PLENARY PROGRAMME

In Programme Order

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CARLOS DOS REIS PEREIRA DE ARAUJO

"Clinical aspects and scientific considerations for the aesthetic and functional utilisation of single implants"

Dr Araujo wished to share with the delegates over 20 years of clinical experiences in the use of implants in dentistry. Dr Araujo presented his experiences from two environments, the dental school and private practice. Dr Araujo defined *"clinical evidence"* as learning by trial, for example in the early use of implants in dentistry, implants were placed in humans and only with hindsight was clinical knowledge derived. Dr Araujo went on to say that although scientific evidence was starting to replace clinical experience as an exceptable way forward, the only way to learn about implants was to place them and see how they react. Much of the earlier clinical evidence in implant dentistry had been confirmed by well-conducted scientific studies.

Dr Araujo started by showing some classic cases designed to the Branemark protocol, stating that at the time of these constructions no one believed that implants could survive on their own. Until 1982 when the first single implants were placed in the posterior segments, he presented 4,6 and 10 years case follows ups of these implants placed to the absolute Branemark protocol showing no bone loss. The success of these implants raised questions about the understanding of occlusal forces on the implants. In particular the use of angled abutments on implants as short as 9.5mm. As the clinical picture developed the use of implants became more daring, he showed the successful placement of an implant in type 3, poor quality, bone with unfavourable occlusal loads.

Dr Araujo explained through clinical evidence they had learned that implants needed to be placed deeper in the aesthetic zone. Also, that if the implant abutment connection was left undisturbed, healing would occur more quickly.

They started to learn that implants could be placed and loaded immediately, providing the implant had good primary stability. He presented work carried out at the University of Frankfurt where implants were immediately loaded using a relined denture with no metallic components connecting the implant and the denture. 1000 cases were followed longitudinally, giving a 94% success rate. He questioned the design of the implant and the related success. Dr Araujo, who works as a team with his wife providing the surgical work, said that in the early days the criteria for immediate loading was unknown; he trusted his wife's intuition. Various systems had been used to test the bone quality but no test had produced any scientifically accurate evidence. Dr Araujo presented a case in which he had immediately loaded the implant; he questioned the concept of progressive loading. In his opinion once the implant was placed and restored with a crown during the normal function of eating it was difficult to control the loads on a implant. He stated that the world literature on success rates on immediately placed posterior implants was in the order of 96%.

Dr Araujo went on to share with the delegates what had been learned from placing immediate implants in the anterior aesthetic region. Firstly, to fill the dimensions of a central incisor socket, one needs to use an implant with a wide diameter head. The width of this would go on to cause resorption of the adjacent buccal alveolus. These experiences lead to the use of narrower diameter implants in the anterior region so that the minimal bucco-palatal dimensions of the buccal plate were 1-2mm. The use of narrow implants required them to be placed deeper into the tissues enabling the creation of a good immergence profile. Dr Araujo demonstrated a suture sling that he had developed to aid in the placement of the single tooth implant when a single tooth was missing between two natural teeth. A black silk suture was placed at cemento-enamel junction level and crossed over in the edentulous space area, creating an "X". The point that the two strands of the suture crossed over was the ideal location for implant placement. This would allow the placement of the implant with at least 1.5-2mm of bone buccally. Such placement would give predictable aesthetic results. The lack of adequate bone width should be correct using bone grafting techniques before implant placement.

Dr Araujo discussed his soft tissue management protocol, the use of a small atraumatic incision to expose the implant followed, at 4 weeks, by an under-contoured provisional crown. At six weeks the under-contoured crown could be replaced with a crown with the more definitive dimensions. His reasoning for this approach was that the connective tissue around the abutments requires between 4 and 6 weeks to show a mature structure. Manipulating the tissues earlier than 4 weeks can result in the loss of some of the connective tissue. After 6 weeks the interdental tissues can be pressed with the contours of a provisional crown to create interdental papillae. Dr Araujo described his current prospective study in which he is carrying out a Palacci procedure followed by his connective tissues stimulation. He currently has thirteen patients in this group and he had generated papillae even when the bone to interdental contact point dimension was greater than Dr Tarnow's 5mm. He stated that his team were still experiencing more difficulty generating papillae between adjacent implants when compared to implants and adjacent natural teeth. He did feel that his team would be able to in the future restore an edentulous case with single tooth implants and predictably restore the anterior aesthetics with the necessary papillary architecture. He suggested that in the future we would need to develop a way of regenerating bone into the inter-implant areas. One way to achieve this would be to graft bone to the site prior to implant placement and the deeper placement of the implant into the bone. Another way to generate the interdental bone could be the use of alloplastic materials and membranes; this area would need much more work.

He also showed a case, suggesting the role of slow orthodontic extrusion of teeth before extraction to generate new tissues that could be manipulated later in the treatment sequence.

Dr Araujo presented a case in which he had immediately loaded an implant that had been placed into recently grafted bone. During work on this immediate case, Dr Araujo learnt that the implant abutment connection should not be disturbed for the first sixty days. The reason behind this was that a mixture of proteoglycans and fibrin would form creating a milky tissue type immediately adjacent to the implant abutment connection, this tissue type takes sixty days to mature. A team of researchers in Gothenburg had recently confirmed his experiences.

Dr Araujo completed by stating that clinical experiences would most probably pave the way forward and that scientific evidence would slowly start to confirm these clinical experiences.

PETER S. WOHRLE

"Predictable aesthetic outcomes in implant dentistry based on biological principles"

Dr Wohrle started his presentation in a truly West Coast, Hollywood style, big screen way with fully integrated sound. The focus of his presentation was the increasing demands of patients and our need to address these patient needs. His patient population was partially edentulous patients as opposed to the original Branemark edentulous cases. He considered the location of his practice as serving the most physically aware population in the world. He had noticed that his patients demanded, more than ever before, that their dental implants felt and looked like natural teeth. The key issue for him was not just the survival of the implants but the quality of the survival.

The basics of predictable aesthetic outcomes in implant dentistry can be covered in 3 basic areas: a harmony of the hard and soft tissues, the right implants in the right places, and sound execution based on an understanding of sound principles both in the laboratory and at the clinical level.

To understand what is happening around the neck of the tooth requires a sound knowledge of the principle of biological width. Around natural teeth, from the crown working towards the apex, firstly we have the gingival sulcus, next we have the junction epithelium, then between the junctional epithelium and the bone is the connective tissue. The junction epithelium has within it undifferentiated cells, and has a potential to form attachments with underlined structures via hemidesmosomes and/or the basal lamina. The sum of the above components is the biological width. Dr Wohrle was confident that it had been shown clearly through research that the biological width concept holds true around the dental implant as well. The main difference between natural teeth and dental implants is that the true connective tissue attachment between the bone and the tooth does not exist between the bone and the dental implant.

The remodelling that occurs around the current implant abutment interface is now considered to be a normal phenomenon. The main reason that dental papillae exist around the single unit implant is because the bone that is available on the adjacent teeth supports them. Looking at the original Branemark protocol in the edentulous patient, implants lost 1mm of bone in the first year and 0.1mm a year thereafter. However, when we use implants in the partially edentulous patients we see more bone loss much faster. What is different? If you look at the original Branemark protocol, the abutment is left in place throughout the treatment sequence. When the abutment is removed for the first time some bleeding can be observed indicating that an attachment has been disturbed. With implants in the partially dentate patient, a considerable amount of work is carried out using temporary components. This disturbs the implant abutment interface several times so by the time we are ready to secure a definitive crown, the sulcus has become epithelialized. Subsequent to the epithelialization the biological width tends to re-establish itself. The easiest way to understand the biological width is to bear in mind connective tissue will always exist between the epithelium and the bone. To make room for this connective tissue, bone around the head of the implant resorbs. This bone remodelling ultimately results in remodelling and collapse of the soft tissues and loss in the height of the dental papillae, thus making predictable aesthetic outcomes unachievable.

Dr Wohrle went on to present a new approach with the scalloped margin implant. The scalloped margin implant is a regular implant with a scalloped bone apposition surface and a scalloped soft tissue apposition area. This design moves away from the traditional flat top cylinder implants that were originally designed for use in the completely edentulous patient. In the partially edentulous patient we have a 3 dimensional configuration with high interdental peaks and lower buccal and lingual plates, which were not seen in the edentulous cases. Looking closer at the soft tissue apposition area and the hard tissue apposition area immediately beneath it. There were different requirements in terms of design. In producing a universal implant only one soft tissue apposition area contour was selected and one scallop that would fit most cases was selected. A 1.5 mm soft tissue apposition area seemed to perform the best during a prospective, randomised, controlled, multicentre clinical trial. This also conforms with the biological width studies. The height different between the high point and the low point was 2mm. Hirshfelt was the first to describe the bone morphology in different profiles of partially edentulous patients as either flat, scalloped or pronounced scalloped. After much research, the average height difference between the interproximal and the low buccal plate in patients not affected by periodontal disease is found to be: central incisor, 2.7mm; lateral, 2.5mm; canine, 2.7mm; premolar, 2.0mm. In the molars there tends to be no difference between the interproximal and buccal plate. The shape of the scalloped implant profile would have to be compatible with a wide range of indications.

Clinical research studies showed higher

coronal bone to implant contact interproximally with the scalloped implant. It is a requirement of the implant placement that the soft and hard tissue apposition areas are placed adjacent to the points where the connective tissue attachment and bone are required to be, respectively. The soft tissue apposition area is the area you would wish to avoid disturbing, as a hybrid between traditional one stage and two-stage implants. The presence of an interproximal bone apposition area would also allow for after-grafting into the interdental area. The aim with the scalloped implant design would be to have a shallow sulcus of the same 1.5mm dimension 360° around the entire implant. Dr Wohrle reminded the delegates that with the use of a flat top implant, positioning the implant head at the level of the interproximal bone carries the risk of abutment margin exposure on the buccal surface. Conversely, placement of the implant head at the level of the lower buccal plate leads to interproximal remodelling, resulting in loss of height of the papillae.

Dr Wohrle advocated the use of under-contoured temporary restorations to generate soft tissues, in width and height, which could later be manipulated into place. In the final restoration there needs to be a balance between biology and aesthetics. For an aesthetic restoration, the margins need to placed sub-gingivally. However, in respect of the biological width, the margins can only be placed minimally sub-gingivally. We have learnt that the deeper we place our margins, the more problems we should expect over time. Radiographs of scalloped implants show a three-dimensional bone contour, as opposed to the one-dimensional contour which was seen around flat top cylinder implants.

Another key issue in the predictable aesthetic outcomes of implant treatment is the corono-apical position of the implant during placement. Corono-apical implant placement is multifactorial. Quality of the tissues is an important factor. For example in highly scalloped thin tissue, you choose to place the implant deeper than in thicker less scalloped tissues. The size difference between the restoration and width of the implant head is another factor to consider when determining the corono-apical position of the implant. The larger the difference between the implant head and the restoration, the deeper the implant needs be placed to get good prosthetic running distance for a good emergence profile. The current trend is to place the head of the implant 2 mm apical to the location of the future free gingival margin, and avoid placing the implant head too far apically. Aesthetics are more predictable if we have thick tissues, a shallow sulcus, and an adequate prosthetic table in relation to the crown emergence. The implant head should be placed an additional millimeter apically for each of the following features: highly scalloped tissue, thin tissue, an external connection, and an inadequate size difference between the prosthetic head of the implant and the crown margin.

One area that had always proved to be problematic in the aesthetics zone was multiple adjacent tooth loss, which resulted in the appearance of a flat edentulous ridge. The use of the original flat head implant in this area offered no predictable regeneration of the interproximal papillary areas. The use of the scalloped margin implant offered the most exciting change for these patients. The placement of adjacent scallops margin implants with the use of after-grafting should provide a more predictable aesthetic outcome for these patients.

Dr Wohrle showed delegates slides of a new scallop design implant. The interdental areas had peaks, as you would normally see on a tooth that had been prepared for a crown. He suggested that this design of implant would allow for a more predictable papillae reconstruction. He showed many cases in which the papillary reconstruction had been made more predictable with the use of bone grafting. He recommended that the head of the implant should always be placed 2mm apical to the future location of the free gingival margin/crown margin. The use of such countersinking would cause bone loss in the buccal area with the use of conventional flat top implants. Another method to reconstruct the papillae more predictably would be the placement of the implant 2mm apical in relation to the buccal free gingival margin, and supplement this with after-grafting into the interdental area to provide support for the future papillae. The after-grafting can be performed with autogenous bone, bio-oss or a combination of these two under a titanium reinforced membrane. Over-grafting with countersunk implants was preferable to after-grafting. In most cases the entire surface of the implant is within bone and the function of the after-graft is to support soft tissues more than the implants. Current research shows that this after-grafted bone can be maintained for 4 years. He compared the countersinking of the implant to conventional crown lengthening procedures, the intentional removal of bone.

When placing multiple implants in the aesthetic area it is important to place those implants first, which will dominate the appearance of the smile. A surgical stent should always be used, adjacent implants should always be placed at the same height and, when using the scallop form implants, the interdental peaks should be positioned in the correct location.

Slow orthodontic extrusion of fractured roots can regenerate alveolar tissues thus creating tissues that can be manipulated after the implant placement. Soft tissue support could also be provided by occluding extraction sites with graft material.

When placing implants into a flat edentulous ridge, by the time the osteotomy preparation is complete the site has 3-dimensional form. Therefore, the bony margin is more apical in the buccal plate area and more coronal in the interdental area.

In closing, Dr Wohrle said that we currently have standard implant systems borne from the original edentulous arch systems and we have systems developed for the partially dentate patients. The systems currently designed for the partially dentate patient were struggling to deal with the 3-dimensional needs of the clinical situation. In the future, implant selection will be guided by bone quality, and morphology: if you have good bone in a flat ridge and you do not want to alter it, choose a parallel-sided screw. Poor bone quality and a flat ridge would indicate the choice of a tapered screw. To recreate 3-dimensional morphology you would probably use the scalloped implant.

THOMAS D. TAYLOR

"Predictable aesthetic outcomes in implant dentistry based on biological principles"

Professor Taylor informed delegates that his normal areas of interest were implant occlusion and the biomechanics of dental implants. He posed the question, *why would a prosthodontist be interested in discussing periodontitis?*. Prof. Taylor felt that the usual professional, the periodontist, to talk about this topic was fundamentally too close in terms of training, medical microbiological knowledge, aetiology and progression of periodontitis to be able to provide a independently objective view. He also felt that a lot of what had been learnt about the study of periodontology had been extrapolated into the study of dental implantology. He had observed that what he was being told by periodontists, what he was seeing in his practice, and what he had learnt from the literature, were not the same.

Prof. Taylor said that during his presentation he would not offer the answers, but merely pose the questions. He wished to stimulate the delegates present in to debate and considered himself to be merely a messenger pigeon. He wished to share with the delegates, concerns that had been raised to him by other colleagues and also points that concerned him.

Prof. Taylor classified implant failure into two broad groups - early failure and late failure. He described early failure as infrequent yet predictable failure. Early failure was not associated with the type of infectious process that one would imagine a foreign body, being ejected, would be associated with. Early failure cannot usually be detected by observation alone there is no oedema, erythema or suppuration. These implants tend to be painful on application of tourqing force and are usually slightly mobile. He suggested some possible causes of early failure - overload of the interim denture, heavy-handed surgery, a dull drill, contaminated implants but concluded by saying that it was always difficult to establish why a particular implant had failed to osseointegrate.

Prof. Taylor continued his discussion concentrating on the late failure of titanium surface implants. He wished to ignore hydroxyappetite surface implants as he felt that the more dominant type of implant used in modern implant dentistry was the titanium surfaced implants and also that the disease process that prevailed around these two different types of implant surface was very different. Prof. Taylor's opinion was that the hydroxyappetite surface implants was something considered ten years ago for a number of perceived advantages - they integrated faster, it would give a more histomorphometrically complete osseointegration, a stronger initial integration in the torque-out test and in the short term it used to be a more predictable type in poorer quality bone sites. He went on to share with the delegates several research papers showing late failure of hydroxyappetite coated implants. The suggested reason for failure was as a result of the resorption of the hydroxyappetite surface layer at about seven years, a layer which was then subsequently not replaced by any tissue type. On removal these implants tended to have very little hydroxyappitite remaining on the surface.

Periodontitis was defined as a disease of the investing organ of the tooth, the periodontium. Extrapolated to the dental implant system, simply speaking if you do not have the organ, you cannot have the disease. Peri-implantitis is an inflammation of the tissues around the dental implant and or its abutment. Prof. Taylor was happy with this definition of peri-implantitis and had seen this phenomenon around very few dental implants. Prof. Taylor commented that with his 20 years experience in the use of dental implants, he was surprised with the scarcity of this sort of phenomenon around dental implants. He posed the question, that if periodontitis, as a disease entity, did have an impact on the health and success of dental implants then why had he and his collegues not seen more cases of peri-implantitis in his 20 years experience? What was the relationship between periodontitis and peri-implantitis. One faculty at his university was teaching undergraduate students that implants were contraindicated in patients with periodontitis, he himself in his own faculty teaches undergraduate students that the use of dental implants is the solution for patients with advanced periodontitis. The truth may lie somewhere in between these two positions.

Prof. Taylor was of the opinion that the disease pathways and the associated pathogens that resulted in attachment loss around teeth, were different to the disease pathways in the development and outcome of peri-implantitis. He stated that there were clinicians around the world who had been treating perio-implantitis as though it were periodontitis, admittedly with some success. His concern was not how you treat the infection around an implant, but moreso, how the infection occurred in the first instance.

Prof. Taylor reviewed a study paper by Linquist and his colleagues studying the effect of plaque on the attachment of dental implants. The study reported on 46 patients, including a retrospective chart review of levels of plaque around dental implants. Only nine patients had been documented as having poor oral hygiene. Oral hygiene was found to be the most important factor associated with marginal bone loss. Up until this time no one else had made such statement, like this. Cross examination of the study shows that only nine patients showed poor oral hygiene, these nine patients were then compared to nine other patients from within the study population. How these nine patients from the study were selected, the authors do not tell us. Measurment difference between the groups was 0.5 mm after six years, this was shown to be a statistically significant difference. This study was an honest attempt at finding an association between plaque on implant surfaces and peri-implant attachment loss. Prof. Taylor did doubt the results of this study,

Prof. Taylor went on to say that supragingival calculus was commonly seen around dental implants but they did not demonstrate the same inflammatory reactions as seen in association with calculus around the natural dentition. He had never seen sub-gingival calculus around dental implants or their abutments.

Prof. Taylor shared some cases with the

delegates, in slide form. These cases were ones, in which the implants had been successful. However, he had difficulty explaining and justifying why the implants had been successful. He provided the delegates with questions to which he suggested the answers needed to be provided, scientifically. The first case was one where an implant had been placed apical to the ideal position. It was approximately 1cm apical to the free gingival margin, the crown to the root ratio was less than 1, it had been restored with a ridgelap design of crown, the crown had never been removed for cleaning. When the restoration was finally removed, or epithelially lined,none bleeding sulcus was evident all the way down to the head of the implant the only inflammation that was evident was at the microgap. Around a natural tooth a probing depth of 1 cm would be called a periodontal pocket and it would be assumed that the tooth was well on its way to being lost, in a fairly short time period. The same probing depth around an implant is considered to be normal, for a two stage implant, it is described as successfull if it stood the test of time. Prof. Taylor presented a possible theory for the phenomenon he had seen. At the University of Buffalo, Professor Meenahan wrote a paper on titanium oxide in the oral environment and demonstrated chemically that in proteinatious solutions, titanium oxide will form a peroxide. His theory was that the peroxide coating on the surface of the implants would tend to be bacteriostatic or bacteriocidal medium between the implant surface and the surrounding micro organisms.

Prof. Taylor asked the delegates to ignore two studies that had been published ten years previously, the research had been carried out by a group of researchers at the University of Toronto under the supervision of George Zarb. These studies had proposed that periodontitis and periodontal pathogens are the aetiology of implant failure. The findings of these studies were that probing depths around implants were shown to decrease over time. They found no correlation between failure of osseointegration or mucosal health with poor oral hygiene. This finding was contrary to the findings of Lindquist. Prof. Taylor felt that the statements made in these papers were very courageous, as the authors have tried to compare traditional periodontal indices with success and failure of dental implants. One statement that was made by the authors of this paper was agreeable to Prof. Taylor and this was that the use of a periodontal probe to measure sulcus depth around the dental implants was not recommended, as it provides no usable or useful information. Concerns had previously been raised that not only was the use of a probe around an implant painful for the patient but it may also be causing damage, possibly by introducing pathogens into the space between the dental implant and the adjacent mucosa. Another reason for not using the probe around implants was that the sulcus on many of the dental implants used today is not a linear sulcus. Prof. Taylor went on to show delegates many slides of pathology around implants that he was convinced the dental probe had been the aetiological factor. The food and drug administration of the United States no longer require probing depth measurements for the assessment of, or monitoring of dental implants.

Prof. Taylor urged the delegates to consider what came first. *Was it the host susceptibility and presence of the periodontal pathogens that was causing the implant failure? Could some other initiating factor be causing the initial tissue breakdown, which subsequently was being invaded by the opportunistic periodontal pathogens?* Prof. Taylor made many references to the possible initiating factors poorly fitting prosthetics, extruded cement lute, distorting forces on the implants from non-passive prosthetics, local anatomy, periodontal probe.

Prof. Taylor finished his presentation with a case in which a patient had been restored with some implants, correcting tooth loss that had occurred as a result of advance periodontitis which had been successfully treated. Three year's after implant placement the patient had returned with evidence of active periodontitis around several of her natural teet. The implants were unaffected by any inflammatory changes. Prof. Taylor concluded by stating that there were many studies that corroborated no association between periodontitis and peri-implantitis. There were also studies showing that these two diseases shared the same aetiology and progression. More scientific evidence was needed.

DENNIS P. TARNOW

The interdental papillae : An interdisciplinary approach to its preservation and reconstruction between teeth and implants.

The dental implant systems that are are available today have extremely high successful osseointegration rates. We are no longer concerned about the osseointegration of our implants. The focus has moved to predictable aesthetics, in particular the dental papillae in the aesthetic zone. The successfully osseo- integrated implant in the anterior aesthetic zone would be considered a failure in the patient eyes, without the reconstruction of the dental papillae. **Dr. Tarnow** considered the dental papillae in three different situations, firstly between natural teeth, secondly between teeth and implants and lastly between multiple implants in aesthetic zone.

Dental papillae between natural teeth.

The normal contact point is between 1 and 2 mm in area, the shape of the col is determined by the shape of the contact area. In Dr Tarnow's opinion the biological width is not 3mm. The biological width should be the one millimetre of epithelium and the one millimetre of connective tissue above the bone, the sum being 2mm. The gingival sulcus is excluded because its dimension varies between the mid buccal (0.69mm on average) and the interproximal area. In the interproximal area, the sulcus is always deeper. Where a dental papillae exists, it is always a hypertrophy of tissue. If the contact area is removed the dental papillae will shrink away into an edentulous area. The papillae will only be regenerated if the contact area is re-established. When we remove a tooth, unless we place a fixed temporary

with a contact area, the dental papillae will shrink. In the interproximal area your have on average an extra 2 mm of sulcus deepth, the biological width in this area accordingly should be on average 4mm.

You always have a biological width around teeth and you always have a biological width around implants, irrespective of whether they are one stage or two stage implants. Bone always covers itself with connective tissue and this in turn always covers itself with epithelium. This feature is genetically predetermined in three hierarchy of our healing. On the implant surface this biological width starts at the micro gap and continues 2mm apical of that point. Important consideration must be given to where this biological width occurs on the surface of the implant. It is important to remember that the biological width occurs in two dimensions, the vertical dimension and the horizontal dimension. The biological width starts where the abutment touches the implant. The research on the some of these dimensions is still to be validated.

Dr Tarnow made reference to his famous 5mm article. He measured from the base of the contact area to the crest of the bone. When the distance was 5mm or less the papillae was present between teeth almost 100% of the time. Beyond this point for every extra millimeter of bone missing, the probability of the papillae being present was reduced by half, so at 6mm the papillae was seen 55% of the time, at 7mm the papillae was seen 25% of the time and at 8mm the papillae was seen only 10% of the time. Dr Tarnow agreed that most of the time with flat top implant we place it on average at the cretal level of the mid-buccal bone. This violates the interdental biological width causing remodelling. The scalloped implant had been designed to prevent this from occuring.

Dental Papillae between teeth and implants.

We already appreciate that the vertical component of the biological width is 2mm from the micro-gap apically. This is irrespective of whether the abutment connection is internal or external. It is where the abutment connects with the implant. It is also important to remember that bone will not osseointegrate with a smooth implant surface. Dr Tarnow was more than confident that the biological width was the reason behind the famous *"first thread"* phenomenon seen after implant placement. A key feature of the biological width is its horizontal component, which on average is 1.4mm. This feature was published by Dr Tarnow in 2001. This explains why when Esposito in his 1993 articles, placed implants adjacent to teeth, the closer he placed his implant to the adjacent tooth the more bone loss was demonstrated. Implants should ideally be placed 1.5 mm away from the adjacent natural tooth.

Jemt, a Swedish prosthodontist gave us the dental papillae index. zero papillae index, no tissue; one, partial tissue but less than half full; 2, very good but not perfect; 3, perfect; 4, overgrowth. Jemt showed in his study with 25 single tooth implants that more that 50% of the time the *"black triangle"* will be visible at the time of crown placement. 80% of dental papillae will increase in size after the placement of the crown, however they may not all be perfect. The papillary regrowth is determined by the distance between the base of the contact piont and the bone crest, it is not effected in the long-term by the use of an early undercontoured provisional crown. Jemt showed in a latter study (1999) that it made no difference to the long-term position of the papillae if he sutured around a healing abutment or a provisional temporary crown.

Dr Tarnow made a brief reference to the position of the mid-buccal margin. He had noticed that most people replacing implants for susceptible restorations were aiming their implants at the incisor edge people. Dr Tarnow disagreed with this approach. He favours slight palatal positioning of the implant aimed at the cingulum area. He felt that if the head of the implant was aimed at the incisal edge, the surgoen would have to work twice as hard to maintain the mid buccal contour of the soft tissues. Recession was a prominent feature of buccal placement.

The *"5mm rule"* was valid for implants placed adjacent to natural teeth. Predictable papillae regeneration was governed by the distance from the contact point to the crest of the bone on the adjacent tooth and not by the position of the implant. The periodontal probing to establish the position of the bone on the tooth that will be adjacent to any future implant should be performed as part of the diagnosis, before any extractions are carried out.

Gomez Roman published his article in JOMI in 2001. During surgery avoiding disturbance to the papillae results in less bone loss, 2/10th of a millimeter compared to 7/10th of a millimeter when the papillae was raised. This is very important as every millimeter has been shown of a great significance. This correlates well with the periodontal literature which shows that a mere disturbance to the periostium can result, on average, in the loss of 0.5mm of bone. Dr Tarnow stated that he no longer raised tissue flaps for the purpose of tooth removal, nor was he happy to place immediate implants unless thick fibrotic tissue was present over a thick mid- buccal plate of bone. Dr Tarnow reminded delegates that the placement of an implant does not save the buccal plate. Titanium does not supply blood supply to the buccal plate; if the implant osseointegrates, the tissues are prevented from collapse as the buccal plate resorbs. Authors had recently shown that during healing, the buccal plate resorbed 4mm in the palatal direction, even if primary closure was achieved. Covanni in his study, placed an immediate implant behind the buccal plate and still got 4mm of resorption.

Also, with the placement of immediate implants into fresh extraction sites there is a wound healing issue. If a bucco-palatal defect greater than 1.5 mm exists adjacent to the head of the implant this will repair with fibrous tissue. Bone would not regenerate in to this defect to cover the implant surface; this could be a potential future problem. Dr Tarnow's aim would be to maintain the soft tissue contour. He achieves this by grafting the site a suitable graft; this could be auto allo-graft. He then covers the graft material with a resorbable collagen membrane. No attempt is made to advance the flat and achieve primary closure. The buccal bone can, predictably, be prevented from resorbing by gentle palatal placement of the implant, so the head of the implant appears in the region of the cingulum and not the incisal edge.

Papillae between implants.

Is the 5 mm true in between implants? Henry, showed that the outcome depends on the

level of interproximal bone. In his second article in compendium 2001 he showed that a tooth to implant interproximal height averages at 6.5mm; whereas an implant to implant interproximal height averages at 4.5mm. There was a 2mm difference if you removed a tooth and placed two implants next to each other. Dr Tarnow had published an article stating that if adjacent implants were placed 3mm apart, the papillae could be successfully regenerated. This was not to be the case.

The reason that implants do not work aesthetically when placed next to to each other is simply because we do not have supracrestal fibres around implants. We have supracrestal fibres on a natural tooth and the biological width on a tooth is supracrestal. These fibres give physical support to the papillae and blood supply to the papillae; this biological system does not exsist between two implants. The only support offered to a papillae in between two implants is the periosteum covering the interproximal bone.
Dr Tarnow presented the findings of his yet unpublished research, in which he and four other authors measured the height of the papillae in between two implants. The measurements were taken from the height of the tissue to the crest of the interdental bone in 136 sites. The 5mm rule did not hold true in between two implants. The average height of papillae was 3.4mm. With today's technology, if the central incisor and lateral incisor need to be restored for predictable papillary aesthetics, one of them should be an ovoid pontic, cantilevered from an adjacent tooth. Two central incisors can be restored with two implants as there is no visual basis for comparison. Dr Tarnow stated that his team were working on a scalloped top push fit implant as they saw this as the next logical step in predictable papillary aesthetics. The raised interproximal areas on a scalloped implant were aimed at supporting some supracrestal fibres.

NITZAN BICHACHO

"Modern implant therapy: the transmucosal prosthetic unit (TPU) and its major role in the aesthetic result"

Professor Bichacho came from a private practice background. His presentation was based on his experiences in private practise.

Prof. Bichacho started by defining *"aestheicology"* as the integration of beauty with quality, evidence-based dentistry. He outlined that he would concentrate on the gingival integration of restorations with the soft tissues. He stated that the visible part of the restoration was in the hands of our technicians. As dentists we have a limited influence on its appearance. As dentists we control the tissues from which the laboratory-created work emerges.

Treatment protocol for predictable aesthetic outcome in brief

1. ***Pre-operative wax up***
2. ***Design of the ideal shape through provisional***
3. ***Support and guide the soft tissues***
4. ***Impression of the abutment and the soft tissue***
5. ***Definitive restoration***

Concepts implemented in the natural dentition

Using a case in which a midline diastema had been corrected, Prof. Bichacho discussed the creation of buccal and palatal papillae and col area, all with defined margins. The restorative phase of treatment needs to go through the provisional crown stage. Prof. Bichacho considered the use of provisional restorations as soft tissue treatment. Intentional over-contouring of these provisional restorations is used to support the dental papillae. The intrasulcular component of the provisional restoration supports the dental papillae.

Prof. Bichacho stated that longitudinal monitoring of our restorations for at least 6 years was necessary for us to realise the potential of some of the concepts that we apply to our dentistry. Concerning the concept of the papillae support, Prof. Bichacho thanked Mr Geller, a dental technician who had provided over three decades of influence and inno-vations.

Prof. Bichacho demonstrated a case in which two adjacent teeth in the lower arch had no contact point between them; this had resulted in flat interdental tissue. The creation of a contact point with some restorations provided the necessary support for the regeneration of dental papillae. He advised the delegates that surgical recreation of dental papillae was very unpredictable.

Emergence profile

Prof. Bichacho was not keen to accept the term emergence profile. In his opinion the restoration has a margin and an area where it emerges from the gum. The distance between these two points is intra-sulcular. The profile of the intra-sulcular area is very important, as it is this area that will support the gingivae. He felt that we should talk about the restorations emergence angle and its cervical contour.

Implant supported crowns

Prof. Bichacho stated that when an implant was restored and loaded there was always going to be some shrinkage of the buccal gingivae. If this was agreed, then the delegates should agree that under these circumstances when the treatment is started, there is actually a net deficit of tissue. Maybe we should start our treatment by regenerating some excess tissue. One way to achieve this would be to extrude orthodontically the tooth before its extraction, as suggested by the Salama Brothers of Atlanta. The eventual shrinkage of this excess tissue should result in the final resting position of the tissues in the correct place. At stage 2 surgery, palatally placed incisions can allow for creation of excess buccal tissue. This excess tissue can later be manipulated with intentionally undersized provisional crowns. These crowns can be modified with the addition of cured

resins to recontour the intra-sulcular area as the tissues respond to the treatment. The placement of these crowns with additional material will press the adjacent mucosa causing some blanching. If the tissues do not regain their colour within 8 minutes the dimensions of the recontouring are too big and should be readjusted. Misplacements of implants can also be dealt with using this soft tissue manipulation. Soft tissue recontouring in pontic areas can be manipulated by undercontoured pontic design.

The transmucosal prosthetic unit (TPU) is responsible for the appearance of the soft tissues around implant crowns and is composed of three main elements: the implant head, the abutment, and the shape and material of the crown cervix. The TPU can be modified in each of its 3 components in each individual case.

When implants have been placed deep, it is better to support the interdental papillae with a custom-made abutment. With this custom-made abutment the crown margins can all be placed at the same distance subgingivally 360° around the implant, allowing the monitoring of cement overflow during cementation.

Adjacent implant situation

When looking at multiple implants, a major factor is the impression. Prof. Bichacho felt that impression handling, in his experience, had suffered low compliance from the profession. Prof. Bichacho's personal preference was to splint adjacent impression coping with an addition of cured acrylic, but not necessarily splinting all the copings. These splinted units were picked up in an open tray with a polyether material. He recommended the use of *"Peakoplast"* from Bredent as it demonstrated shrinkage of only 3%. He also found no reason to perform cross-arch splinting in more extensive cases. Another important fact to remember during the impression procedure is that unsupported papillae start to collapse after only 1-2 seconds. To transfer as much detail as possible to the model, Prof. Bichacho prefers to place his transfer copings and follow this immediately with the injection of a flowable resin in between the abutment and the soft tissues. This is all subsequently picked up in the impression.

Prof. Bichacho always protects the porcelain of his restorations with the use of night-guards, irrespective of para functional habit. His preference is for a lower hard acrylic device with a soft lining.

On occasion, when implants are placed in the adjacent position, the boney inter-proximal peak may well be present. However, it will always resorb: with the use of flat top implants. He described the historical development of the concepts of vertical biological width and the later accepted horizontal biological width. He wanted to include a dimension from his own experience: the inclination of the implant in relation to the buccal plate of bone. The pressure that the implant places on the buccal plate can resorb up to 4mm. He felt, therefore, that the biologic width, being 3 dimensional, should be called the *"biologic space"*. The dimensions required for this space are 1.5mm between implants and teeth, and 3mm between adjacent implants. Prof. Bichacho demonstrated a case, which agreed fully with Dr Tarnow's finding that the average height of papillae between implants was 3mm. Prof. Bichacho had restored adjacent missing central and lateral incisors with 2 adjacent implants. The papillae height between teeth and implants was 6mm and between implants was 3mm.

CRAIG M. MISCH

"Enhancing outcomes using block bone grafts for onlay augmentation"

Dr Craig Misch is a double specialist, he has specialist training both in surgery and prosthodontics.

How do we enhance our results with onlay augmentation ?

Dr Misch tackled this question by breaking his topic into four main areas:

1. ***Soft tissues matrix around the block grafts***
2. ***Local factors, smoking in particular***
3. ***Donor site selection***
4. ***Horizontal verses vertical bone augmentation***

Dr Misch started by saying that with the technology currently available to us, we almost never have to turn a patient away from implant treatment. He felt that the success rates had been increasing and this in turn had resulted in an increase in the use of implants. He also felt that with the developments occuring in biological engineering the use of dental implantis for facial reconstruction was going to change dramatically over the next few years. Dr Misch quoted the classic works of Dr Bob Marks in looking at discontinuity defects. Dr Marks had sudied the use of growth factors. He showed in a split population using platelet rich plasma (PRP) with cancellous bone grafts, that we can enhance the amount of hard tissue that we regenarate and accelerate the healing of our cancellous bone grafts.

Block bone grafts that are cortical in origin have a very different biology of incorporation. The number of viable cells in the transfer are much reduced in the cortical block grafts. His experience of cortical bone grafts harvested from the oral cavity started in the 1980's, when he reviewed the literature and found researchers in the Netherlands repairing alveolar cleft palate defects with cortical bone harvested from the synthesis. He and his brother started a pilot study at the University of Pittsburg, where they looked at a section of the population of maxillary defects treated with cortical block bone harvested from the symphasis. They looked at a 4 month healing protocol. At 4 months these grafts were well incorporated with very little resorption and good maintenence in the quality of the bone. These results lead Dr Misch to abandon the use of many of the allogenic materials avaliable at the time and focused more on the use of autologous tissue. He also prefers to harvest the graft from the ramus of the mandible as it has fewer complications when compared to chin grafts. After 15 years of experience in onlay grafts Dr Misch no longer raises extensive flaps for retension screw removal or implant placement. The retension screws are removed via a stab incision and implants are placed via minimal incisions.

He quoted a group of South American researchers who had looked at onlay bone graft healing, they too found that 4 months was an adequate period of time to allow a graft to integrate before considering implant placement.

Could PRP accelerate the healing of a cortical onlay bone graft and possibly enhance the reunion of the graft to the host bone?. He demonstrated a case where he had used platelet rich plasma around the graft site and platelet poor plasma around the harvest site. He did not feel that it had made the greatest amount of difference.

The effect of PRP on soft tissue healing

Platelets are important for heamostasis, clot formation and they do contain a number of growth factors. The properties of these growth factors include stimulating angiogenesis, activated fibroblasts for collagen deposition and stimulated cell replication. Research has confirmed that we do get an increased number of these growth factors when we utilise PRP into our surgical site, using PRP as a membrane/dressing.

Tension free wound closure

Looking at the complications of onlay grafting, a review of the literature by Tollman, incision line opening and dehiscence is the most detrimental to the onlay grafting. The three factors that topped the list were, smoking, inexperienced operator and the provisional prosthesis resting on the soft tissues. The experience of PRP was the paper by Anuda that looked at improved epithelialzation when augmenting sockets with autogenous bone mixed with PRP. Dr Bob Marks looked at split skin grafts. He reported less inflammation, less pain, accelerated epithelialization and reduced scaring around the PRP sites compared to thrombin.

Suture material of choice.
Vicryl sutures have a tencency to stimulate an inflammatory response. Faster recovery can be realised if these sutures are removed earlier, healing permitting of course.

Prosthetic guided bone augmentation, a provisional prosthesis designed with the information available from a computerised tomographic scan and a pre-operative wax up should be used to guide the surgeon as to where to place the onlay graft. Over-building is essential. Two types of surgical template can be utilised; a tube design and one that shows the shapes of the intended teeth.

Smoking and onlay bone grafts

We know that smoking effects implant success and sinus grafts. Dr Misch suggested to the delegates, not to treat patients with onlay grafts who smoke; you can expect failure in this population. One study showed that 4 out of 5 patients who smoked had failed bone grafts. Dr Misch submitted to the delegates that it was a local factor as opposed to a systemic factor and if the patient stops smoking for enough time to allow the mucosa to heal over the graft, the graft would be successful. Thus abstenence from smoking for two weeks allows their inclusion for grafting, in combination with the use of an extra-oral technique to avoid wound breakdown. He presented data from a population of 32 patients with only 1 failure.

History of infection

These patients should be left for an additional period of three months after the treatment of the infection. If an excess of poor quality scar tissue exsists, then soft tissue reconstruction should be performed prior to hard tissue reconstruction. At extraction sites, the site is best left for 6-8 weeks for the realization of wound closure, thus allowing the regeneration of soft tissues over the extraction site, enabling primary closure over the onlay graft. A history of apical root surgery always results in more tissue loss.

Grafts in the sinus

Reports show that cancellous bone used alone suffers more resorption than a Xeno-graft, so Dr Misch mixes the cancellous bone with some Xeno-graft material; he adds PRP when carrying out a posterior graft procedure.

Immediate Loading in the maxillae

Dr Misch did not feel that the data, knowledge and principles were avaliable to support this concept. Rather than immediately load his implants he prefers to use provisional implants in lateral incisor and first premolar sites used to support a fixed provisional prosthesis. These provisional implants are catered for in the treatment plan. Also any provisional prosthodontics needs to be tooth/ implant supported to avoid any disturbance of the underlying soft tissues and graft; no micro-movement of the graft should be permitted.

Vertical and Horizontal deficencies

The literature indicates the limitations of vertical bone grafting using autologous bone grafting. Using particulate material under a membrane the range was from 7mm to an exposure of the membrane, with no bone gain. A recent publication from Loma Linda looked at block cortical grafts from the ramus with the average gain of 6mm in the first month, four months later after incorporation of the graft they did lose some volume of bone and showed an increase in height of 5mm; 17% of the graft had been lost. We know that onlay grafts are continually remodelling and bone volume change occurs, usually resulting in 2mm loss in height. Another group from Sweden used iliac bone for the grafting and used CT scan to measure the change in bone volume at 3 weeks, 3, 6, 9, 12 months post operatively. They had a height gain of 8.2 to 6.2mm over a 2 year span; losing 2mm of bone over this time. The width decreased by 4mm from 3 weeks to 2 years. They concluded that height continued to change from 3 months up to 1 year, the width loss occurred very early and then stabilized; after 1 year bone volume loss was low. When we place implants at 4 months we need to keep in mind that they are still remodelling, which is a disadvantage to the use of these grafts.

Distraction osteogenesis in increasing vertical height

Less relapse is seen once a distracted distance has been achieved. Maybe there are specific indications for the use of osteogenesis distraction. Good mobilization of the ossicle is needed at the time of surgery. As osteogenesis distraction does not allow three dimensional increase in the bone, it only increases the vertical height, subseqent to it

a horizontal onlay graft needs to be used; Jemson's work showed that he had to carry out secondary bone grafting in the majority of cases. Some concerns had been raised of cortical anchorage with the use of PRP. Dr Misch has never experienced any complications with its use.

Head of implant fracture requires the implant to be removed by sectioning of the bone, leaving a vertical and horizontal defect. These cases can to be treated by osteogenesis distraction to increase the vertical height. A secondary block onlay graft can then be used to regenerate the horizontal width.

Factors that make cases more challenging

High lip line, thin highly scalloped gingivae, recession on adjacent teeth, tooth movement resulting in a larger edentulous area than the original tooth lost.

LUC & PATRICK RUTTEN

Luc Rutten

Patrick Rutten

"Implant Aesthetics – The Challenge"

The Rutten brothers are Belgian technicians with a company called *"Dental Teamwork"*. They Specialise in ceramic work.

They started their guide to aesthetics by looking at the natural dentition. They felt that they copy nature rather than create something new.

In their view, the ultimate goal in implant bridgework was to achieve passive fit. They had learned that a high level of compliance with firing protocols was required to achieve this and milled components were absolutely essential.

Achieving passive fit

They stted that with full-arch bridges transisting more than 21mm, gold castings experienced difficulty with getting passive fit. They suggested that the metal work always be tried-in, the dentist approve the metal work and set index pattern framework. Cast is not a problem, firing is the problem. Cast with open flame in combo with investment, apply opaque material, further firing. To avoid distortion after the first firing they would fabricate an individual tray. This would record the position of the metalwork after the first casting with refactory die material. The metal work would always be screwed to this tray at subsequent firings. They only ever used gold-platinum alloys and never used non-precious alloys. They recommended that the casting spurs be no larger that 4mm diameter. In their laboratory 59% of cases were screw retained and the screw holes were restored with resins. When constructing numerous single unit crowns these should be returned to the dentist on a fixed, un-worked master cast, as this reduces the necessity for crown adjustment.

Casting teeth beyond natural dimensions

The Rutten brothers had been using pink porcelain to create this new type of restoration for over 15 years. They felt that the aesthetics were better than root imitation restorations. They recommended the Vita company for pink porcelain.

Articulation

Mounting on adjustable articulators to provided records was essential to achieve a functional occlusion. They advised a pre-glaze try-in to test the occlusion and make any alterations. A plastic night guard was advised to protect the porcelain.

Phonetics

The palatal surface needs to be adequate to avoid whistling noise. It must be efficient enough to create an air and saliva seal. The crowns contours should feel like the adjacent teeth, and conform in shape.

Bright white teeth

Some patients who want bright white teeth can have bright white teeth; this is fine but the dentist should use some characterisation and be creative. Explain to patients what the natural situation should be and what they should expect. The colour is not the only factor in natural creation of teeth: form, shape and position are equally important. The dentist can cement the restoration and arrange a visit to the lab to discuss any required changes. High fluorecence is required in the cervical area. Shoulder porcelain always looks better than metal margins; recent developments in shoulder porcelain have also contributed to the popularity and effectiveness of its use. Under ultraviolet light you sometimes get a black spot adjacent to the gingivae. This can be overcome by shortening the coping and using fluorescent shoulder porcelain to get light into the gingivae.

Basal surfaces need to be homogenous and smooth. This cannot be achieved just by firing: hand polishing with diamond paste is also required.

Characteristics of the natural gingivae

The soft tissues are opaque, as generally no root surface is visible. They demonstrate a degree of translucency, as we can see light travelling deep into the tissues. The Rutten brothers use 3 colours to create natural-looking gingivae: one basic shade, one for the papillae and one interdentally.

Provisional bridgework

This can be modified with hooks to allow wire connection for root extrusion.

Ovate Pontic design

This is to support adjacent soft tissues. Gingival recontouring can be carried out on the cast to produce the pontic outline. Pontic design is more than just closing the gap, as smooth surfaces are required for flossing and gentle pressure needs to be applied on the adjacent soft tissues. The ovate shape needs to present not only mesio-distally but also bucco-palatally. Final finishing can be carried out in the mouth. A 30° emergence is desirable to support the papillae. Immitation of a natural root emergence is advisable.

Metal free ceramic

Metal blocks light from radiating into the root surface and makes gingivae look unhealthy.

The Rutten brothers prefer the semi-translucent procera system, or semi opaque, which means that it can be applied to a metal die and the metal does not shine through.

Communication between lab and dentist had been made easier with better shade guides.

Implant Abutments

The abutments available for use were titanium, alumina and zirconium.

If the gingival line is not perfect with the adjacent teeth after implant placement, we would like to allow some transmitted light into the restoration and into the gingivae. This can be achieved with the use of zirconium abutment. The use of the zirconium abutment would prevent a further unfavourable factor. The flexural strength of zirconium is greater than alumina. Zirconium is very white and sometimes this needs to be masked using zirconium ceramics.

The Rutten brothers prefer a wax-up abutment to control its features. This can then be scanned for zirconium abutment manufacture. In transmitted light there was no difference between alumina and zirconium.

PROFESSOR H. F. HAMMERLE

"Matrix structures for hard and soft tissue generation"

Professor Hammerle is trained both in periodontics and prosthodontics and is now Head of Prosthodontics at the University of Zurich.

Overview of presentation:

- ***Bone regeneration in clinical practice***
- ***Application of growth factors for bone regeneration – where do we stand?***
- ***The impact of new carriers and matrices***

He felt that tissue generation is commonly performed in two situations: at the time of implant placement or, in more dramatic cases where more bone is lacking, prior to placement of implants.

Bone regeneration in clinical practice

We all currently use technology, which is universally accepted. This technology is guided bone regeneration, (GBR).

3 factors which are important for our clinical success:

- ***Exclude undesired cells. These are the cells from the covering tissue flap, the connective tissue cells and the epithelial cells: this is achieved with the use of a membrane***
- ***Space, which is maintained over the course of healing for the development of desired tissues***
- ***Access for tissue-forming cells. In this situation it is the bone-derived cells that we need in order to get new bone formation in the bone defect***

With the additional use of growth factors we would like to expand the indications for the use of GBR and also increase its predictability. The motivation for researching the field of growth factors and differentiation factors is that, we would like to be able to influence biologically the body's own capacity to regenerate. This would end our dependency on any products and limit the use of invasive procedures.

Bone formation by auto-induction

Marshall Hewist presented the breakthrough in the knowledge of growth factors in 1965. He showed that growth factors and morphogenetic proteins IGF1 and 2, PDGF, TGF beta 1, and BNPS stimulate the natural regeneration process of the organism. However, a brief look at the available literature since 1965 shows the effect this knowledge has had in clinical practice. It is less than impressive.

Bone regeneration with growth factors

GBR in conjunction with growth factors has different requirements. With GBR alone we required access for desired cells, but now we want access for all cells. We also want access for cells from the covering flap. We do not need space maintenance any more we need form shaping. Exclusion of undesired cells is not necessary; we want specific induction of all the cells in the vicinity of the defect.

The potential for healing should be much greater due to the fact that we can influence all the cells that have the capacity to form the desired bone tissue, and that there are cells residing in various tissues that have this capacity. The basic principle is very different, but whether it will be different from a clinical handling perspective will depend on the products that are available.

Application of growth factors for bone regeneration as it is being performed today

Different systems utilise different carrier systems for bone growth factors. The current systems use methyl cellulose, collagen sponges, plastic particles and, most recently, growth factors which have been incorporated into materials used as bone substitutes.

A key study, The Evaluation of Recombinant Human Bone Morphogenetic Protein 2 Carriers, by Sebodson and Lozen, gave a good overview of the results using different carriers, and used the dog model. Professor Hammerle felt that a vertical defect was a very demanding defect in this model and he felt that any regeneration that occurred in this model would be reproducible in the clinical situation. Bone was removed to create a vertical defect. The carrier and the matrix were used to induce the bone fracture and the flap was sutured for primary and unintentional healing.

Results: The use of a collagen sponge produced, in general, good quality dense bone and periodontal ligaments, but poor quantity. The question was whether the absorbable collagen sponge had enough space-providing capacity. A bone substitute material, Bio-oss with BNP2, gave poor quality bone with lots of voids. In general, they did not find good quantity and they questioned the resorption of the carrier, the Bio-oss. One of the goals was to have the carrier disappear leaving space for new bone to form. De-mineralised bone matrix and BNP2 showed excellent

results here: good quality and good quantity, but they lacked reproducibility. Using poly-lactic acid (PLA) beads or structures with BNP2, they found poor quality and poor quantity. They found the PLA fragment was broken up and they speculated that some of the regenerated bone had been resorbed due to the fragmentation process of the PLA and the production of acids in this area. Finally, they looked at polylactic and glycolic acid with BNP2. Here they found good quality and varying quantity, but again they had a space-providing problem.

Lynch and co-workers looked at the effects of platelet-derived growth factor and insulin growth factor 1 combination on bone regeneration on titanium dental implants. They used specially designed implants. They used a gel with growth factor inside. They studied bone regeneration and bone to implant contact on the top of the implant. The study looked at 40 implants in 8 beagle dogs, using PDGF, IGF1, gel alone, or no treatment at all. They looked at peri-implant bone (the bone around the implant, but not in contact), the bone fill in the hole and the surface contact at 7 and 21 days post-healing.

Results at 7 days: saw 2 significant differences in the growth factor groups: peri-implant bone density and the surface contact were considerably higher, but the bone fill in the hole was minimal. **At 21 days:** they still had a significant difference in the peri-implant bone density, but the difference in surface contact is no longer apparent. It seems, therefore, that we can influence positively the integration of the implant and the density of the bone around the implant, but we cannot get regeneration of defects.

Bakker and co-workers compared some e-PTFE membranes alone, in combination with platelet-derived growth factors and insulin-like growth factors 1 or de-mineralised freeze-dried bone, for the promotion of bone formation around immediate extraction socket implants. They made standardised defects around the implants and they looked at height gain of bone from the original defect. Bone height was best with the membrane alone. The growth factor did not add to the bone height, but it did add to the height of implant contact. Again, we see some benefits, but nothing which we would use in our clinical practices.

Cochran and co-workers did a study: recombinant human bone morphogenetic proteins were used to stimulate bone formation around endosseos dental implants. They used a different model, a human female. They had 4mm defects around 2mm diameter implants, the defect being 1.5mm in width. They used 5 variables, with the following results:

1. ***BNP and membrane: with this they were able to confine bone regeneration mostly to space below the membrane. Professor Hammerle felt that this combination was a possible way forward***
2. ***BNP without membrane: this encouraged a large amount of bone formation, but there was no control over the amount of bone formation. Professor Hammerle would not use this combination clinically due to the lack of control over the amount of bone generated***
3. ***No BNP and no membrane (negative control): very little bone formation***
4. ***Membrane with no BNP: no big difference at 4 weeks***

In summary, Professor Hammerle concluded that a GTR procedure may be used in conjunction with growth factors in order to gain a better control of the amount of bone we regenerate, but it was not ready for clinical use at the moment.

However, we see a number of clinical studies appearing, which use growth factors and implant therapy. Here is a brief overview of some important studies:

Boyn and co-workers

The absorbable collagen sponge BNP2 in a sinus floor elevation study. Results were quite good.

Howell and co-workers

Used same collagen sponge to look at preservation and augmentation of extraction sockets.

Cochran and co-workers

Used a similar approach, with the same product. They looked at extraction sockets, where they placed this product to see if they were able to maintain or regenerate the bone. They have excellent contour for late implant placement. This is the one study, which shows a great success. We have no other means today to produce anything close to such an excellent result. The price for one socket, however, is $3650.00.

Detailed study by Ronald Yung – The effect of recombinant human BNP2 on guided bone regeneration in humans

Using Bio-oss with BNP2 for peri-implant defects present at the time of implant placement. This was a randomised, controlled, clinical and histomorphometric study. It is now accepted in clinical oral implants research and will be published this year. The aim was to improve guided bone regeneration therapy in relation to volume, density and maturation of bone. The study involved 11 patients who all had peri-implant dehiscence defects. Yung used a split mouth randomised design. The test was Bio-oss with BNP2 and the bio-guide membrane; the control was Bio-oss and Bio-guide alone. Yung had a true masking of treatment allocations and a randomisation table to make sure treatments were randomised. Forming a clinical impression, the investigators felt that when they used the BNP2, they had a better maintenance of the ridge and a harder regenerated tissue. Biopsies were used to assess the maturation of the bone.

Results:

	Control	Test
Baseline defect	6.4mm decreased to 0.4mm	7.7mm decreased to 0.2mm
Defect fill	96%	98%

Histological analysis:
2 analyses performed:

	Control	Test
Mean area density	44% woven bone 56% laminar bone	25% woven bone 75% laminar bone
Contact between Newly formed bone And Bio-oss particles	30%	60% - much better grafting material due to BNP2

Conclusions of the study:

- ***Highly promising initial results***
- ***It is a resource-demanding production process involving recombinant technology***
- ***It is not commercially available for most dental applications***
- ***The optimum carrier material is still missing***

- ***A high dose, which is necessary, leads to absolutely prohibitive costs for clinical practice***

Professor Hammerle suggested that what we need for new dental developments are randomised, controlled clinical trials. The idea here is that we have a randomisation of treatment allocations. The benefit of this would be that all patients have an equal chance of receiving test or control treatments. The second important factor is concealment of treatment allocations to eliminate investigator bias. Another key factor is risk tolerance. Patients need to give informed consent because it is their risk tolerance at stake. Ethical approval is also very important.

New carriers and matrices

Presently encountered problems are:

- ***Lack of retention of growth factors***
- ***Uncontrolled release***
- ***Large amounts of active factor necessary***
- ***Prohibitive cost***

The ideal growth factor delivery system allows for:

- ***Retention of the factor***
- ***Releasing of factor according to spatial and temporal needs***
- ***Stability in storage***
- ***Resorption during the healing phase***
- ***Clinically ease of application***
- ***Reasonable cost***

Professor Hammerle felt that such a carrier material did exist. Fibrin is an ideal matrix and it is a natural product. Fibrin should ideally carry a growth factor, then the cell would be stimulated to form bone. We need to do this through a growth factor binding site, which should be cleavable by the invading cell.

Professor Hammerle had carried out a study of fibrin gels prepared from commercially available or autogenous fibril gel, using platelet-rich plasma as a delivery system for BNP2. He did an analysis on newly formed bone in rabbit calvaria.

Results:

	New bone formation
Control	30%
Fibrin	31%
Platelet-rich-plasma	33%
Fibrin + BNP2	56%
PRP + BNP2	78%

PRP is a suitable delivery system for BNP2 and can substitute human fibrin gels.

The next step is to study the effect of binding biologically active factors to a synthetic matrix with optimised cell growth capabilities. Synthetic products have a number of advantages.

Matrix degradation by proteolytic remodelling

In Professor Hammerle's opinion this was the way forward. In this situation we would still see the same cells. The fibrin would be mimicking hydro-gel, which would be our new artificially formed matrix. We would have hydrogen degradation products.When cells migrate, they would re-model their matrix. We should exploit this to release the factor, bind the factor to the cell invasion matrix *(step 1)*, and bind it with a link that an invading cell can cleave *(step 2)*. The factor would be released right at the surface of the cell. When it would cleave the link exactly where it is needed, and only when the cells are ready for it, this is called *"release on demand"*. This should be the next step when we look at growth factors and matrices for the delivery of growth factors. Professor Hammerle stated that *"Release on demand"* was a well-known principle in the industry and considered to be very successful.

Professor Hammerle's group is in the process of doing further studies, using the rabbit model, to test different products under different circumstances.

The aim is to test whether or not bioactive peptide bound to polyethylene glycol gel is capable of enhancing bone formation in a rabbit cranial model. The group could not show any results as yet, but the research was said to be very exciting and is continuing.

Conclusion

- ***Carriers and matrices – are they the key to success when it comes to growth factors? We have seen almost 40 years of knowledge of growth factors, but they have not reached the clinic***
- ***Will the carriers allow for such a break through? Professor Hammerle thinks that "release on demand" will be the key and he thinks his we are very close to a breakthrough in this area***

FRIEDRICH W. NEUKAM

"Treatment Strategies Related to Jaw Resorption"

Professor Neukam is a maxilo-facial surgeon who has been specialising in cancer surgery for many years. It is here that he found the need for implants and implant therapy rehabilitation in some of the difficult cases that we see.

Professor Neukam performed an extensive review of the literature and found that, whilst conforming to the standard protocols of Branemark, the success rates of implants both in the maxilla and mandible were very high. He found that bone quality and quantity did influence success rates more so in the maxilla than the mandible. Despite this, well conceived treatment plans, demonstrated very good success rates. This convinced Professor Neukam that he could use implants in cancer patients. The resorbed maxilla in some studies demonstrated a failure rate as high as 40%. This led him to investigate the use of the zygomatic arch as an end of the line treatment option. This approach seemed to be a predictable possibility. However, he only had data from a few patients, and showed a survival rate of about 80 to 85% during the first 3 years.

Distraction osteogenesis

Distraction osteogenesis has been a new tool in the last few years. Professor Neukam had used this procedure in some of his cases. He found that his patients did not like the distraction device much. In most cases the bone was mature enough to place his implants after 4 months of healing. He also found himself supplementing the distraction procedure with an autogenous graft. Professor Neukam, preferred autogenous material due to its osseo-inductive properties. Fielding and co-workers published a high survival rate of

implants after the distraction osteogenesis but they did not mention any complications during the destruction. Professor Neukam found these procedures difficult to carry out in the posterior areas of the mouth.

Immediate Loading

Professor Neukam had noticed that today patients do not want to wait and wondered whether we could load implants immediately. He suggested that if we did maybe we should confine these to the anterior regions, where the loads are lower than the loads in the molar regions. He was not convinced that the researchers were able to perform meaningful tests of the level of integration of an implant as torque testing was, in his opinion, a very crude measure. Some of the literature relied on only a few cases and others had very short follow-ups. Nevertheless, the implant survival rate seemed to be comparable to survival rates in the lower jaw that had been placed using a standard protocol.

Sinus Lift Procedure

Looking at the literature, this procedure seems to be very safe. Many good studies have been published in this field that show high survival rates of about 95%. Professor Neukam however, was not convinced that this procedure was so successful. In reality, it is difficult to know if there is a perforation in the mucosa. Bone substitutes are used very often; these bone substitutes can only be osteoconductive. Maybe in the future, with the inclusion of growth factors, osteo-induction may be achievable.

In an interesting study by Yenzen and co-workers, published several years ago, implants were placed into the grafted maxilla. The sinus had been grafted with either autogenous bone or allografts. The authors showed that the allografts resulted in only a limited amount of bone to implant surface contact, and there was a greater bone to implant surface contact area where autogenous graft had been used. Professor Neukam commented on a recently published meta-analysis which had reached a similar conclusion using bone volume as a measure. Professor Neukam stated that even meta-analysis has some limitations, as studies are not standardised.

When major bone grafting procedures are necessary for a severely resorbed jaw in the maxilla and in the mandible, Professor Neukam prefers to harvest bone from the dorsal aspect of the hip. The quality of the bone in the dorsal aspect is much higher and the amount of bone that can be harvested is much greater: between 60-80cm. This affords him the ability to re-construct the maxilla and the mandible simultaneously. Sceptics of this technique feel that bone-grafting procedures are not predictable and that the resorption process results in a diminished unusable bone. Professor Neukam's group set out [was published in the British Dental Journal some years ago] to evaluate the resorption pattern during the first month after the grafting procedure. They performed CT analyses preoperatively, immediately post operatively and 4-5 months after grafting, before implants were placed. Results showed that during the 4-5 months after grafting there is only limited vertical resorption of the graft and only a little resorption in the transverse aspect.

Professor Neukam found interesting a publication by Neustron and co-workers, published last year, dealing in a similar way with the question of bone resorption. They had the opportunity to perform CT evaluations 3 weeks after grafting, then at 3 months and 6 months after grafting, then at 1, 2, 3, 4 and 5 years after grafting. These provided very valuable data in the grafting field. They demonstrated that there was resorption in the very beginning of about 10%, no more. Further, if there were no dehiscences in the covering soft tissues that there was a limited amount of resorption in the first year until the implants were loaded.

When looking for bone augmentation procedures in the mandible, there are a lot of publications showing a high survival rate, comparable to implant placement in the original bone. There does not seem to be a big difference if we insert implants in a secondary way after remodelling of the grafting material, as long as the remodelling period is 3-4 months, no longer. With regard to the maxilla after only grafting procedures, the data is similar, although the number of sites that are reported is limited. Professor Neukam's group had data showing a 93% success after only grafting procedure in the maxilla. He recommended that in younger patients we should reconstruct the resorbed maxilla or mandible before implant placement, otherwise there would be a non-acceptable aesthetic result of the face.

The future

There are several problems that have to be resolved including problems in immediate loading when loading implants simultaneously after a grafting procedure, as well as in immediate loading after simple implant placement. The current research is looking at the use of growth factors, with bone substitutes or as a combination. Professor Neukam felt that different approaches were possible such as biometric surfaces, tissue engineering, regional gene therapy and others.

Bone volume and the bone quality in the upper jaw is less than that in the lower jaw. Also, bone quality and bone density is higher in males than in females. In many cases, the bone has a harder structure in the anterior aspect than in the dorsal aspect. The upper jaw is problematic because the females maxilla has a mean crevicular bone volume of about 20%, where as the males is about 30%. There is a big difference between the upper and lower jaws: the lower jaw offers a maximum of primary stability to implants, but not the upper jaw. Therefore, the upper jaw has problems with bone quality and, to a certain extent, with jaw resorption. This problem is further compounded because often grafting procedures involve complex procedures in low quality areas, for example, for elevation of sinus floor and ridge expansion in the anterior maxilla for aesthetic reasons of upper lip support. Professor Neukam's group is looking for a combination of non-vascularised bone grafting with growth factors. They have done a lot of animal research in the field of growth factors and normally use the pig model. They had evaluated the remodelling pattern and the regeneration process that takes place when they use different bone substitutes in combination with plasma rich platelets (PRP). Results obtained two weeks after grafting autogenous bone in combination with a high concentration of PRP showed a difference in regeneration processes. However, if they used bone substitutes alone there was no effect. This data was comparable to that presented by Professor Hammerle: PRP strengthened the regeneration process by about 20%.

Professor Neukam' group felt that it may be possible in the future to place implants into a grafted site immediately, with good stability.

This data coincides with another publication produced this year by the Vienna Group. The group could show that after 3 weeks there was a significantly higher bone to implant contact if they used the same combination. This was only demonstrated in the early results; after 6 weeks there no longer seemed to be any additional effect. [There was no more new bone on the threads. The total volume of new bone was higher, indicating the combination's clinical suitability.]

Tissue Engineering

One possibility is that we harvest bone-forming cells or stem cells; these could be cultivated. Professor Neukam's group inaugurated a procedure in their laboratory. Only 2 weeks was needed for the cultivation process. A large amount of newly formed cells was cultivated and seeded to a collagen structured sponge (other substitutes could be used too). One week after the seeding and maturation process it was possible to produce a sponge for the transplantation process, for example, in the maxilla sinus. They are conducting a study currently, in which they are using these techniques in their clinic. The first data from this technique seemed to be very promising – it seemed that it might be possible, using this technique, to form new bone to a higher standard. However, Professor Neukam did not think this technique would be a breakthrough because it would be too costly and time consuming. A better solution would be to look for some kind of local gene therapy, for example, to produce the bone or soft tissue required locally.

Conclusion

The data available for the long-term prognosis using standard protocols is extensive and the literature shows that the procedures are safe and successful. Nevertheless, they are time-consuming. We need to modify these protocols so we can load our implants simultaneously in both jaws. Professor Neukam felt that we need to wait a number of years before his group have promising results. He stated that we know that autogenous bone grafts are very safe and that they are predictable from a resorption and stability prospective. In the future there will be a certain kind of mixture between substitutes and factors and, for example, intelligent surfaces of implants in which we could also impregnate these growth factors.

ARUN K. GARG

"Growth Factor Enhancement of Bone Grafting"

Professor Garg is an oral surgeon working in Miami. He has a great deal of experience in the area of plasma rich platelets (PRP).

Professsor Garg's lecture involved taking the scientific data presented by other speakers on PRP and showing how they may be used in the clinical environment. *He concluded the lecture with several clinical cases.*

The first thing to remember is that bone is a living tissue, not something static. It is dynamic, constantly turning over at a rate of about 0.7% per day. What this means for each of us is that our entire skeleton turns over approximately every 142 days. During this resorption process, the osteoclasts are resorbing the old bone. This takes place in an area known as the ruffle border. The ruffle borders are releasing proteolytic enzymes. The enzymes are very acidic and dissolve the old bone. The osteoblasts are working in conjunction to form bone at a similar rate. In a normal healthy individual the two processes work at the same rate. If the osteoclastic activity was decreased, this would not be very good because the old bone is not being resorbed, even though new bone is being formed. This is similar to marbled bone disease (which is actually a defect of osteoclastic activity). The result is that the old bone is brittle and relatively avascular. So, in an healthy individual these two processes need to function together.

The osteoblasts, once they surround themselves and become embedded within the bone, are known as osteocytes. They remain alive and continue to receive their nourishment and chemical messages through prolongations. They receive their nourishment through a diffusion from the capillaries in the bone, but the diffusion can only occur approximately 0.1 – 0.2mm away. This means that every vital bone cell is at least 0.1 – 0.2mm away from a capillary, which explains why, when drilling in bone, there is so much vasculature in the area.

In the early 90's, we were looking for a way to hold large particulate grafts together. At that time in Europe the fibrin glues were available from pool donors of blood. In the US, donor blood fibrin glue was not commercially available. We began to use autologous blood – taking blood from the patient, to make a crude fibrin glue. Our plan was to utilise this material to hold the large particulate grafts together, and thereby allow better stabilisation. We expected the results to be better than those where we did not use the fibrin glue, but we actually found that the results were dramatically better. In fact much more than could be explained by the better particulate stabilisation. We then looked at the haematology literature for a possible explanation of this enhancement beyond just particle stabilisation. We realised that the platelets have growth factors contained within them and, as we all know, platelets are the first cells to arrive at the site of injury, primarily for haemostasis. But now we recognise that an equally important function of those platelets which are the first cells to arrive at the site of injury is to release the growth factors. The platelets have a life-span of approximately one week. After a week, the capillary buds are beginning to form in the area, macrophages are coming into the area. Classical belief was that macrophages are there to clean up the area, but now we recognise that they too have growth factors within them. In approximately the third week there is more angiogenesis, more blood vessels are formed in the area and the growth factors from the platelets and macrophages are gone at this point. Now, as a resorptive process, either the autogenous bone graft takes place or the resorptive process of the surrounding host bone takes place, then the bone morphogenic proteins within that autogenous bone are liberated to continue this process. We were surprised that by kick-starting this process at a higher than usual level, by placing a higher than native level of platelets at a concentration of approximately five times the native levels, this process did continue at 2 months, 3 months and long-term as shown in the clinical research.

What we are doing with the plasma rich platelet process is spinning down the patient's blood, concentrating essentially the platelets. Whereas, normally, we would have approximately 20 red blood cells (rbc's) for every one platelet, we would be reversing that ratio, having greater concentrations of platelets in the same volume space and thereby having greater concentrations of growth factors. The second thing that we are doing is creating in essence a better fibrin, leading to more pathways, or better pathways for the bone-forming cells to travel along.

When whole blood is spun in a centrifuge-like device, rbc's are the densest of the major components they migrate to the bottom layer, which would be about 40 - 50% of the volume. The plasma (or serum) is approximately another 50% of the volume and this is the least dense, therefore it is the top layer. The platelets lie between the two and have a similar colour to the plasma but are typically slightly more yellow, and account for approximately 5-10% of the volume. White blood cells (wbc's) would also migrate to the middle layer They have a similar density as the platelets. What we actually get when drawing off the concentrated platelets is a mixture of concentrated platelets and concentrated wbc's. We also find that the young, most robust platelets because they have not released all their growth factor, are slightly larger in size. In this segregation process they will migrate to the top layer of the rbc's. So, in order to optimise the concentration of platelets and to get the best most robust platelets, we need to capture the top layer of the rbc's, but we would also inadvertently get a few wbc's in the mix. The last component of the PRP would be some of the plasma, because, we would inadvertently draw off various amounts of plasma to leave different quantities of the concentrated platelets.

4 components of the PRP

- ***concentrated platelets***
- ***concentrated wbc's***
- ***small component of plasma***
- ***small component of rbc's***

In 1992, the device which was being utilised to produce PRP was called the cell saver device. It was very expensive, required a trained perfusionist to operate it and required a whole unit of blood. It was not therefore clinically practical. Since then, devices have become commercially available which are cheaper, can be operated by the dentist or nurse and only require approximately 20-60cc of blood, making it very practical in the clinical setting.

It would be energy inefficient for the body to have lots of repair cells for bone, soft tissue etc. floating around in the event of injury to any one of these tissue types. So, from an evolutionary perspective, we have evolved in such a manner that there are a few repair cells floating around, but the undifferentiated bone marrow cells can at times of injury, wound healing, bone grafting or dental implant placement, undergo three different processes:

1) ***They can differentiate into the cell type that has been injured***
2) ***They can increase in number very quickly***
3) ***They can chemo-tactically arrive at the site of injury***

It is growth factors that provide the signal for all 3 of these events to occur.

Normalized natural blood of a healthy individual would have approximately 200,000 platelets/ml. That is the average baseline for most individuals.

Steve Handsworth performed a study in which he looked at human stem cells in a culture dish. He examined the effect on these stem cells of different concentrations of platelets. He found that decreasing the concentration of platelets to 62% or increasing it to 125% had no effect, and that increasing it to 250%, had no great effect. Only when he increased the concentration to about 500% did he see a dramatic difference in its effect. This means that we have to be very clear when we are creating a PRP about the necessary concentration levels. Taking native platelet levels and increasing them by 25% will give us no noticeable benefit histologically or clinically. Increasing the percentage to 250% above baseline will not give us a clinically noticeable response, but may perhaps give a histologically noticeable response. In order to get a clinically noticeable response we need to get 400-500% above baseline.

A study by Arnold Kapland from Cape Western Reserve University looked at the prevalence of undifferentiated mesenchymal stem cells in different age groups. In the newborn, 1 out of every 10,000 cells are dedicated to repair; in a teenager, 1 out of 100,000; at 35 years of age, 1 out of 250,000, at 80 years of age, 1 out of 2,000,000 million are undifferentiated mesemchymal stem cells.

PRP is not for every individual. It is suitable for those individuals who due to age, systemic disease, radiation or some other mechanism, have a decreased healing response, in which case we have to increase the healing response. In the normal healing process we have a clot formation, inflammation, tissue regeneration, greater quantities of tissues are being formed than resorbed and then finally tissue remodelling where the same amount is undergoing resorption as is deposited. But, when we add exogenous growth factors such as PRP, we take these same processes and reduce the time period for healing.

4 identified growth factors in the PRP:

Platelet-derived growth factor
Transforming growth factor
TGF-beta
IGF

There are also various isomers. Platelet-derived growth factor, for example, has 3 different isomers. TGF-beta has 2 different isomers. A number of different growth factors and isomers, and probably other, as yet unidentified growth factors must be taken into consideration.

We also recognise that the fibrin network is enhanced in the PRP, providing better pathways for the bone-forming cells to travel along within our graft and within our soft tissue matrix.

One of the important criteria for bone grafting success of any type, whether orthopaedic, maxillo-facial or periodontal, is graft stabilisation. PRP helps in the particulate graft stabilisation and soft tissue stabilisation. Finally, as a practical consideration, it provides for better haemostasis, less bleeding and less post-operative pain.

Review of some clinical studies

In 1998, Dr. Marks showed faster mineralisation uitilizing continuity defects as the

models. Half the patients had pure autogenous bone grafts and half had autogenous bone graft and PRP. He showed graft mineralisation in half the time, with 15-30% improvement in trebecular bone density. In summary, faster bone formation and better bone density was achieved using PRP.

Another study compared bovine-hydroxyappetite(BHA) with PRP against BHP without PRP. Without PRP, the healing time was 8 months whereas with PRP similar results were seen at 4 months. Theoretically, with the use of PRP, allo-plastic material could heal at the same time that we ordinarily would have reserved only for pure autogenous bone.

In a study using the dog model, 30 implants in total were placed and subsequently defects were created. 10 of the implants had no graft material; 10 of the implants had a plaster of paris type material to fill the defect; the remaining 10 used a combination of plaster of paris and PRP. Due to the osteo-conduction provided by the titanium surface of the dental implant, there was some bone growth even with no graft material. The plaster of paris, probably by acting as scaffolding demonstrated additional bone growth. The PRP group demonstrated an up-regulation of probably about 40-50% at 6 weeks, despite the allograft being plaster of paris. This shows that we can indeed up-regulate materials other than autogenous bone. The defects need to be of an appropriate size. The PRP does not exert its action on the graft material, it exerts its influence on the surrounding cells. Smaller defects have a larger abundance of local cells than do larger defects. Larger defects do not enjoy as much up regulation as do smaller defects.

Another study looked at PRP and bovine porous bone mineral combined with guided tissue regeneration for intra-boney periodontal defects. The results showed that PRP and the bovine mineral provides a greater regenerative effect than simple guided tissue regeneration alone.

Dr Watson's group, found that the platelets provide the bulk of the benefit, but there are actually growth factors contained within the membranes of the white blood cells as well.

Maxillary sinus augmentation with de-proteinated bovine bone (Bio-oss) and PRP with simultaneous insertion of implants.

Conventional science teaches us that, to insert implants simultaneously into the bone graft, there should be at least 5mm of residual crestal boneheight. Research had been carried out on a selection of patients with less than 5mm of residual crestal bone. The implants were placed simultaneously, without autogenous bone, using only Bio-oss and PRP. The researchers found that they could expose these implants and load them at 4 months. This type of results that had been previously reserved for autogenous bone.

The influence of PRP on the oseous healing of dental implants.

A histological and histomorphometric study of mini-pigs; looking at topical PRP application. This group showed that PRP is found to have a time and site-dependent effect. The healing was assessed at weekly intervals up to 16 weeks. The effects of the PRP were not so evident after early healing because after early healing the remodelling and bone formation process is taken over by other mechanisms, and is no longer dependent on the growth factors. The site-dependent effect is that, clearly, the further from the site you deposit the PRP the more limited will be the effect. In this study, after osteotomy preparation PRP was injected into them, prior to placing dental implants.

Growth factors have many different activities; they can enhance or decrease the healing.

A paper from the Journal of Cell Biochemistry in 1998 shows that multiple brief (acute) exposures to platelet-derived growth factors will provide better bone formation. Conversely, chronic and long-term exposures will actually decrease bone formation.

If we look at different PRP machines, studies have shown that there is a difference in concentration of platelets in PRP using different machines. The important thing is that we should have about one million platelets per microlitre: approximately, a five-fold increase over baseline levels.

Professor Garg had noticed, clinically, that patients have less post-operative discomfort when using PRP. Other specialities, for example orthopaedics, showed 30% less pain medication, 15-20% earlier hospital discharge, and approximately 60% less IV narcotic use post-operatively, when using PRP.

To review, the clinical values of PRP:

- ***Accelerates the bone generation***
- ***Forms a more dense bone***
- ***Accelerates soft tissue healing***
- ***Better haemostasis***
- ***Less swelling***
- ***Less post-operative pain***
- ***An adhesive for soft tissue and particular graft stabilisation***

Professor Garg concluded his lecture by looking at some clinical cases.

YVAN POITRAS

"Symphysis Graft and Implants: The Gold Standard for the Edentulous Premaxilla"

Dr Poitras is a general dentist who founded an institution in Canada for dental implants. He devotes most of his time to treating challenging patients who require implants and bone regeneration.

Dr Poitras' presentation was very much a visual one with an extensive number of slides for the delegates to feast their eyes on.

Subsequent to tooth loss, the bone resorption can give patients dramatic facial changes and can lead to functional problems as well. Generally speaking the greater the time span between tooth loss and attempted restoration, the greater the challenge. Dr Poitras suggested that the best time to place implants is immediately after tooth extraction, if there is no infection and the socket is in good condition. An immediate implant will save the bone.

Moreover, if we use the one-stage technique with a non-functional temporary in place, this will also save the soft tissue and capillaries. An impression can be taken at this stage for the final restoration in 4-6 months time. In the Premaxilla, very often the socket is not intact and the buccal wall is missing. In these cases, Dr Poitras prefers to wait 6 - 8 weeks, until the soft tissues have healed and closed the extraction site. He then embarks on the bone regeneration. For the single missing tooth he prefers what he calls *"the wine bottle cork"*: bone is harvested from the chin using a trephine, particulated in a bone mill and then used to cover the defect. The grafted site is then covered with a reinforced membrane and closed. 4 months later, the case is ready for an implant. Dr Poitras commented that he always has a proper volume of bone and a good density because the graft bone was from the chin.

Where there has been a long lapse of time since tooth removal, Dr Poitras tends to find that an unsuitable ridge has developed, demonstrating a large one-wall defect. The *"wine bottle cork technique"* is no longer appropriate.

When more teeth are missing, more bone tends to be missing as well. This requires a more extensive surgical approach, and a square or rectangular block is harvested from the chin. The chin can give a 7-10mm thick block of bone, 32-33mm in length and 10-12mm in height compared to the ramus, which can only give a 4-5mm thick block, up to a length of 40-45mm. Dr Poitras preferred the chin for partially edentulous cases and the ramus for edentulous cases.

When patients lose the anterior teeth, the diameter of a central incisor is about 6mm, on average. If the buccal plate is lost, the patient tends to develop a new buccal plate, which is the previous palatal wall of the socket. The new buccal plate being 6-7mm more palatally, these premaxillary cases, in Dr Poitras's opinion should be augmented with bone in almost 100% of the cases.

KARL-ERIK KAHNBERG

"Onlay and inlay grafting of the severely resorbed maxilla-surgical techniques and follow-up"

Professor Kahnberg started by qualifying that these resorbed maxilla cases were very difficult to treat.

Resorbed maxilla can demo as little as 2-3mm.

Graft of the mandible is very rare. Branemark started in the mandible. The mandible offers more problems for denture wearers. Maxillary dentures can be more forgiving but it is still in Sweden considered to be an invalidity. In Sweden after the age of sixty, patients only pay a max of 1 thousand pounds.

Closure with thick tension free flap is very important. Tension in the flap acts to occlude the vasculature.

In 30 consecutive cases the flap was raised to expose the maxillae. The nasal mucosa was also lifted to be able to put implants through the graft material. Grafting and implant placement was carried out in the same surgical session. The bone was harvested from the hip because a large horseshoe shape graft was needed. The graft was remodelled to fit onto the residual crest. The graft was secured to the residual ridge with 6 machine polished Branemark implants, modified with conical necks. Cancellous particulate bone was placed in between the block graft and the residual ridge. Careful closure with continous suture, haematoma formation was prevented with the use of a stent over the entire surgical site. Ten days later, the soft tissue healing was good but he realized that the conical shape of the implant heads did not retain bone as well as was anticipated.

The mandible was fitted with a stent with posterior extentions to prevent biting forces disturbing the grafted area. This was devised after a patient early in the study managed to bite through the mucosa and lost the graft.

Complications

Exposure of some part of the bone up to 2 months after the graft. He waited to see that the soft tissues would reject a piece of bone that was not vitalized. Occasionally a fixture would be lost at the same time.

The provisional denture could sometimes traumatize the mucosa exposing the fixtures.

The success of the graft procedure was measured by the post-operative intake of analgesia. The need for analgesia peaked on day 2, Professor Kahnberg was happy with the success of the hip graft procedure.

Cephalometric analysis revealed that the graft material did not remain as stable as was anticipated. At 2 years on average 2mm was lost in the bucco-palatal direction. The patients were functionally rehabilitated even though they started to resemble an edentulous apperance.

The implants were not always placed in the correct position for future restoration but rather they were placed in locations where enough residual bone was available for fixation.

Measurement with CT scans and scanora radiographs have been made to assess the total bone height over 5 years and then 10 years. There was an initial loss of 2mm. There was no difference between 5 and 10 years. Professor Kahnberg felt that the implants were keeping the bone in this position. The width also lost an initial 2mm then stabilized. At 10 year follow up there was an over 80% success rate.

One of the study population died in a car accident four months after the graft surgery. Professor Kahnberg was able to remove the entire maxilla for histological analysis. He found that at four months there was very little bone to implant contact, as low as 8% bone to implant contact was recorded. The conclusion was to advise colleagues not to load implants that had been placed at the same time as the graft too early. In the same patient he also performed a histological analysis of the harvest site, there was good

bone health.
Professor Kahnberg concluded that nobody really knew what the balance between stimulatory bone loading and tissue distruction with concomitant implant losses. Immediate loading should be used cautiously in situations of compromised bone, especially in the grafted stuations.

A colleague of Professor Kahnberg had done some animals studies to assess one stage and two stage procedures. His one stage procedure was similar to that described in Professor Kahnberg's work above. Histomorphometric analysis showed normal healing into the residual bone. In the grafted bone the initial healing was slower but over time the bone to implant contact area was the same. However, if you carry out the graft first and then place your implants at a later stage you get a more vascularized tissue which allows for faster osseointegration.

Another method to treat a resorbed, retrognathic maxilla would be to repostion the maxilla at the same time as inlay grafting. Hollow structures within the maxilla allow for the placement of the inlay graft, this inlay would be stimulated during healing from many directions. Of course if the maxilla demonstrates extremely thin high crests; then an onlay graft would be most suitable.

Professor Kahnberg had used PRP, but had not evaluated it scientifically. He referred to a study in the rabbit calvarium by Peter Malloy and collaborators.They looked at four defects in the rabbit and carried out radiographic, histomorphometric examination. PRP alone did not induce any bone formation. The control groups had slower healing. The best results were achieved when bone graft material was mixed with PRP. Professor Kahnberg now uses this research to support the use of PRP with his autologous graft procedures. He was unsure of the effects of the PRP on bone formation, but he had found that the PRP did have an amazing effect on the soft tissue healing. The post-operative swelling and pain is much reduced, making the patient feel much better after the surgery.

Professor Kahnberg views these resorbed maxilla patients as oral and dental invalids and is embarking on an interview study in Gotenburg in association with a psychologist to see how they feel about there situation before and after having fixed dentures or bridges in their mouths.

In a situation where there is no bone under the base of the nose or under the maxilla you cannot perform a onlay graft, but an inlay graft is possible. The inlay graft is placed into the sinus and nose. The graft is left to heal before a second surgical procedure for the implant placement. The patients have a denture 2 weeks after the first surgery, however they are asked not to chew with this denture. The osteotomy that is performed during the placement of the inlay graft is not free of risks and complications. The bone structure is so fragile that there is a real risk that a fracture could occur to compromise the whole situation further. During the inlay graft procedure the mucosal lining of the sinus is removed and the site is filled with cortical and cancellous bone in a combined effort. The maxilla can be positioned up to 1cm for and 1cm down. The graft is very rarely exposed with this technique as good flap closure is achieved. The site is allowed to heal for 4 months. The repositioning adds a lot of bone volume. Professor Kahnberg always places 8 implants in the grafted maxilla to allow for any failures. Professor Kahnberg treated 25 patients with Nobel Biocare machined surface implant, demonstrating between 2-4mm of maxillary bone. He lost some implants at abutment connection and later due to prosthetic overloading. He had a success rate of 85%. In his next study he used the Astra implant with the Ti Unite blasted surface the study group was similar to the above study. The same treatment was provided. Most of these cases have been followed for 3 years, 20 patients were treated and only 4 implants were lost; a success rate of 97.5%.

Smoking is an absolute contra-indication. Professor Kahnberg disagreed with Dr Misch and felt that the effects of the smoking were systemic and not local.

CARL E. MISCH

" Occlusal overload and crestal bone-loss, fiction or fact ?"

The author of six book chapters and over 80 articles, with a private practice in New York; with over 30 years experience in dental implantology

Dr Ken Judy agreed to present on behalf of Dr Carl Misch who had been advised not to travel by his medical practitioner, due to a back injury.

Once implants are placed there is a controversy as to weather early crestal bone loss is depedent upon occlusion. We have two forms of bone loss, one which occurs early in the first few months after placement. We then go through a steady state phenomenon and after 1 year there is very little change. The controversy is over, what is the aetiology of the early crestal bone loss itself.

The first thread phenomenon

Design of the implant abutment connection, is relatively critical.
Premature occlusion overstressing the implant restoration no matter what the system.

In agreement with Dr Misch is premature occlusion. We need to control this up to the pre-final loading conditions. The bone loss in the first years varies from 0.5-1.5mm depending on the author. The fight to avoid bone loss should be in the first year because after this time most authors show very little bone loss averaging at less than one tenth of a millimetre. The risk of avoiding the early crestal bone loss are of superimposed infection and aesthetics. Suggested aetiologies of early bone loss is surgical trauma, immediate or delayed loading, the nature of the implant crest module or the connection between the body and the abutment, infection, peri-implantitis, micro-gap, biological width. They all seem to have a variety of reasons why the early crestal bone loss does exsist.

A large number of researchers do not feel that crestal bone loss is due to stress and that stress should be eliminated as a cause of early crestal bone loss. Other clinicians feel that there is a direct relationship between stress and bone loss. Dr Judy was one of these clinicians. He felt that we can not ignore a contributing factor to early bone loss if it is obvious.

What is present in the scientific literature supports stress and crestal bone loss ?

The modulus of elasticity, a change in length of a material after an applied force. Dr Judy went on to describe the phenomenon of abfraction, seen as a class 5 cavity on the bucco-cervical margin of teeth in bruxsist; often mistaken for tooth brush abrasion. He reminded the delegates that abfraction was the result of micro-fractures at the junction of the tissues, enamel, dentine and root cementum; with differing modules of elasticity. When the tooth is flexed the three tissues have differing changes in dimension with a concentration of stress at the junction, resulting in micro-fractures; manifesting as a cavity. He suggested to the delegates that the same phenomenon was responsible for the bone loss seen at the crestal bone level around implants. Titanium had a very high modulus of elasticity compared to the components of teeth and bone, so under stress we are at risk of micro-fractures at the crestal bone. The implants need to be inserted at an optimal angle so that stress is concentrated along the long surface of the implant, otherwise we get a magnification factor of the difference in the modulus of elasticity.

Carl Misch used finite element analysis in the university of pittsburg many years ago to find that loading an implant produces a stress concentration at the crest of the ridge. The stress numbers decreased as he went down into the bone. In the narrow ridge this stress would be absorbed by a very thin plate of buccal bone. There are two ways to correct this in either ridge augmentation or the use of a narrow headed implant. Torsion, also produces a fair amount of stress at the ridge.

Looking at Miata's work where he placed crowns in hyper-occlusion, to a magnitude of 150 up to 250 microns, allowed the monkeys to function and then looked at the histological results. At a hyper-occlusion of 150 microns the crestal bone maintains itself, at 180 microns a considerable amount of the crestal bone was lost and 250 microns the bone was completely destroyed virtually down to the apex. Dr Judy was very confident of the direct relationship between force applied and crestal bone loss.

Another study had shown a great deal of bone loss around implants which had been used to cantilever pontics. Dr Judy advised against the use of cantilevers that are overstressed.

Quirynen produced a study on how fixture design and overload influence marginal bone loss and fixture success in the Branemark system. He says that, there is a clear correlation between excessive marginal bone loss after first year of load and or implant loss with occlusal overload. He found fixture fracture, screw loosening.

Badez and Misch published a paper that showed that loading of an implant eccentrically will cause bone loss. If the implant an implant were the load pass along its length irrespective of the angulation of the implant, there will not be any bone destruction. Whereas if the forces was directly laterally onto the implant you could expect to see bone loss at the crestal level in the line of the force.

Dr Judy suggested that most clinicians could place implants with good early success, but how should these implants be managed to realise long-term success. The occlusion is an important factor in long-term longevity, so get the occlusion right and eliminate occlusal stress. If we ignore occlusal stress and accept crestal bone loss we are taking 2 main risks, an aesthetic one and infection due to the fact that we creating real or pseudo pockets which are susceptible to infection.

Factors affecting long term success

Implant design, different implant systems have different surface finishes. An important feature is the surface between the abutment connection and the first thread. The importance of these differences can be realised when different implants systems have been used in the same patient and differential bone loss can be seen. Crestal modules should ideally have a rough surface.

Bone density and bone volume are critical to the long-term success of the implants that we place.

Stress in a compressive strength, compressive force tends to move two points together and tensile forces tend to do exactly the opposite. Shear forces tend to cause sliding or angular deformation of a material. The worse thing that can happen to implants are shear forces, but is also important that the surface material we are dealing with at the implant body abutment connection (implant module), because in the design of implants a polished collar results in localised shear forces which result in early crestal bone loss. The textured surface, such as the Astra Ti-unite, promotes compressive forces. Badez and Misch concluded in a 1999 study that smooth surfaces equals bone loss. The earlier photoelastic studies indicate that we need to minimize in the healing phase the amount of forces applied to the crestal areas; which cause distruction. Implant designs need to into consideration that shear force does not promote bone.

Godfredson's work indicated that the bone reaction adjacent to titanium implants with different surface characteristics subject to a static or consistent load in dogs. The textured surface maintained its bone and the smooth surface lost its bone. This bone loss was attributed simply to the surface and not the design. In Dr Judy's opinion the smooth collar was the aetiology behind the early *"First thread phenomenon"*.

SASCHA A. JOVANOVIC

"Aesthetic implant reconstruction of the anterior maxilla - A clinical, biological and implant design challenge"

Dr Jovanovic works in Los Angeles in a research department and also in an implant clinic, dealing with modern implant challenges.

He intended his presentation to combine surgical intervention with the restorative phase, to give a better aesthetic predictability.

Dental aesthetics and dental implants have seen parallel increase in demand over recent years. *How do we combine our knowledge in these areas to give our patients more predictable outcomes ?*

We always look at the bone foundation as being the establishment of this work. So we are either maintaining the bone we have from resorption or we are replacing the bone to the levels we need it for tissue support.

We maintain our bone through Implant design, the body and neck of the implant are equally important. If the bone and the implant complex supports itself, then the soft tissue profile just goes with the combination. Once the soft tissue profile has been established we now can promote the correct emergence profile, through the right prosthetics.

There are at our disposal a wide spectrum of treatment with clinical evidence, the spectrum needs to be expanded to patients with massive bone loss. These cases need the graft procedures , increasing the overall time taken - sometimes two years to complete. End product should be the same.

Immediate tooth replacement

This treatment option is at one end of the spectrum as it truly preserves tissues and we can atraumatically place implants and provide tooth restoration within 24 hours for a patient. This treatment can be offered when patients attend with very little overall tissue loss. The opposite end of the spectrum are patients who attend with not only tooth loss but with large areas of soft and hard tissue missing. In these cases we should aim to recreate the lost tissues in a controlled and sequential manner, firstly the bone, then the soft tissues and finally the emergence and prosthetics.

Function versus aesthetics

Functionally implants have been shown to have great success and stability. The failures tend to occur in the natural aesthetic development, a recent study of single tooth implants; 58% of these showed a papillae with appropriate gingival contour, resulting in an overall aesthetic failure in 42% of cases.

Predictable aesthetics can only be achieved, if the implant is placed in the ideal position based on the biological requirements of the tissues. Then regenerate any tissue, achieve functional stability in such a way that the bone and the neck of the implant can support the overlying soft tissue profile.

Selection criteria for predictability

Edentulous span, in a single tooth case we can be precise and accurate. The larger the span the more difficult it is to bring back the gingival contour and preserve the bone in between implants.
The bone housing, the more bone there is the better the outcome. Horizontal loss is better for us than is vertical loss.
Soft tissue quality, thick, keratinised tissues offer the greatest predictability.
Periodontal morphotype, the flatter scallop is easy to reproduce, highly scalloped more difficult to reproduce. We need to understand the limitation of treatment depending on the patients morhphotype.

Criteria for successful regeneration of bone and soft tissue

Gingival morphotype and gingival level around the margin of the natural tooth as well as and implant crown. The distance between the crest of the bone and anticipated free gingival margin should be a total soft tissue height of 3-4mm. Implants do have some remodelling; crestal bone loss averaging at 0.7- 1.5mm. therefore apico-coronal placement should be 2-3mm from the intended position of free gingival margin. Bucco-palatal position should be 1-2mm from the buccal surface of the buccal plate. The measurements needs to be calculated depending on the surface finish of the implants for example Branemark Replace select has a 1.5mm marginal polished collar, bone integration starts 1.5mm from apical to the head of the implant, so this will be placed at a maximum of 2mm apical. Over angulation towards the buccal plate area can result in bone loss in this area, resulting visually in recession. The guide stents should be precicely accurate for these procedures.

Periodontal morphotype, the interproximal gingival tissue, this should at the same level as the adjacent teeth.

Multiple implants in relation to each other should be placed 3-4mm apart to maintain a gingival peak of bone. The interdental bone is not very stable, this recedes and leaves us with a flat shallow papillae; resulting in a black triangle and teeth with a long contact point. It is hoped that we may overcome this with the use of the scalloped implant. The scalloped implant should preserve the interdental bone or provide a stable base for a graft procedure to regenerate the bone.

Interproximal soft tissues should be at the level of the adjacent teeth, this is impossible to achieve between adjacent implants.

Bone There is a good literature base that guides us towards the ***preservation of bone,*** for the placement of immediate implants.
Ridge augmentation for the regeneration of bone tissue. Once we understand these principles we can either preserve or improve the tissues.

Guided bone regeneration (GBR) procedure has the big advantage that we can control the 3-dimensional growth of bone. One feature to remember is the that bone formation always starts on the surface of residual bone. The vascularity around the

defect site is an important consideration when deciding on the regeneration materials. The vascularity had a direct influence on the boney regenerative capacity of a site. The choices are resorbable or non-resorbable membranes, with or without titanium reinforcement and tenting pins. Our first choice is autogenous particulate graft preferred to cancellous block grafts. Allografts and xeno-grafts like Bio-oss are used to expand the area and as fillers.

Larger defects, which require more than 5mm horizontal regeneration are carried out in two stages. The autogenous particulate bone is held in place with a tacked titanium reinforced membrane and left to heal for 9 months. A second procedure can subsequently be performed. In two stages it is easier to manage complication and reduce risks.

Vertical alveolar regeneration. *When to perform vertical GBR and when to perform vertical osteogenesis distraction?*

Vertical GBR can develop a 3-dimensional block of bone, however a defect more than 10mm in height results in soft tissue problems when using titanium reinforced membranes. With distraction osteogenesis the limitation is that it is unidirectional in the direction of the vector. It also requires a good bone base to utilise this technique. The base should have good bucco-lingual width and be at least 3 teeth wide. Distraction is reserved for cases where more than 8mm of vertical regeneration is required. Sometimes a combination of distraction and GBR can be used in stages to realise a successful biological outcome. Distraction is not good in small areas. PRP is good when there is a lot of scar tissue present. Surgical guides need to be perfect for accurate results.

Soft tissue

The biological situation with the soft tissues is that they undergo some settling over the first 6 months. Insertion of the temporary restoration as early as possible to act as a guide and aid in the formation of the soft tissue contour and emergence profile. Keratinized and attached tissue demonstrates less recession. The use of under-contoured and semi-submerging healing abutments can act to preserve tissue. At the abutment connection stage we need to consider two pieces of literature, firstly, the mucosal barrier follows a certain pattern just depending on the abutment material as well as how many times you reconnect the abutment. Several reconnections of an abutment result in apical tissue migration and bone resorption. So we have to be careful not to disconnect and reconnect these abutments too often. Also with abutments, titanium and ceramic allow for normal soft tissue dimensions, with a gold alloy to which porcelain has been added very often will result in tissue loss.

Dr Jovanovic presented a case with an intresting dilemma. The patient had already lost one central incisor and needed to have the contra-lateral one also removed. He presented his preferred staged protocol of management with maximal preservation in mind. He recommended that an implant be placed in the edentulous site, this would support the adjacent tissues. The adjacent tooth could now be removed and restored with immediate placement of implant and provisional crown. This can result in good tissue maintanence.

Another clinical situation that offers some challenge is when periodontal losses have occurred on adjacent natural teeth. In this situation Dr Jovanovic has found success with the use of enamel matrix derivatives(EMD). He presented a case where a patient needed a single tooth restoration in a central incisor site but he had recession on the adjacent lateral incisor; with papillae loss. The implant site was prepared with the use of autogenous particulate bone under a tacked titanium reinforced non resorpbable gore-tex membrane. Using the available periodontal literature he gained tissue back with the use of (EMD) to get vertical tissue regeneration on the mesial surface of the lateral incisor. The implant was placed utilising a papillae saving incision and the case restored normally.

The future

When looking at the anatomy of bone and soft tissue profile we know that the cemento enamel junction is followed by bone; which in turn is covered by the soft tissues.

Attempts are being made through a current muti-centre study to develop a scalloped implant which would duplicate the CEJ. In cases with good bone height the scalloped implant would be placed with its interproximal peak at the level of the interdental bone; its lower buccal and palatal surfaces would be placed adjacent to the lower buccal and palatal plates of bone. When bone is missing around the interdental areas of the scalloped implant these can be grafted and covered with membranes. The presence of the interproximal peaks on the scalloped implants does not lend themselves to self regeneration, the bone needs to be grafts to the sites.

Dr Jovanovic completed his presentation with the same scalloped implant described earlier by Dr Wohrle.
