with low and high power lasers
J Marotti (University of São Paulo, Brazil)
Low and high power lasers are used extensively in medicine. High power lasers increase the temperature, reduce bacteria and allow tissue cutting, while low power lasers can have a biomodulatory effect. Lasers are used for a number of situations in dentistry, including decontamination in peri-implantitis. Photodynamic therapy (PDT) has also been used – this involves a photosensitizer and a light source, where photons absorbed by a dye lead to microbial death. Methylene blue is often used as the dye due to its low toxicity and low cost. The advantages of PDT include its selectivity and hygiene. A previous study showed that PDT can be effective and that red lasers produce the best results.[62]

In this study, 108 implants with TiUnite, SLA and Osseotite surfaces were placed in saliva for 5 minutes and then treated with either chlorhexidine, PDT, laser only or no decontamination. The number of colony forming units were then evaluated. No differences were found between implant surfaces. More bacteria were noted at implants without decontamination or treated with laser only, but some bacterial reduction was noted in the laser only group. The results with chlorhexidine and PDT were similar to each other. The results were similar to those previously reported in the literature. PDT may therefore have similar efficacy to chlorhexidine for decontamination in peri-implantitis.

Development of a novel polymer scaffold for tissue engineering
K Schander (University of Bergen, Norway)
Scaffolds of non-human and non-animal origin may help in tissue engineering as a possible treatment to help restore function and esthetics. Such a scaffold must be biocompatible, have 3D interconnected pores, be able to integrate well with the host, allow vascularisation and support osteoinduction. A variety of materials have been evaluated, including the aliphatic polyester PLLA, but many have certain drawbacks. The aim of this study was to evaluate a new generation of biomaterials as novel bone scaffolds.

A number of monomers were combined, e.g. L-lactide, ε-capronolactone and 1,5 dioxepan-2-one, with 89-94% porosity. The combinations were LLA-CO-CL and LLA-CO-DXO with pore sizes < or > 90 µm. Cell proliferation was observed after approximately 3 days, and materials with larger pore sizes appeared to be preferable. Larger pore sizes were still preferred when proliferation and spreading were observed up to 14 days.

These scaffolds were also placed subcutaneously in a mouse model and evaluated after 3 and 6 weeks. Blood vessel formation was observed to and into the materials and again a preference for larger pore sizes was observed. Clinical trials with the materials are due to be performed. The study demonstrated that the scaffolds are biocompatible, and that cells attach and differentiate better on those with pore sizes > 90 µm.

Prospective clinical study of osteotome sinus elevation in the severely resorbed maxilla
R Nedir (University of Geneva, Switzerland)
The posterior maxilla is still a challenging area and one of the most common sites for augmentation procedures. Rough-surfaced implants have improved the success rates, with further improvements by

chemically modified surfaces. Tapered Effect (TE) implants are also well suited to the posterior maxilla. However, there is no consensus as to what the best graft material is, or whether graft material is actually required.

In this investigation, the 1-year viability of osteotome sinus floor elevation with short TE implants, with or without bone grafting, was evaluated. Residual bone height, endosinus bone gain and crestal bone loss were measured. Tooth extraction was performed at least 4 months prior to surgery, and the residual bone height was ≤ 4 mm. In 12 patients, 37 implants were placed in 37 sites (20 with graft material and 17 without graft material) and loaded after 10 weeks.

Similar results were observed after 8 weeks for both the grafted and non-grafted sites. After 1 year, however, more of a dome shape was seen radiographically at the grafted sites. 'Spinner' implants were found after 8 weeks in some patients, which were loaded after a further 3 months of healing. There were two implant failures after 1 year. Endo-sinus bone gain was significantly better with the graft material, but there was no difference in crestal bone loss between the groups.

The TE implant was thought to be relevant for achieving primary stability in a residual bone height < 4 mm. The results indicated that osteotome sinus floor elevation without grafting and with SLActive TE implants may be a good standard in the severely atrophic maxilla. Although bone gain was greater with graft material, it is not a prerequisite for new bone formation. More patients and follow-up times are warranted.

Complications in Implant Dentistry or Dealing with Reality
Session 8: Surgical and Biological Complications

Complications – introduction and overview
NP Lang (University of Hong Kong, China)
As every dentist knows, complications happen, often in the most unwanted moments and patients. Complications can be biological or technical; the latter are mostly system-specific.

A systematic review of complications, which evaluated 51 studies, suggested that 2-3% of implants are lost before functional loading, i.e. early and perioperative complications. These depend on the particular environment.[63] Biological complications may be influenced by the natural teeth and physiological structures.

Gingivitis may be a risk factor for subsequent tooth loss. Data show that 50-year tooth survival is 99.5% with minimal gingival inflammation and 93.8% with moderate gingival inflammation, but only 63.4% with severe gingival inflammation.[64] If gingivitis is a risk factor, then mucositis, which causes recession and inflamed soft tissue, may be also. One study with a mean follow-up of 10.8 years suggested that 16% of patients and 48% of implants have mucositis, i.e. probing depth ≥ 4 mm and bleeding on probing but no bone loss.[65]

Based on knowledge from numerous studies, peri-implantitis appears to be an infection, but it is not a classical-type infection, but rather an opportunistic infection – the pathogens prevalent in peri-implantitis are present in normal conditions in low numbers, but in a peri-implantitis situation they have the opportunity to proliferate. Antibiotic therapy is only half the answer in this case.

A recent study suggested that 48% of implants with peri-implantitis have no adequate access for oral hygiene, giving a 65% positive predictive value; only 4% of the implants with good accessibility had peri-implantitis, giving an 82% negative predictive value.[66]

With implants in close proximity to each other, the main concern is the bone loss in the long-term, not just critically. Careful planning and placement of implants needs to be done. Peri-implant infections are not system-specific,[67] but implant therapy can be successful in periodontally compromised patients, as demonstrated by a study with 75 periodontally compromised patients who received a total of 93 Straumann and 31 Astra Tech implants. After 5 years, 69.5% of the implants were free from excessive probing depth (≥ 6 mm).[68] In a 10-year study of patients with Straumann implants, implant survival in patients with a past history of periodontitis was 90.5%, and 71.4% were free of complications.[69] However, other data suggest that patients with periodontitis may have more bone loss and more complications,[70] and another study suggested that 28% of patients had implants with progressive bone loss[71]. Smoking and a former history of periodiontitis have been identified as implant level risk factors. Another recent study suggested that peri-implantitis-associated bone loss occurred in approximately 40% of implants.[72]

Peri-operative complications – occurrence, prevention and handling
SS Jensen (Copenhagen University Hospital, Copenhagen, Denmark)
Peri-operative complications are those that occur during surgery or soft tissue healing, such as bleeding, swelling, nerve injury, infection and pain. Severe haemorrhage is rare but potentially life-threatening – it if occurs, it is mainly a problem of the anterior mandible.

Peri-operative complications should be prevented as much as possible by e.g. systematic per-operative evaluation including full history and clinical examination. The medical history should take a note of systemic diseases – if in doubt, the patient's physician should be contacted. Medication needs to be considered, especially antithrombotic drugs, although this should not necessarily be discontinued as the risk of a thromboembolic event may be greater than the risk of bleeding. Clinical examination should include palpation to identify lingual cavities.

Surgery should be as atraumatic as possible, involving sharp instruments, constant cooling and gentle soft tissue handling. Swelling can be a frequent complication, but there is large inter-individual variation and it is not necessarily related to implant survival. Low trauma surgery can help prevent swelling, but there is no evidence that cold packings have a significant effect, but corticosteroids can help. A minimum distance of 1.5 mm from adjacent teeth should be maintained and the gap for implant placement should be at least 6-6.5 mm, or damage to the neighbouring teeth can result. Damage can also result from non-parallel adjacent tooth roots or the wrong direction of the implant preparation site – anatomic landmarks and drill guides are therefore important.

Occurrence of nerve injury is rare (< 2%) but can be severe. It is most frequently a potential problem in the atrophic mandible. Proper radiographic imaging to visualize the mandibular canal can prevent this. A vertical safety limit of 2 mm above the mandibular canal is necessary, and the incision should be made a safe distance from the mental foramen. Post-operative neural disturbance may be due to compression, transaction, tearing, laceration or needle penetration. Compression from the implant may lead to intraosseous bleeding or edema. A feeling of shock or 'give' or profuse bleeding always requires radiographic examination, as does any kind of altered sensation. A possible effect of high-dose NSAID or corticosteroid should also be considered.

There have been few reported cases of displacement of the implant between insertion and second-stage surgery, but this is due to a lack of primary stability. Proper treatment planning and two-stage bone augmentation can help prevent this, and tapered implants may also be useful.

Infection occurs in approximately 2-3% of cases. To help prevent this, it is better to identify the patients who may be at risk (e.g. smokers, immunocompromised patients) and avoid implant placement in infected sites. Aseptic technique should always be applied. Prophylactic antibiotics may have a limited but significant effect and may be indicated in standard placement. A single dose may be sufficient, and subsequent biologic sampling should be initiated.

Pain may be a frequent complication but is normally considered mild. Severe pain is rare, but a few cases of neuropathic pain have been reported. The relevant information for the patient prior to the operation is essential, emphasizing the need for sedation and relevant medication in a calm atmosphere. A calm atmosphere is also important during the operation, and afterwards the patient should be advised to rest and take prophylactic painkillers.

Mandibular fracture is extremely rare (only 0.2% of implant placements), but palpation and 3D imaging can help prevent its occurrence. Short implants may be appropriate, and surgery should be atraumatic. If the implant is very mobile, fracture can be suspected. If confirmed, the patient should be referred to an oral-maxillofacial surgical specialist for rigid fixation and bone grafting.

In general, peri-operative complications are relatively rare, but may be under-reported and may be fatal in some cases. A systematic pre-operative evaluation can help prevent these complications, and special care needs to be taken with severely resorbed mandibles.

Biologic complications – prevention and management

GE Salvi (University of Bern, Switzerland)

Peri-implant diseases have been well defined, and can be thought of as a collective term for inflammatory reactions.[4] They can be broadly categorized into peri-implant mucositis and peri-implantitis. The prevalence of peri-implantitis has been suggested as from 27.8% to 55.6-77%. A recent study suggested a prevalence of 47.1% at the subject level and 36.6% at the implant level.[73]

An ongoing 10-year retrospective study at the University of Bern is evaluating over 500 implants in over 300 patients, predominantly with a history of periodontitis. The patients received SLA implants, which have been in function for at least 10 years, with appropriate maintenance therapy. Implant survival and technical and biological complications have been recorded. Preliminary results for approximately 300 implants in around 200 patients have indicated three implant losses so far. Peri-

implantitis has been diagnosed in only a small number of patients, with mucositis noted in approximately 20% and ceramic chippings in approximately 10%. The anticipated implant survival is approximately 98%. The prevalence of peri-implantitis is low but the prevalence of mucositis is high.

Factors associated with peri-implant diseases include a previous history of periodontitis, poor oral hygiene and smoking, but there is only limited that poor diabetic control and alcohol consumption are risk factors.[74] It has also been noted that periodontopathogens begin to reappear after full-mouth extraction.[75] Early colonization of implants with bacteria is associated with periodontitis in partially edentulous patients. There also appears to be a positive relationship with excess cement – in a clinical investigation of 42 implants with inflammation (test) and 20 implants without inflammation (control), excess cement was found at 81% of the test sites versus none of the control sites.[76]

A number of procedures can be used to diagnose peri-implant diseases, including peri-implant probing with a conventional probe, signs of observation of signs of inflammation (e.g. bleeding on probing), suppuration in deeper pockets, and implant mobility.[77] The goals in terms of disease management are to control the bacterial etiology, eliminate inflammation and decontaminate the implant surface. These can use both regenerative and/or resective approaches. Therapies for peri-implant diseases include mechanical debridement, antiseptics, antibiotics, surgery and laser therapy.[78,79] Mechanical debridement, with or without the addition of antiseptics, can improve the clinical symptoms of peri-implant mucositis. For peri-implantitis, debridement alone shows no clinical or radiographic improvement, and the addition of antiseptics shows only minimal improvement of clinical parameters. In addition, bacterial recolonization has been observed after delivery of local antibiotics. Adjunctive laser therapy has shown clinical improvements, but more information on this is required.

Surgical therapy includes open flap debridement and regenerative or resective procedures. Open flap debridement with hydrogen peroxide was evaluated in nine patients with 26 implants showing signs of peri-implantitis. Seven implants were lost over 5 years despite treatment and re-treatment.[80] For regenerative procedures, the available studies are very heterogeneous and the chance of complete fill is unpredictable. Only partial defect fill is often obtained, and membrane exposure is a frequent complication.

Re-osseointegration is possible, but the rates vary considerably.[81] Decontamination of the surface significantly improves the chance of re-osseointegration, and higher BIC has been observed with SLA compared to TPS or turned surfaces.[82] A study on resective surgery with surface topography modification compared to resective therapy alone showed that implant survival is improved after surface topography modification (100% survival after 3 years versus 87.5% with resective surgery only).[83]

Therapy for peri-implant disease must include anti-infective procedures, and patients with a history of periodontitis are at higher risk. Peri-implant mucositis can be treated with mechanical therapy and antiseptics, but the evidence is not so clear for peri-implantitis therapy. It is not yet known whether antibiotic therapy is always required, but the evidence suggests that regenerative procedures alone do not provide predictable outcomes.

Session 9: Management of Technical Complications

Technical complications – implant-related

B Pjetursson (University of Iceland, Reykjavik, Iceland)

Fairly high rates of complications have been suggested – for example, in a systematic review that included 266 implants in 21 studies, only 61.3% were free of complications after 5 years.[84] Complications can be biological, technical (e.g. material fractures) or esthetic.

Technical complications generally concern issues with the implants and/or abutments. Previous recommendations for implants have stated an implant length of 9 mm in the mandible and 11 mm in the maxilla; however, these guidelines do not work for severely resorbed ridges. Data have been published suggesting that occlusal overload can result in loss of osseointegration, as indicated by a study of implants under progressive load.[85] Loss of osseointegration may therefore be a result of mechanical stress. However, another study suggested that there is no significant difference between implants under occlusal load and non-loaded implants.[86]

Evidence indicates that SLA surfaces show a greater rate of bone formation than turned surfaces.[87] Machined surface implants may also have a greater failure rate. Short implants may also be a viable treatment option, particularly in cases of reduced residual bone height.[88] The survival rate of short implants is comparable with those of longer implants with rough surface implants when the surgical preparation is related to bone density.[89]

Implant diameter may also be important – an increase in diameter from 3.75 mm to 5.5 mm increases the available surface area by 70% (for a 7 mm long implant). A study of wide platform implants evaluated 85 implants in 63 patients found implant failure rates of 19% and 29% in the mandible and maxilla, respectively – the mean implant survival rate was 77.6%.[90] Prof Pjeturrson indicated that in his clinic he favours wide body implants but without a wide neck.

All implant systems have a weak link, and this is often the narrow diameter implants. The strength of these implants is generally lower than standard implants, but different implant design and materials may improve this. For example, data have indicated that Straumann 3.3 mm RN implants have a fatigue strength of around 145 N, while those of the 4.1 mm and wide neck implants are 340 N and 440 N, respectively. The 3.3 mm Bone Level Implant has a mean fatigue strength of 180 N, but with Roxolid this is increased even further to 220 N, a very high fatigue strength for narrow implants.

Screw loosening is a frequent abutment complication, and is more frequent with single crowns. However, abutment designs such as the synOcta and the new Bone Level Implant CrossFit connection prevent against rotation. To help prevent screw loosening in single crowns, two single crowns can be splinted together, where appropriate. Loss of retention has been found to be similar for both cement-retained and screw-retained crowns. Expert opinion seems to suggest that screw retention preferable in the anterior region but cement retention is preferable in the posterior region, as the risk of ceramic fracture can be increased by the presence of screw holes. Screw retention is preferable for full-mouth prostheses.

Implants with an internal connection are also preferred – abutment/prosthetic screw loosening are reduced in theses systems. In addition deviations in angulation can be corrected from the implant collar, unlike with external connection implants, which need more metal to do this.

Technical complications – prosthesis-related

D Morton (University of Louisville, KY, USA)

Prosthetic complications are certainly not unusual, but data are for the most part unpublished. The majority are not related to the choice of implant system but are most often related to the manner in which implants are utilized. Acute issues can be a real challenge for the restorative dentist.

A systematic review from the recent ITI Consensus Conference identified mechanical risks (failure of prefabricated components as a result of mechanical forces) and technical risks (failure or complications associated with fabrication and service of the prosthesis).[91] Ten risk factors were identified as associated with the risk of complication, including retentive elements for overdentures, presence of cantilevers, cement/screw retention, bruxism/parafunction, restorative material and length of superstructure.

Considering retentive elements for overdentures, adaptation of the base to the soft tissue is an important aspect. Locator abutments are considered state-of-the-art for overdenture retention, and bars have been used to improve support, stability and retention by reducing potential rotation of the base. Fabrication and passivity of the overdentures is more challenging, however.

Cantilevers are determined by the spread of implants, but their use is still controversial. The use of cantilevers can increase the risk of implant failure and complications due to the load distribution characteristics. The use of tissue level implants can reduce the likelihood of many complications, as they allow correct gap location and connection, and stability as the restorative margin is on the implant not the abutment.

Retention passivity can be affected by cement or screw retention. A moving cement junction is recommended, and the right materials are needed for mechanical integrity.

Cantilevers should be avoided in cases of bruxism, and inter-occlusal spaces may be recommended. A provisional restoration is necessary before a definitive restoration fabricated from an appropriate restorative material. Problems have been noted with acrylic resin as a restorative material. A full-contour wax-up is necessary for fabrication of a viable restoration. The length of the superstructure can present problems in certain situations, depending on the numbers of implants and the restorative material. Zirconia appears to have the same flexural strength as titanium, and material toughness in both cases can be enhanced by alloying with another material.

The key to avoid complications is to plan for success, not failure. Regular maintenance and intervention are necessary, and the clinician should beware of any prevailing conditions that may affect the outcome of the treatment.

Session 10: Esthetic Complications

Surgical and prosthodontic management of esthetic complications
D Buser (University of Bern, Switzerland) and U Belser (University of Geneva, Switzerland)
Important elements for a good esthetic result include a scalloped gingival line, intact papillae, convex buccal contour of keratinized mucosa and harmonious volume/form of the crown. Esthetic failures can occur with single tooth implants, adjacent implants (where implants can be placed too far buccally and apically, leading to inflammation and tissue damage) and in multiple implant placements.

Esthetic failures can have a number of causes, e.g. improper performance of the clinician, inappropriate implant dimensions used, inappropriate number of implants, malpositioned implants, or utilization of a surgical approach that overstresses the healing capacity of the tissues. Esthetic failures can also be caused by peri-implant infections, resulting in vertical tissue loss. Many factors can influence the outcomes, such as the patient, clinician, treatment approach and the various biomaterials used.

Education is important, and is a big challenge. To assist in education regarding esthetic cases, the SAC classification has been developed by the ITI, where cases are categorized as Straightforward, Advanced or Complex. Esthetic sites are difficult to deal with for a number of reasons. For example, patient expectations are high, there are multiple risk factors in many patients, precise 3D implant placement is required, and the clinician needs to be able to perform contour augmentation with GBR. For these reasons, esthetic cases are always A or C under the SAC classification. A risk assessment tool for the SAC system has been developed and is available on the ITI website (http://www.iti.org/?a=1&t=0&y=3001&r=0&n=188&i=&c=25&v=page&o=&s=)

There is a recognized surgical recipe for successful outcomes in esthetic cases, which requires an understanding of the tissue biology, detailed risk assessment and correct 3D implant positioning. 'Comfort' and 'danger' zones need to be considered, as described in the literature.[92] Problems in the mesio-distal plane can result if implants are placed too close to adjacent teeth or adjacent implants, and interproximal tissue height is a key factor. Implants with or without platform switching have been used, but the evidence suggests that there is significantly less bone loss with platform switching.

Placement with adjacent implants can be problematic because some flattening of the bone can occur, leading to the problem of black triangles. The minimal distance between implants therefore plays an important role. Clinical situations that include the lateral incisor tend to be the most challenging. Problems may also result from malpositions in extended edentulous spaces.

Problems in the corono-apical plane also need to be considered – the clinician needs to take care not to place the implants too far coronally or apically. Apical malpositioning should be avoided. General recommendations are to use a surgical stent and to avoid countersinking.[93] Facial malpositions may be common in the orofacial plane, but palatal malpositioning is rare. Malpositions in this plane are more likely with flapless surgery and/or immediate implant placement. The use of wide implants should be avoided in the anterior region, and the implant should be positioned inside the alveolar process.

Profs Buser and Belser showed a series of 10 cases with esthetic issues to illustrate their points. Each had a different challenge from a surgical point of view. General points to consider were that implant removal causes hard and soft tissue defects, additional bone loss should be avoided, the soft tissue should be allowed to heal as much as possible, and a routine procedure of implant placement with GBR should be followed. One of the main limiting factors is the vertical bone loss at the adjacent teeth.

Case 1 involved mucosal recession 2-3 months following implant crown insertion in a patient with a medium lip line. This was due to deviation from the ideal implant position – the implant was placed too

far distally and facially. The crown was removed and the soft tissue allowed to heal before the implant was removed and a new implant placed in the correct 3D position with simultaneous GBR.

In case 2 there was no facial bone at re-opening due to facial malposition of the implant and disturbed wound healing after implant placement. The implant was removed and a new implant placed in correct placement using contour augmentation and autogenous GBR to cover the implant surface. A bioresorbable membrane was placed, primary closure was achieved and proper wound healing allowed.

Case 3 involved infection as a result of an oversized implant being placed. Massive radiolucency was observed radiographically. The crown was removed and vertical bone augmentation was performed, although the defect was substantial as the palatal bone was no longer present. After implant placement GBR was performed with autogenous bone chips and some Emdogain, and good volume was obtained. A collagen membrane was placed and tension-free wound closure achieved. The procedure resulted in substantial vertical augmentation.

In case 4, an Al_2O_3 implant had been used approximately 8 years previously and significant recession had resulted. A titanium implant was subsequently placed using the procedure described by von Arx and Buser (2006).[42]

The fifth case involved an attempt at vertical ridge augmentation with block graft, but a resulting infection led to exposure of the cover screw and significant vertical tissue loss and vertical deficiencies at the adjacent tooth. Pink porcelain was used in the final restoration, which was a slight esthetic compromise.

Loss of an immediate implant occurred in case 6 as a result of post-surgical infection. The root surface of the adjacent tooth was exposed and this tooth was subsequently removed. Simultaneous GBR was performed to rectify the situation. Infection also occurred in case 7, resulting in major damage so that the implant had to be removed with a trephine. A large defect resulted and ridge augmentation with a block graft was done. Implant placement with simultaneous GBR was subsequently performed.

In case 8, there was a major recession around 3 implants, which were subsequently removed and two implants placed instead. Long crowns were necessary in this case due to the size of the overbite. Infection and tissue damage also occurred in case 9, resulting in major vertical deficiency. Horizontal augmentation with implants was necessary. In the final case, implants were placed too far apically and had to be removed, leaving a dramatic vertical deficiency. Pink ceramics were also required in the final restoration of this case.

In conclusion, failures often occur due to inappropriate treatment quality, infections or both; however, the former is more frequent. Outcomes are often non-optimal, so the best strategy is to try to prevent complications from occurring. Clinicians should only treat the patients they feel comfortable treating, or should team up with a more experienced implant surgeon.

Interactive case discussion

F Higginbottom (Baylor College of Dentistry, Dallas, TX, USA), L Cordaro (Eastman Dental Hospital, Rome, Italy), D Weingart (Katherinen-Hospital, Stuttgart, Germany) and A Schönenberger (private practice, Glattbrugg, Switzerland)

In this session, four cases were presented by HP Weber (Harvard School of Dental Medicine, Boston, MA, USA) and L Heitz-Mayfield (private practice, West Perth, Australia) and the members of panel were asked to give their opinions on the case and potential treatment.

The first case involved esthetic issues and soft tissue recession at teeth 11 and 21. The patient was a 28-year-old female, non-smoker, who had implant crowns in lace for 4 years. The panel suggested that more investigation would be necessary to determine whether this was peri-implantitis – implant malpositioning or cement issues may be responsible. The crowns should be removed and replaced with provisional screw-retained restorations, and non-surgical debridement in conjunction with systemic antibiotics would be necessary. Pink porcelain may also help.

The second case was a 45-year-old female with maxillary and mandibular fixed implant-supported ceramo-metal prostheses. Chipped porcelain was observed after 2 weeks, necessitating composite repairs for the original and additional fractures. The case showed excessive occlusion, and complications are often seen with superstructures of this type. The occlusal scheme therefore needs to be changed – one suggestion was to use several units in segments instead of a single full-arch prosthesis.

The third patient, a 53-year-old, complained of bad mouth odour. Probing depth was found to be 7 mm and there was bleeding and suppuration. Two of three implants in the lower arch showed extensive bone loss, with bleeding and suppuration. Peri-implantitis was therefore diagnosed. Implant malposition was a factor in this case, but occlusal overload did not appear to have an influence. The problem was mainly biological in terms of the host response. The patient was a smoker with poor oral hygiene who had previously been treated for periodontitis – a previous 4-unit bridge had failed as a result. It is very difficult to obtain passive fit on three implants in the mandible – if it were in the maxilla, only two implants would be placed in the same situation. The panel therefore recommended the removal of one of the implants but keep the provisional fixed restoration.

The final case was a 29-year-old female with tooth mobility and esthetic problems. Teeth 12 and 11 had been extracted due to external root resorption and autogenous bone graft used in a staged approach, with subsequent placement of two implants when the patient was 18 years old. The patient may therefore still have been growing when the implants were placed, so the bone could have changed position. Implants placed in central and lateral incisor positions are a bad combination. The treatment of choice in this case would be two new crowns, and crown lengthening could be performed on the contralateral side.

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