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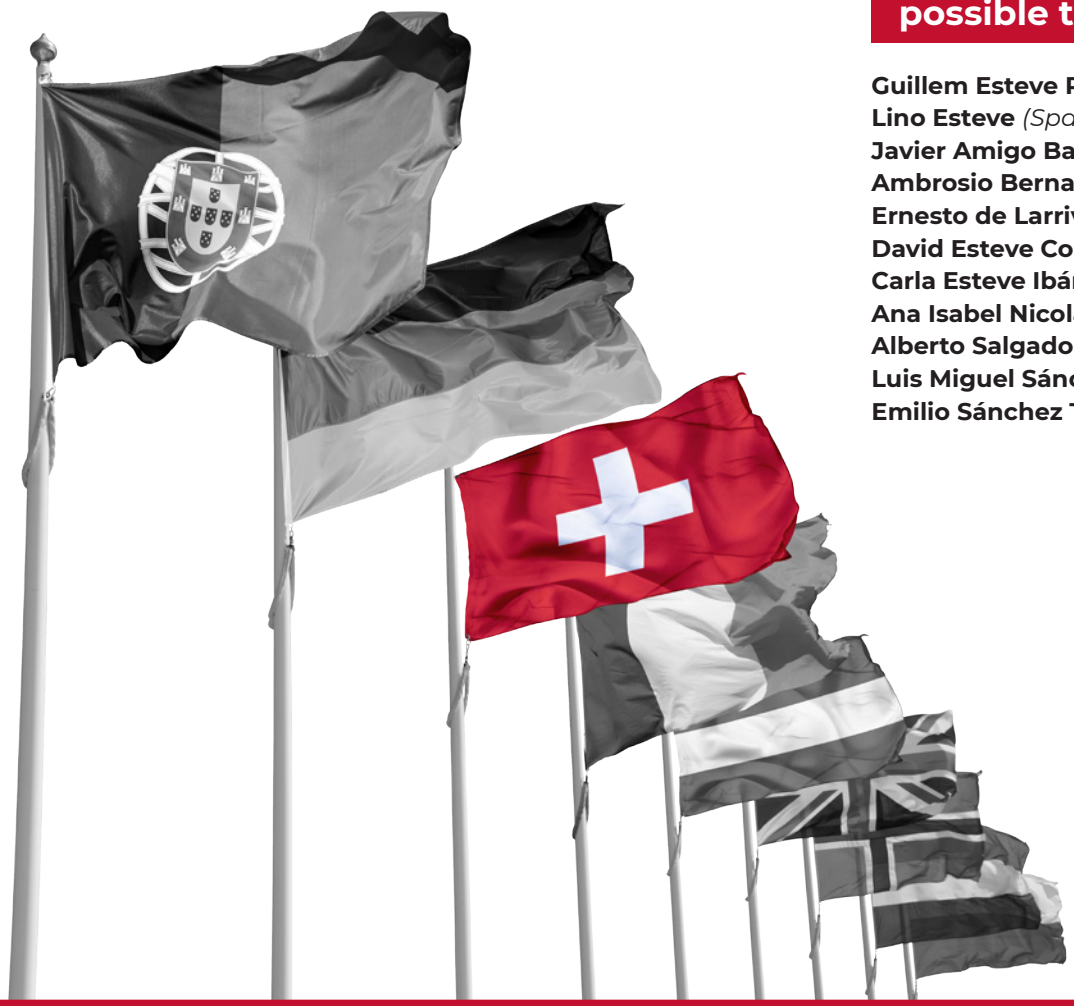

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PLENARY 1

The virtual patient

Session summary

The session explored the intersection between entertainment and medicine, with reference to the ability to create virtual humans using new and emerging technologies. The concept of the virtual patient is getting much closer and offers increasing scope for practitioners to diagnose, plan and execute a wide range of treatment tasks using virtual models that combine patient data and records with facial and physical imagery.

Learning outcomes

Attendees learned how far the creation of the virtual patient has progressed, and how this can enhance communication, treatment planning and realisation as part of a digital workflow.

Relevance to daily practice

New digital capabilities are being developed at a very fast rate. It is essential to keep pace with new developments in order to understand the full range of treatment approaches that are available, and to satisfy patient demands.

Digital human technology. From entertainment to medical applications.

Thabo Beeler *(Switzerland)* **and Markus Gross** *(Switzerland)*

In entertainment, the concept of the digital human has been around for a long time and can be considered to have fully arrived. Digital human technology has been employed extensively in film production using the Medusa Facial Capture system developed by DisneyResearch|Studios.

In order to render the human face, four aspects are taken into account: the face's surface (skin surface); how it changes with expressions (skin deformation); the position and shape of the teeth; and how they move with the mandibular movement. The first two aspects can be recorded more accurately and efficiently with photogrammetry than with extraoral scanners.

Databases comprising extensive data-sets obtained from scanning patient models are used to render teeth. Mandibular movement is rendered through analysis of Posselt's envelope of motion, which evaluates the displacement of the mandible and reflects its six degrees of freedom. Finally, the records are merged to obtain the avatar or digital human face.

In the medical field, the primary purpose of patient digitalisation is to simulate proposed surgery. The goal of recent technological developments has been to increase the realism of the rendering. Earlier versions were insufficiently accurate and unaffordable. The use of light stages enabled the complex response of skin to light (a mixture of reflection and penetration, which creates a sub-surface scattering effect) to be captured, meaning more natural skin tones and skin appearance can be rendered.

The processing pipeline is similar to what is described above, but with what the speaker described as 'different ingredients'. After obtaining precise facial data from high quality scans, a parametric head model is made. When combined with semantic blend shapes that simulate the underlying surgical deformation, a differentiable simulation of how the jaw and facial structure would look before and after treatment can be created. Finally, artificial intelligence can be used to visualise the possible treatment results more realistically (using more advanced neural visualisation, rather than base visualisation, which looks overtly simulated). This technology can be applied to mandibular advancements in orthognathic surgery and advanced cleft lip and palate treatments.

By training artificial intelligence using large datasets, it is possible to generate a neural network in which expressions from real faces can be retargeted to fictional characters (such as non-human science fiction characters), and synthetic human faces can be created directly, without the need for a real human model. The same technology can be used to 'auto-complete' faces, add missing areas, such as hair and eyes, or even to change a person's age or to add features that are not originally theirs. This can be useful because systems such as Medusa don't provide complete scans of the face.

Virtual patient: where are we at in daily practice regarding digital workflows?

Ricardo Mitrani *(Mexico)*

The role of the virtual patient depends on the perspective from which it is viewed, with different definitions and benefits for the patient, the clinician, the technician and industry.

In the past, prosthetic prototypes were required to accurately plan surgery. Now, digitalisation and virtual prototypes have improved planning, predictability, accuracy and timing.

In the last century, Aldous Huxley defined three pillars of western prosperity, the third of which was 'planned obsolescence'. The speaker summarised this by saying 'yesterday's innovation is tomorrow's obsolete commodity'. However, in dentistry, patients believe that implants are unaffected by the planned obsolescence in other sectors, and think that they will last for ever (see 'The biggest dental lie', Ricardo Mitrani, 2018[1]). This is not the case in other areas of medicine.

Dentistry today is uniquely positioned at the intersection of healthcare, lifestyle and technology (Diego Gabathuler, CEO, Ivoclar). There is also an analogy between dentistry and the world of hospitality, which has three elements: the guest, the operator and supporting technology. As a result, the profession is evolving from a dentist-centric perspective to a more patient-centric one. A potential consumer goes through an active research process when purchasing a product or service (the 'buyer's journey'). This journey involves awareness, consideration, and decision-making, which are linked to having a problem, looking for a solution and purchasing a product or service. Dentistry has three equivalent pillars: communication, planning and execution, which complement the three buyer's journey stages of awareness, consideration and decision-making.

One of the greatest challenges we face is how to communicate in a way that is adapted to the current era and context, and which connects with the patient. The speaker articulated the challenge by saying 'the single biggest problem in communication is the illusion that it has taken place'. Technology is only helpful if we know how to listen to patients first. Understanding their emotional, cognitive and behavioural state is essential in order to connect with them and communicate effectively with them.

The speaker closed by illustrating three cases in which he had applied a digital workflow to rehabilitate natural teeth and implants in both arches, along with the tools and techniques he had used to communicate effectively with the patients. These included showing one patient a short educational video explaining their condition, then emailing them a link to the video, along with a PDF explaining how it linked to their case. He closed by emphasising that patients will only buy into dental treatment if they know that their practitioner cares about them and is technically competent to deliver the treatment. If we cannot communicate this successfully, technology becomes meaningless. Conversely, the same technology can be used to communicate effectively with patients, overcoming barriers to treatment acceptance and understanding.

[1] *https://www.speareducation.com/spear-review/2018/09/the-biggest-dental-lie*

SESSION 1

Innovations in patient treatment planning and communication

Session Summary

Communication is at the heart of all treatment steps. It begins at the initial consultation and only ceases when the relationship with the patient ends, whatever the reason for this is. As crucial as it is, dentists often neglect communication in favour of technical expertise. This session explored the role of innovations in helping to address the key issue of communication with reference to treatment planning.

Learning outcomes

Attendees learned about a range of communication protocols that were centred around digital technologies. They were also introduced to the psychological factors that influence patients' feelings, including how satisfied they feel about their treatment. Finally, a range of technological tools was described that can be used to share the visual outcome of the treatment with the patient. These included a range of inexpensive tools that are accessible to any practice.

Relevance to daily practice

The session addressed a dilemma that is experienced by all dentists: how to make appropriate choices when investing in digital technology in order to avoid being left behind, and at the same time how to make good choices when faced with a rapidly evolving market. It also looked at the key goal of facilitating communication with patients, and the role of digital technologies in improving communication. Finally, it looked at whether the adoption of digital technologies as a communication tool would automatically lead to an improvement in patients' trust. These are all key issues that dentists need to consider in their practice.

Innovation and technology for patient treatment planning and communication

José Manuel Navarro (UK); Pablo Ramírez (Spain)

This session looked at how an interdisciplinary approach, combined with new technologies, influences communication in modern dentistry. New technological tools aim to make treatment more predictable, efficient and effective.

The speakers stressed that technology is only an adjunct to the dentist's professional expertise, and the dentist continues to be the driver of treatment within this new virtual world.

Visualising the treatment outcome from the outset leads to an architecture-like protocol. Files from the planned design are continuously referred to throughout the treatment, with the goal of precisely replicating the planned treatment in what has been referred to as 'copy-paste' dentistry. The lab plays a big part in this digital process, which takes advantage of new materials, new procedures, and uses new types of information.

Following data acquisition, a virtual planning phase follows, and at this stage many different software packages are available. Making an appropriate choice is important and it is advisable to take advice from experts in digital treatment planning.

Experts agree that digital workflows are changing dentistry. The planning and design stages occupy a much more significant amount of time – around 70% of the total – with the remaining 30% spent on execution of the treatment.

Evidence on the importance and effectiveness of patient communication: how do we gain trust?

Rino Burkhardt (Switzerland)

The enormous amount of literature on patient communication makes it challenging to identify and summarise relevant evidence about patient communication and its effectiveness. The speaker commented: 'I am convinced that patient communication and the trust that we receive from the patient is of utmost importance for the outcome and for patient happiness'.

Apart from knowledge, both technical and non-technical skills impact the therapeutic relationship. Non-technical

skills include communication, decision-making and teamwork.

Many factors can make the difference between a clinician being competent and actually delivering high-quality treatment, and the capacity to communicate with the patient is one of the more relevant factors.

The evidence-based treatment paradigm we previously relied on is increasingly in crisis.

- From the operator's side, the clinical decisions they make are influenced by their beliefs, experiences, a range of different confirmation biases, and their emotions. For example, the reputation and influence of associations and companies have significant influence, as does the vast array of published information.
- Patients are also susceptible to similar biases. Importantly, **feeling** informed (perception) does not directly correlate with **being** informed (factual knowledge).

Cognitive bias can lead to a whole range of issues including errors in diagnosis and poor clinical performance. This can result in a range of serious adverse outcomes. The problem can be reduced by developing meta-cognition skills and undertaking debiasing training.

A sense of being informed generates trust, which is important for treatment adherence, although as detailed above, feeling informed is not the same as being informed.

Implant surgery is frequently elective, and problems can occur when patients' expectations are not matched by outcomes, especially aesthetic outcomes. This highlights the importance of good communication and the need to be aware of biases, such as overconfidence on the part of the dentist, which can then lead to assumptions being made and the patient being dissatisfied. Equally, problems can occur if the patient does not actively participate in their treatment, or is unable to understand aspects of the treatment, including potential risks.

The goal is to achieve 'evidence-based patient choice', with a democratic distribution of treatment decision-making between patient and clinician. Shared decision-making is the ultimate goal, especially for elective surgery. Equally, it is important to be aware that some patients may be unable or unwilling to engage in democratic decision-making and assessing patients beforehand to identify these challenging patients is important.

Computer-designed smiles

Andrea Ricci (Italy)

The speaker explained that his presentation would focus on 'feasible' technology, which he defined as approaches that audience members could introduce into their own practices without making large investments. Similarly to the first presentation in the session, he advocated that 'Planning should involve 80%, while execution just 20%', adding that when you build a house, the architect comes before the engineer, who comes before the craftsman.

The clinical assessment cannot be made solely intraorally, since all prosthetic parameters should be considered with reference to the face. Treatment planning should start with a virtual face bow which defines the incisal length, midline and horizontal aesthetic plane.

This is critically important because many patients have asymmetric faces where neither the interpupillary line nor the midline is reliable, and in these cases, we need to rely on the natural position of the head in 3D space.

Facial analysis can be carried out quite simply using PowerPoint or Keynote to transfer data from a facial photo to an intraoral photo, including transferring the midline, incisal length and occlusal plane. This 2D information relating to the frontal and occlusal planes can then be given to the technician.

However, the challenge of this approach is to make the transition from 2D digital images to a 3D wax-up, since no copy-paste technique is possible. The result depends on the technician's interpretation, as the clinician is not involved in the wax-up. Thus, the clinician's role as an architect risks getting lost.

The next stage in the evolution of this approach is to use a 2D photo and merge it with 3D imaging without making a wax-up, using software such as exocad. This produces 3D images in STL (stereolithography) format, and these can be merged and aligned with 2D facial photos. The result has limitations mainly relating to the quality of the 2D facial photo, but is a significant improvement on 2D alone.

A native 3D file from a facial scan is the optimal option. Despite this, it is important to remember that facial scanners still have limitations to their accuracy, and there are also challenges with aligning the two scans. Furthermore, some scanners are also expensive.

The speaker concluded by saying that despite these challenges, computer-based design is necessary because it shifts the design of the case to the 'architect' (dentist) and away from the technician. Additionally, the case can start with the end in mind, then be reverse-engineered. Finally, it provides an outstanding communication tool to show the patient what outcome is feasible and desirable.

SESSION 2

Is 3D radiology a mandatory part of treatment planning?

Session summary

3D radiology is now an integral part of dentistry, and this session confirmed that appropriately used CBCT has a key role to play as a diagnostic and planning aid in implant surgery.

Learning outcomes

Attendees learned that MRI (magnetic resonance imaging) should now be considered among the technologies that can provide 3D images of the jaws. MRI, which is increasingly being used in various medical specialties, is gaining a growing role in dentistry and oral surgery. They also learned how to optimise radiological images and obtain better diagnostic and therapeutic results.

Relevance to daily practice

Knowledge of 3D imaging technologies and their use in daily dental and implant practice is essential. 3D imaging is a diagnostic tool that is continuously evolving, and staying up to date is vital for optimising the results it can offer.

Update on technology and current accuracy of 3D imaging (CT, CBCT, MRI)

Florian Probst (Germany)

3D imaging is essential for computer-based implant planning and computer-assisted implant surgery. Until recently, the 3D imaging techniques that were available were CT and CBCT. The most significant advance in scanning has been a lowering of the radiation dose. New technology means the bone resolution is improved, while simultaneously reducing exposure time and correcting artefacts.

CBCT is a proven technique for obtaining high-resolution volumetric bone images. Its benefits include compact equipment size that is appropriate for a dental office; a reasonable cost; and an acceptable radiation dose. On the downside, it still exposes the patient to ionising radiation and provides relatively low soft tissue contrast. MRI (magnetic resonance imaging), a non-ionising 3D imaging technology, is currently being evaluated.

Significant progress has been made in developing MRI as a reliable radiation-free alternative to radiological imaging in dentistry. Recent studies have shown good reliability and accuracy for MRI-based treatment planning and surgical guides, compared with CBCT.

The accuracy of different scanning techniques is an important factor. The accuracy of linear measurements for CT-based 3D scanning ranges between 0.2 mm and 0.5 mm. In a recent comparison, the accuracy and reliability of MRI-derived virtual 3D bone surface models was equal to CT and CBCT.

Segmentation of both MRI and CBCT images is quite labour-intensive and involves a lot of manual post-processing. Automatic segmentation algorithms may provide a solution in the future.

Because of its excellent soft tissue contrast, MRI makes it possible to see the course of the mandibular nerve and assess soft tissues. For example, when planning palatal grafting, being able to measure the mucosal thickness and locate the palatine artery can be very useful. Additionally, postoperative monitoring of autologous bone grafts can be performed free of radiation by using MRI scans, thus facilitating longitudinal studies. However, MRI is currently limited in assessing the immediate peri-implant situations accurately, due to artefacts resulting from the titanium implant. On the other hand, MRI might be more suitable than CBCT for the visualisation of osseous defects around zirconia implants.

MRI is helpful for assessing periodontal disease as it can discern osseous oedema clearly. This measurement could be used as a substitute marker for active inflammation and treatment control.

MRI easily differentiates apical lesions, enabling the identification of cystic lesions, odontogenic tumours and granulomas. With regard to orthodontics, radiation-free cephalometry using MRI is highly reliable compared with CBCT. In third molar surgery, MRI allows preoperative visualisation of neurovascular structures and assessment of postoperative nerve lesions.

In conclusion, MRI is an innovative option for radiation-free 3D imaging to support computer-assisted surgery, as well as for screening and monitoring purposes.

Evidence for the need for 3D imaging

Dennis Rottke (Germany)

Evidence-based medicine and the hierarchy of evidence have limitations, particularly in the field of medical imaging. For example, it's not possible to conduct randomised controlled trials (RCTs) where one group receives 'real' radiation exposure and the other receives 'fake' radiation. In the absence of RCTs, guidelines published by appropriately informed groups are what are available to clinicians.

The best way of improving performance is by raising the practitioner's level of clinical expertise. Educating the clinician and improving their skills is essential for interpreting 3D radiological images accurately and minimising the radiation dose. There is an important distinction between energy and dose: energy can be measured, but dose can only be calculated.

Radiation exposure is cumulative, and each mSv (thousand µSv) of radiation exposure increases global cancer mortality by 5%, with some tissues, in particular, being highly susceptible, such as the thyroid, bone marrow, and salivary glands.

Environmental exposure to radiation is an established fact. For example, a flight from Frankfurt to Tokyo results in radiation exposure of 75 µSv, while daily levels of exposure to radon in the air within homes is equivalent to 3 µSv, the same exposure level as experienced during intraoral radiography. Even a banana comes with 0.1 µSv of radiation, because of the potassium it contains. After sleeping close to someone, one receives 0.05 µSv, the same dose as standing 1.5 m from an active intraoral X-ray device. At 20 µSv, CBCT has an excellent dose-information balance. In young patients, such as a five-year-old child, dose/effect calculations should be multiplied by 5.

All forms of 3D radiological imaging must be optimised to minimise radiation exposure. MRI scanning is currently unique in providing high-quality imaging without exposure to radiation, although many people find these scans very difficult to read.

Optimisation for 3D Imaging

Rubens Spin-Neto (Denmark)

Optimisation means the most effective use of a resource. The best use of radiological imaging focuses on acquiring the most information with the least radiation.

Radiology provides additional information over and above the clinical examination of the patient and should be used based on the specific diagnostic need. However, one study has shown that 3D imaging leads to more invasive treatment and surgery compared with 2D imaging, and this more invasive treatment is often not necessary or appropriate. We sometimes forget the best 3D technology that we have in our clinics, which is our eyes.

Optimising radiological results involves two elements: modality and perception. There are physical factors to consider such as the device, projection, and the patient, but it also depends on accurate interpretation of the images in order to arrive at an appropriate diagnosis, treatment and prognosis. Perception means capacity for interpretation pertains to clinical skills and is influenced by psychology and education.

On the other hand, modality relates to physical factors, such as the choice of imaging technique. The aim is to achieve optimal image resolution, combined with a reduction in artefacts, or to put it another way to improve the observation range with an optimal radiation dose. However, no CBCT image is perfect. The highest level of accuracy we can expect with currently available devices is in the range of 0.5mm. A variety of factors produce artefacts in 3D radiology, including metals, external objects, restorative materials, enamel, sensor type and patient movement. The significance and nature of the artefacts differ depending on the composition of the material and the type of CBCT scanner. Artefacts around zirconia implants are particularly problematic.

A low-dose protocol is preferred when planning implant placement or evaluating peri-implant bone loss. Future research is trending towards further dose reduction with a shift towards non-ionising imaging modalities such as ultrasound or MRI. These have the potential to provide a broader range of information, including information on soft tissue, combined with quick acquisition that is more straightforward for professionals to assess, and more affordable for patients.

The speaker stated that 'A good implantologist is also a good detective. We need to put together the pieces of the puzzle that our patient represents.' This means being aware of the limitations of imaging technology and the importance of the practitioner's own clinical diagnosis.

SESSION 3

The unhappy implant patient

Session Summary

At some point in their practice, all dentists have encountered dissatisfied patients. This is a stressful situation that raises some important questions. These include: how can patient satisfaction be assessed? How can the potentially unhappy patient be recognised? What is the best way to manage such an experience?

Learning outcomes

Attendees learned about tools to assess patient satisfaction, along with the quality of life indexes. Questions that may raise red flags were discussed. Other topics that were covered included learning to be aware of a lack of proportionality in patients' expectations, and how to manage a patient with psychiatric issues.

Relevance to daily practice

A dissatisfied implant patient is a major challenge for the practitioner and creates a situation that is hard to resolve. Recognising and adequately assessing an unhappy patient from the outset can be of great help in preventing issues further down the line.

Patient-reported treatment outcomes

Klaus Gotfredsen (Denmark)

Evidence-based medicine is about establishing the best treatment for the patient. It involves combining individual clinical experience with the best external evidence and the patient's values and expectations.

In the context of healthcare delivery, patient satisfaction is essential. How a patient feels about their treatment is closely related to past experiences, expectations and emotional factors. Good communication and a clear exchange of information from the outset are crucial. This should include managing patient expectations and listening to the patient for cues about issues that are important to them.

Having been influenced by social media, today's patient comes to the office with some degree of misinformation, and frequently also with unrealistic expectations. Our task is to provide accurate information and realistic expectations before treatment.

Assessing PROMs using point scales or visual analogue scales is a straightforward way to capture and monitor patient satisfaction throughout treatment. Validated questionnaires can also be used to score patients' oral health-related quality of life, which is another form of PROM assessment.

Capturing these data is beneficial for broader research purposes, but is also a practical means of assessing patient satisfaction during treatment, and aiding decision-making.

How to diagnose the critical patient?

Tim Newton (UK)

Diagnosing a potentially critical patient should be included in the general risk assessment before every treatment. Research suggests that there are five dimensions of patient satisfaction: technical competence, interpersonal factors, conveniences, costs and facilities. Of these, the most important is arguably interpersonal factors, but this aspect tends to receive the least attention.

Interpersonal interactions that patients want from practitioners include responding to pain; discussing fears and offering coping strategies; being friendly; providing explanations; having a reassuring manner; and inspiring confidence. However, there is often a discrepancy between what practitioners believe they do, and what patients see them do. This discrepancy mainly relates to communication.

The most significant shortcomings in how dentists interact with patients include providing insufficient information, communicating poorly, and failing to manage patients' expectations. Effective communication involves creating a good interpersonal relationship; effectively exchanging information; and making shared decisions about treatment.

Dentists can use questionnaires to assess how realistic patients' expectations are. This can help define their 'zone of tolerance' between an outcome that is adequate and one that is ideal. Such questionnaires should raise red flags when unrealistic expectations or potential psychiatric concerns are identified, both of which risk leading to disappointment following treatment.

What to watch out for when treating such a patient?

Páll Matthíasson (Iceland)

Patient satisfaction is heavily influenced by the person's psychological state. Satisfaction partly relates to the objective outcome of treatment but includes feelings that are strongly influenced by the psychological context. We need to identify red flags for patients showing abnormal expectations or behaviours.

For example, conditions like depression, anxiety, or factors such as the expression of delusional ideas will adversely impact how the patient feels about the treatment outcome. Substance misuse, paranoid symptoms, and dysmorphic disorders make it likely to be very hard to provide treatment that will satisfy the patient. Where appropriate, they should be referred to mental health services.

Body dysmorphic disorder (BDD), which is considered to be a type of obsessive-compulsive disorder, is an absolute contraindication for receiving implants. Detail-oriented visual perception means patients with BDD lose the ability to see themselves globally, with the result that the detail they focus on appears distorted. Assessment to see how preoccupied the patient is with their personal appearance can make it easier to recognise cases where self-perception is inaccurate, disproportionate or a source of stress.

With a mean prevalence of about 1.5%, BDD is more commonly found in clinical settings, especially in cosmetic surgeries, where it can rise to over 13%. BDD is an underdiagnosed disorder and is likely to be seen in around one in ten implant patients. Teeth are the third most common body part that people with BDD worry about.

The prognosis is poor, with a likelihood of functional impairment resulting from frequently occurring comorbidities, including severe depression, substance misuse, social phobia, obsessive-compulsive behaviour, and risk of suicide, which can be up to 45% higher than in the general population.

Treatment consists of a combination of cognitive behavioural therapy and medication. Although surgery is contraindicated and worsens BDD, one study found that 84% of surgeons and dentists had operated on patients with the condition.

A high level of awareness is needed to recognise BDD. A minor blemish that is the cause of considerable patient concern should ring alarm bells, as should a history of cosmetic procedures. Beware of patients who are over-flattering and put you on a pedestal: this can indicate unrealistic expectations.

Approaches such as repeatedly providing reassurance; attempting to minimise the patient's concerns; or treating the issue as psychosis are all unhelpful. Terms like 'acceptance' or 'coping' may be interpreted as 'resigning on oneself to be ugly.'

SESSION 4

Innovations in implant diagnostics/ planning

Session summary

The session reviewed new digital approaches that are becoming options for daily practice.

Learning outcomes

Attendees learned how they can use central service providers for some of their workload in order to save time and take advantage of the best available expertise. The session looked at how artificial intelligence (AI) and augmented reality (AR) can help clinicians, and provided an update on the latest research into computer-assisted implant surgery.

Relevance to daily practice

Digital tools have the potential to dramatically improve outcomes in daily practice.

Guided/navigated implant surgery vs. brain driven implant surgery

Atiphan Pimkhaokham (Thailand)

After the discovery of osseointegration with titanium implants, followed by restorative-driven implant placement, the third paradigm shift in implant dentistry has been the development of advanced digital technologies in computer-assisted implant surgery (CAIS).

Static CAIS, which includes guided implant surgery, is an evidence-based technique that is widely used. Results from studies demonstrate that the accuracy of static guides is within 1 mm for platform deviation, 1.5 mm in the apex, and 3 degrees in angulation. A randomised controlled trial comparing guided versus 'brain driven' or freehand implant placement showed that deviation can be reduced by 33% when using guided surgery. Using either an intraoral scanner or model scanner gives similar results. However, when comparing different guide systems, significant differences in mean angular deviations were obtained.

Dynamic CAIS is characterised by freehand implant placement, supported by real-time digital feedback to the surgeon. Navigation accuracy of dynamic CAIS was shown to be within a similar range to that of static CAIS. The speaker's team recently compared the two systems in a range of clinical situations: single gap, multiple gaps, and totally edentulous patients. They obtained similar results in all three types of cases, with consistently superior implant positioning accuracy than with freehand surgery.

The most recent investigation involved combining the two systems, which resulted in a reduction of deviations of 30–50%.

The pros and cons of service centres for planning of implant surgery

Sonia Leziy (Canada)

Streamlined collaboration using a digital workflow can minimise errors and improve outcomes. Poor surgical planning or execution often leads to restorative complications. Outsourcing some aspects of the workflow such as digital wax-ups, facial scanning and face- in smile design, can improve outcomes since it allows the clinician to focus on their specialist role while collaborating with others specialised in digital design or other aspects of treatment. During the planning phase, manufacturing of surgical guides and transitional restorations can be outsourced to the lab or service centre. From the clinician's perspective, this eliminates the need to focus on non-clinical steps in case preparation.

Collaboration with a digital service provider can improve diagnosis and planning, reduce chair time, office and staffing costs, while providing access to complex and costly software and superior printers/mills. Along with more sophisticated techniques, opportunities for teamwork with experts in each sub-specialty needs to be considered. When good quality data is submitted, higher quality results can be achieved with less clinical inventory and in less time. Full control of the process is maintained by the clinician, especially when using asynchronous cloud-based platforms, where clinicians can modify or amend proposed plans inputted from the designers.

Central service providers can anticipate whether the prosthesis will need to be screwed or cemented, along with the screw angulation, plus any need for ridge augmentation or bone reduction. They can prepare surgical guides that provide complete implant guiding, and offer standard or custom healing abutments for 3D tissue support, as well as temporary and definitive restorations.

Artificial intelligence and augmented reality in implant planning

Francesco Mangano (Italy)

New, powerful tools are available which enable the clinician to create virtual models of their patients. Artificial intelligence (AI) software can automatically integrate patient data from multiple file types in a few minutes, and then provide virtual 3D models ready for clinical evaluation. Augmented reality (AR) can create high-definition holograms that are large enough to work inside intuitively and precisely. Any planning based on these models should still be exported to conventional guided surgery software when ordering the surgical guide since many of these packages still need to be certified for clinical use.

These technologies are in a learning curve phase. To illustrate this, a case was presented with intraoral scanning and CBCT performed at the first appointment. Automated file alignment and segmentation were carried out using AI software (RELU Virtual Patient Creator®) and sent to the dental technician for the virtual wax-up. Then, a giant hologram for planning implant placements was built using HoloDentis® AR software. This created an authentic 3D environment which was viewed using Hololens2® glasses and featured masks from different STL files. As previously stated, this type of planning should still be validated by exporting it to a certified application before manufacturing the surgical guide. In the near future, it will be possible to directly import files for a smoother transition from dynamic planning to dynamic navigated surgery.

A typical digital prosthetic workflow starts with intraoral scanning, followed by abutment and restoration designs. These digital workflows are creating efficient new ways to interact with dental technicians by sharing plans in real-time through the web, and even working on them simultaneously.

SESSION 5

Innovations in implant design, components and materials

Session Summary

The speakers provided a historical overview of how implant design, components, and materials have changed over time, along with the features that have remained the same, plus current trends in implants, components and materials.

Learning outcomes

The audience learned how to choose the most appropriate implant, connection and abutment designs for different case types.

Relevance to daily practice

Understanding how implant and component types influence treatment outcomes enables dentists to choose the right implant for each case, in order to achieve an optimal result.

Traditional implant designs

Konrad Meyenberg (Switzerland)

A wide range of implant platforms has been developed and evaluated since the classical Brånemark design in 1965. Some have been more successful than others.

The main challenge for crestally placed implants is to minimise bone remodelling, avoiding bone loss within the first year. Soft tissue level implants are associated with the least overall bone loss, while higher overall bone loss occurs around all subcrestally placed implants regardless of the connection design. Vertical components also influence bone loss. As far as possible, the prosthetic platform should be moved out of the bone to minimise bone loss. With conical connections, risks of technical complications include long-term fatigue problems, especially in small-diameter implants and high-loaded areas like molars. Molar implants need wider implants without conical connections.

Long conical connections show the highest rate of technical failures. Their higher rotation, canting movements, and vertical displacement provoke abutment fractures with low retrievability due to unfavourable cold welding and deformation effects on the titanium.

Conical connections cause a wedge effect, leading to vertical displacement and irreversible intrusion when dynamic loadings are applied. As a result, the vertical position of the abutment cannot be precisely predicted, and frameworks of splinted implants under load cannot be passive. Only flat connections prevent vertical displacement. Well-engineered flat internal connections lead to fewer problems with loss of retention and loss of preload. According to the speaker, the most appropriate indication for conical connections is single anterior implants.

Regarding implant positioning-related risks, implants should not be placed deeper to improve a crown-to-implant ratio since the lower the level, the higher the loads.

There are also some implant design-related risks. Basic engineering principles dictate that circular tubes with thick walls and reinforced necks offer the best mechanical properties. To minimise implant fractures, the design and precision of the butt joint are essential. Splinting is ideal for flat connections. Since there is no leak-proof connection under load, soft tissue-level implants may better address biological implications associated with gaps.

New reconstructions on aged and deformed implants are usually problematic, as wear and deformation on conical implant connections mean new components no longer fit properly.

Design features are also important when it is necessary to remove cracked implants. The potential damage of removal manoeuvres must be considered when choosing a design (the more aggressive, the harder to remove).

Biological complication risks can also be linked to implant design. The risk of peri-implantitis is 3.5 times higher on micro-grooved subcrestal implants compared with soft tissue level finely machined implants. Generally, rough implant necks and porous surfaces are associated with a higher risk of peri-implantitis. Soft tissue thickness is critical for bone stability; with ≥3 mm, no implant system is clinically superior over another.

The impact of implant designs on biological and technical failures should not be underestimated. According to most studies, the ideal restorative platform for the highest precision is a tissue-level implant with a short or long vertical platform shift and genuine flat connection.

Innovative implant designs

Venceslav Stankov (Bulgaria)

Many different implant systems and treatment concepts can provide good clinical results.

Approaches to bone and soft tissue management are currently changing. The trend is for narrower implants that are placed deeper in the bone. The aim is to use the patient's remaining bone, working more with the soft tissue and choosing thinner components that provide more space. When there is more titanium, there is less soft tissue.

New implants are designed to avoid performing bone augmentation procedures wherever possible. The 'V concept' uses a triangular neck that provides space for more buccal bone; increases bone surface contact without compromising buccal bone, and allows a wider implant to be placed than would be possible with one with a cylindrical neck.

A triangular neck permits a gain in bone volume due to better blood clot stabilisation and reduced cortical bone compression, thereby maintaining the implant's primary stability. This system allows wider diameter implants to be placed with more bone surface contact and less stress to the cortical bone using drills with a smaller diameter than the implant.

The neck design is complemented by narrow, concave transmucosal components, which are recommended to increase the space available for soft tissue.

Another advantage of this system is space management, as it enables placement of the flat surface where most space is needed, such as between two adjacent implants or between implant and tooth.

Different concepts of modifying the transmucosal component

Luigi Canullo (Italy)

The interaction between soft tissue and the abutment is considered to be an adaptation. However, real integration is possible, leading to stable long-term direct contiguity of living cells and a foreign body.

Due to the geometrical proximity between the prosthetic and soft tissue components, clinicians can actively influence morphogenesis.

Traditional workflows suggest repeated disconnections of abutments, but this results in connective tissue disruptions which lead to an inflammatory response due to reconnection and contamination of the reused abutments. 'One-abutment one-time' is the only approach that assures zero connective tissue microdamage. Taking an intraoperative impression of the implant allows the clinician to place the definitive restoration when reopening, leaving the connective tissue undisturbed.

With regard to the abutment material, no significant differences in soft tissue integration were observed between titanium and zirconium. However, tridimensional abutment design dramatically influences morphogenesis. The easiest way to treat small zenith misalignment is to narrow the abutment's buccal aspect. Moreover, compared with traditional divergent abutments, novel narrower abutments offer significant benefits in terms of marginal bone levels. More space around the abutment allows the rearrangement of soft tissue fibres, along with a stronger tissue seal, and provides less space for an inflammatory response.

At the early stages, titanium abutments with rough surfaces offer enhanced connective tissue attachment with better stabilisation of the fibrin network, preventing epithelial downgrowth. However, in combination with bioactivation and the one-abutment one-time approach, abutments with a moderately rough surface have better results at long-term follow-up.

Plasma bioactivation of the abutment improves its surface energy and wettability, making it more hydrophilic and cell-friendly. This leads to improved soft tissue integration, as well as layering which forms a broader band of connective tissue that is in direct contact with the abutment.

Abutment decontamination, sterilisation, and the one-time one-abutment protocol are mandatory to achieve the best results.

SESSIONS 6 AND 8

Evolution in regeneration, parts 1 and 2

Session summary

These two sessions provided an update on new trends in tissue regeneration.

Learning outcomes

The presentations outlined a range of approaches to regeneration. The first described a protocol for using CAD-CAM customised meshes for GBR. The second set out a digitally planned and guided workflow for bone harvesting using Professor Fouad Khoury's approach. The third developed the concept of risk/timing for soft tissue management. The fourth focused on restoration-driven soft tissue complications. Finally, the fifth presentation dealt with soft tissue aesthetics.

Relevance to daily practice

A large proportion of patients present with hard and soft tissue deficiencies. Regeneration is an essential part of daily practice when placing implants.

The evolution of bone regeneration and bone reconstructive techniques

Matteo Chiapasco (Italy)

Certain types of 3D bone defects continue to represent a challenge in implant dentistry and are hard to treat without compromising the outcome. GBR and autogenous bone blocks, with or without soft tissue reconstruction, have demonstrated successful outcomes in the long term.

Despite the evolution of augmentation techniques during the last thirty years, the core principles remain the same. What is new is the role of digital techniques for diagnosis and planning with a focus on prosthetically guided regeneration.

Surgical guides are made based on anticipating the final prosthetic outcome, and help the surgeon to work according to the prosthetic plan, knowing how much hard tissue volume is needed, and where. Soft tissue regeneration with adequate extension and thickness is also crucial for improved long-term outcomes.

Titanium meshes are an excellent option for maintaining vertical space. CAD-CAM customised meshes can simplify and shorten the surgical procedure, reducing morbidity. Although volume gain is significant, exposures have been reported in 20% of cases. However, when adequately managed, these do not impede good bone regeneration.

The evolution of bone regeneration and bone reconstructive techniques

Luca de Stavola (Italy)

Autogenous bone continues to be the gold standard for predictable regeneration. It provides double the final volume compared to augmentation with biomaterials alone. Moreover, harvesting bone is well-tolerated by patients.

Professor Khoury's digital approach reduces the risk of harvesting bone freehand in the retromolar area. The recipient site defect is first measured, then a surgical guide is designed for the donor site. Having pre-planned cutting planes controls risks, reduces surgical stress, and immediately increases the predictability and safety of the procedure. The accuracy of digital bone harvesting has been estimated to be within 1 mm. As well as improving safety, the quantity of bone can be optimised. The process of dividing the harvested bone block into two thinner pieces can also be guided, thus increasing control over what has been planned digitally. The procedure is user-friendly for the surgeon since it is entirely guided.

The thrust of this presentation was summarised as: 'the best way to predict our surgery is to create it', based on the assertion by Abraham Lincoln that 'the best way to predict the future is to create it'.

The evolution of soft tissue augmentation: enhancement of peri-implant health

Alfonso Gil (Switzerland) and Daniel Thoma (Switzerland)

Evolution in regeneration means we now understand the critical biological and aesthetic role of peri-implant soft tissue, along with the appropriate techniques to enhance it, supported by evidence-based guidelines.

Recent literature shows that soft tissue procedures successfully help treat peri-implant complications like lack of attached mucosa, volume deficiency, and buccal marginal recession. What is new are guidelines for the clinician to approach the clinical handling and prevention of these complications.

The speakers described a risk scale for peri-implant soft-tissue procedures. They are less likely to be associated with complications before implant placement or during the healing phase, and are riskier when carried out at the same time as abutment connection. After crown delivery, it is a rescue process and treatment is less predictable.

A case was presented with a fractured upper central and an apical fistula. It was treated using a palatal connective tissue graft performed during extraction and socket preservation, plus a second graft after guided implant placement. Following these procedures, the horizontal volume was sufficiently increased to enable an ideal, aesthetic restoration.

In another case, a substitute biomaterial was applied during implant placement in a posterior mandible, resulting in vertical and horizontal augmentation. Recent systematic reviews support soft tissue substitutes in peri-implant augmentation. These were associated with less invasive treatment and better patient perception.

A third case looked at soft tissue management with a prosthesis that was already functioning, but where the soft tissue was deficient and the patient was struggling to perform oral hygiene. After removing the restoration, the deficiency was treated with a free gingival graft.

The best way to avoid a situation like this is through preventive management of the soft tissues before placement of the prosthesis. Failing to achieve this means that treating complications becomes inevitable. To illustrate this, a case featuring a flat buccal profile was presented. In order to prevent papilla retraction, a partial-thickness flap was raised, followed by augmentation using a soft tissue substitute. This dramatically improved the mucosal colour.

The speakers concluded by saying that soft tissue assessment should always accompany implant planning, and soft tissue deficiencies should be addressed as early as possible.

The evolution of soft tissue augmentation: enhancement of implant aesthetics

Alfonso Gil (Switzerland) and Daniel Thoma (Switzerland)

The speakers focused on peri-implant aesthetics, emphasising the critical role of soft tissue, and the ability to predictably prevent and manage soft tissue complications through evidence-based guidelines. They presented a case that illustrated three frequently encountered soft tissue deficiencies: a lack of attached tissue, a lack of volume, and mucosal dehiscence.

Returning to one of the cases that had been discussed during their first presentation, they explained how this scored very poorly on both white and pink aesthetic scores. However, according to recent research by Daniel Thoma's team, patients' perception is not the same as professional assessment. The ability to perceive colour mismatch appeared to be most significant for dental technicians, medium for dentists, and lowest for lay-persons. The same pattern was found with regard to acceptability, but with greater differences between the three thresholds. The higher levels of acceptability demonstrated by patients should be taken into account when making treatment decisions regarding aesthetics.

Insufficient thickness and volume of soft tissue lead to buccal marginal recession, which is not only aesthetically unacceptable but a problem for peri-implant hygiene. Various cases were presented that illustrated different approaches to the timing of soft tissue management; two were treated with an autograph at extraction, followed by ridge preservation at the time of implant placement, either alone or in combination with a soft tissue substitute. The final case, which represented the most challenging scenario, featured an implant that had been placed several years before and exhibited soft tissue deficiency, plus the crown in infraocclusion. After removing the restoration, a connective tissue graft was performed using a VISTA procedure with remote incisions.

The speakers insisted on the need for soft tissue assessment prior to treatment in order to establish quality and quantity, as well as the importance of proceeding with mucogingival surgery as early as possible in the treatment flow.

The evolution of prosthetic design: factors influencing the implant supra-crestal complex

Martin Janda (Sweden)

Most implant complications derive from the implant supracrestal complex (ISC), which is made up of the marginal bone, connective tissue, junctional epithelium and sulcus. Prosthetic components may negatively influence the ISC's healthy stability. Emergence (angle and profile), cervical margin, and junctions (implant-abutment and abutment-prosthesis) are the main points at which the pathology may impact the ISC.

A wide emergence angle (30–45 degrees) elicits bone remodelling with aseptic bone loss. The emergence profile varies depending on the cuff height of the stock abutment or the CAD-CAM abutment design. Usually, shallow implant placement leads to shorter abutments and wider angles. Similarly, a concave profile is preferred, versus convex crowns. Non-natural mucosal angles, like shield and ridge-lap designs, induce mucositis due to plaque retention.

The cervical margin frequently provokes recession when it pushes up the mucosal margin. In this scenario, the crown needs to be reshaped to allow the mucosa to grow.

With regard to prosthetic factors, it's important to take care with gaps in the junctions. Using original components may improve the seal, but cement may leave gaps and undercuts even when cemented out of the mouth. Intraoral cementation runs the risk of excess cement flowing down the tissues, as there are no Sharpey's fibres on the implant side to stop it. In direct porcelain fused restorations, the abutment surface can be damaged by sandblasting, breaking the sealed union with the implant. This may change the mechanical parameters of the conical junction, leading to potentially severe complications.

Framework bending due to lack of passivity can lead to cracks and may also contribute to chipping and fractures of veneer material. The speaker emphasised the need to achieve a good fit between the different components.

SESSION 7

Critical evaluation of immediacy in implant dentistry – are more efficient workflows possible and evidence-based?

Session summary

This session provided an update on the immediate placement of implants post-extraction.

Learning outcomes

Attendees learned about the opportunities that the immediate approach offers and its limits. The session described different techniques in the both anterior and posterior regions.

Relevance to daily practice

The placement of an implant directly after a tooth extraction is technically difficult but leads to shorter treatment times for patients. Learning to anticipate potential difficulties in advance is an important step for avoiding complications.

The staged approach in the anterior region

Ueli Grunder (Switzerland)

The key to success in immediate implant placement lies in selecting cases that are appropriate – namely those that have the right indication. The practitioner's clinical experience will determine when they can opt for an immediate procedure instead of a staged one.

In general, when there is a need to change the tissue through augmentation there is no choice but to go for a delayed procedure. The presence of one or more bone defects typically indicates that a staged approach will be required.

The type of membrane and filling material is selected depending on the bone defect, which may be space-maintaining or not[i].

When bone regeneration is complete (up to 6 months in larger defects), the soft tissue must be augmented since it is as important as hard tissue for a good long-term aesthetic outcome. (Schneider D et al. 2011).

As there is currently no scientific evidence to support this approach in the long-term, clinical experience and identifying an appropriate indication will determine the success of the technique.

One study with follow-up times of 22–24 years reported high membrane exposure rates but did not provide a baseline measurement of bone defects, so conclusions could not be usefully drawn from it. The study reflected extreme variability in the types of defects being treated, with an incorrect indication of the suitability of the technique in many cases[ii].

The speaker concluded by saying that to obtain ideal aesthetics with implants in the anterior region, time is very important and practitioners should take their time and not try to rush treatment.

Concept of immediacy in the anterior regions

Stavros Pelekanos (Greece)

When faced with an immediate post-extraction implant, the challenge is determining when it will be possible to maintain the volume or to recreate it.
Cases in the early 2000s led to complications, but new immediate implant techniques combined with new digital tools have improved success rates, supported by better hardware and software.

The aim is to leave more space for the bone by selecting the correct implant design and diameter and the proper abutment design to facilitate soft tissue support.

The reason for the extraction will determine the type of defect that is likely to be encountered, with vertical root fractures and periodontally failed teeth having the most impact on the buccal bone plate. In such cases, the presence or absence of soft tissue will determine whether or not an immediate implant procedure may be carried out in relation to the future clinical crown.

The recommended treatment workflow involves placing the implant 3.5 to 4mm deeper, then filling the vestibular gap with xenograft in the apical part of the alveolus and allograft in the coronal part to maintain space for bone and soft tissue, respectively. A gap of at least 2mm horizontally from the buccal bone is recommended, as is placing the prosthetic abutment immediately and definitively (the 'one-abutment-one-time' technique).

Depending on the implant torque achieved, immediate prosthetic placement (>30N), the use of a socket seal abutment (>15N), or primary tissue closure (<15N) are recommended.

Versatile implant systems that can adapt to different depth and concavity situations are preferable, as well as those that provide control over the emergence profile angles. These should not exceed 15° in the deep cervical zone but can be between 0° and 90° in the transitional area[iii].

Immediate implants can be placed in compromised sockets when they present with periapical pathology or small vestibular dehiscences but are not recommended for cases with large vertical defects.

The speaker defined the requirements and subsequent recommendations for immediate implantation in the aesthetic zone: adequate pre-planned 3D positioning using a guided approach; contour augmentation performed with hard and soft tissue grafting; the alveolus should be type I, 2A (maintained soft tissue contour and little bone dehiscence); use the 'one-time-abutment' approach; respect the shape and angles of emergence.

Concept of immediacy in the posterior regions

France Lambert (Belgium)

Today's patients are looking for dental treatments that take less time and ideally cost less, without compromising the final result. Modern digital technologies allow for new workflows and provide new opportunities for patients.

Immediate implant placement with a custom-made socket seal abutment (SSA) is a promising technique that has shown promising results at 1 year. Minimal bone remodelling (-0.19mm ± 0.31mm) has been reported, along with adequate maintenance of soft tissue outlines, horizontally and vertically[iv, v]. The patient's prosthesis can be delivered at the second appointment by copying the tooth profile using a digital impression taken on the same day as the implant placement. However, some discrepancies may occur such as the need for a new digital impression due to tooth movement. The technique also requires crown designs with a buccal cantilevered to follow the soft tissue profile and this may compromise cleanability.

The 'one tooth one time' (1T1T) concept is based on the immediate loading of a delayed or late implant with a screw-retained final prosthesis made of indirect composite PICNs (Enamic®). After two years, based on a case series in carefully selected patients, the concept displayed encouraging clinical and radiographical outcomes. All single-tooth restorations in the posterior area were successful and without any implant failures. However, although the results have not yet been published, some mechanical complications, such as the debonding of the prosthesis from the Tibase, can occur after five years.

[i] *Benic GI, Bienz SP, Song YW, Cha JK, Hämmerle CHF, Jung UW, Jung RE. Randomized controlled clinical trial comparing guided bone regeneration of peri-implant defects with soft-type block versus particulate bone substitutes: Six-month results of hard-tissue changes. J Clin Periodontol. 2022 May;49(5):480-495. doi: 10.1111/jcpe.13606.*

[ii] *Jung RE, Brügger LV, Bienz SP, Hüsler J, Hämmerle CHF, Zitzmann NU. Clinical and radiographical performance of implants placed with simultaneous guided bone regeneration using resorbable and nonresorbable membranes after 22-24 years, a prospective, controlled clinical trial. Clin Oral Implants Res. 2021 Dec;32(12):1455-1465. doi: 10.1111/clr.13845.*

[iii] *Pelekanos S, Vergoulis G. Clinical advances in implant transmucosal contouring for single implant sites. Prosthetic and biologic considerations. Int J Periodontics Restorative Dent 2022 accepted for publication*

[iv] *One-Tooth One-Time (1T1T): A Straightforward Approach to Replace Missing Teeth in the Posterior Region. Lambert F, Mainjot A.J Oral Implantol. 2017 Oct;43(5):371-377. doi: 10.1563/aaid-joi-D-17-00136. Epub 2017 Aug 4.PMID: 28777698 No abstract available.*

[v] *One-tooth one-time (1T1T), immediate loading of posterior single implants with the final crown: 2-year results of a case series. Lambert F, Eldafrawy M, Bekaert S, Mainjot A.Int J Oral Implantol (Berl). 2020;13(4):369-383.PMID: 33491368*

SESSION 9

What did we learn in 30 years of implant dentistry?

Round table discussion of cases with surgical/prosthetic/long-term complications with dental implants

Session summary

The session attempted to condense 30 years of dental implant knowledge into short and pertinent messages.

Learning outcomes

Attendees learned about trends in dental implant designs and practices, including key shifts in concepts over time. The session also explored questions that remain unanswered in the field, despite the great progress that has been made and the vast experience of the four speakers across their clinical practice, research and teaching work.

Relevance to daily practice

The session enabled attendees to locate themselves and their knowledge in the big picture of implant dentistry today, in the same way that a panoramic radiograph provides a global overview of a patient's oral condition.

Christoph Hämmerle (Switzerland)

Independent research led to the Tübinger, Brånemark, and ITI implant systems. More than 30 years ago, the fundamental ideas were already there. Their evolution over the last 30 years can be summarised as a series of general trends.

- The 'as many and as long as possible' concept gave way to fewer, shorter, narrower implants. This paradigm shift opened the way to more accessible, simpler, and less costly treatments, facilitating their extension into general practice. Meta-analyses showed the same survival rates and better PROMs in both the maxilla (versus sinus graft) and the mandible (versus vertical augmentation).
- As patients' and clinicians' demands increased and the volume of research data grew, prosthetically-driven implant placement overwhelmingly prevailed. In part, the GBR revolution has made this possible.
- Prosthodontics is undergoing significant change as zirconia is entirely different from previous ceramic materials, and CAD-CAM processes allow for greater precision.
- The era of computerised dentistry and digital data management has revolutionised professional workflows for diagnosis, planning, surgery and prosthodontics.

Björn Klinge (Sweden)

After 30 years, significant long-term evidence has been established to support some key principles:

- The long-term high survival and success rate of implants has continued to be demonstrated.
- Early loading has been shown to have the same clinical efficacy as conventional loading.

However, despite a huge amount of data and studies, a 2022 systematic review revealed considerable heterogeneity in outcomes and outcome measures, with primary outcomes often not clearly defined. Prosthetic outcomes, implant survival and patient-related outcomes were only infrequently reported.

This means that despite a vast amount of studies being published each year, we still need a lot of important additional information in order to practise safely.

The profound technological advances of the last decades, such as 3D imaging and planning, and CAD-CAM procedures, must never make us forget biology, which does not change so rapidly.

Peri-implantitis was recognised as a site-specific infection as long ago as 1987. However, this is still a source of academic dispute, even though practitioners can see that it is a major problem in their clinics. From the periodontist's point of view, peri-implantitis is a topic that should reshape our current implant practice, based on a number of key principles.

- Supportive treatment is mandatory for every implant patient. This means communicating to them from the outset that they have a shared responsibility for their own oral health, and hence for the health of their teeth and implants.
- Dentists should stop thinking about the oral cavity in isolation, and instead consider the whole body when diagnosing, treating and maintaining their patients.
- Assessing the tissues by probing during follow-up visits is essential.

Dennis Tarnow (USA)

Implant dentistry now has a history of 60 years, rather than the 30 mentioned in the session title. Despite decades of innovation, some implant shapes that are used today continue to be very similar to examples from the early years.

Early implants had the right shape in many respects, but many were polished, meaning they had the wrong texture for osseointegration. However, some did osseointegrate because their surface was biologically acceptable. There are rare examples of blade or screw implants placed by the pioneers 60 years ago that exhibited osseointegration and survived for many years, despite immediate loading and an inappropriate choice of material.

We now understand osseointegration as a dynamic process, made up of an interface that is always in flux at the two sides. Electron microscopy allowed us to study the osseointegrated surface in depth, revealing a layer of titanium oxide and then a layer of cement-like substances between the bone and the implant. This structure is always in continuous change.

Titanium surface topographies were soon addressed as a crucial factor. Surface roughness of less than 0.5µm (defined as smooth) did not integrate, and moderately rough surfaces, from 1.1 to 2.0µm, have become the standard.

Together with implant surface improvement, subtle but significant changes in implant shapes have also taken place over the last 30 years, allowing the dentist to select from different options to address a range of different clinical situations. However, each implant must be judged by its own long-term multicentre study for both survival rate and success rate, with success rate defined as no significant bone loss.

We are moving towards faster, easier, cheaper and better procedures. However, it's not only short-term outcomes that matter, but long-term success too. An implant design's capacity to minimise clinical complications must be considered alongside the risk of the patient developing peri-implantitis, which is closely linked to surface texture.

Niklaus P. Lang (Switzerland)

Linkow's blade implants were fibro-encapsulated rather than osseointegrated because they were made of stainless steel, a material that is less resistant to corrosion than titanium and hence much less biocompatible. Osseointegration (direct bone-to-implant contact), which was discovered independently by Brånemark and Schroeder, paved the way for modern implant dentistry.

When the bone-implant interface was studied with electron microscopy, direct bone-to-implant contact was corroborated, with no interposed material apart from the osseous matrix.

When SLA surfaces were compared experimentally with turned surfaces, where contact osteogenesis did not occur, more rapid bone-to-implant contact was shown in the first three months. Similar results were obtained with fluoride-modified surfaces, which also provided faster osseointegration. These types of surfaces support early loading protocols.

Human biopsies were carried out in a sequential study to test the impact of increased hydrophilicity. Again, significantly more bone was seen on the implant surface after the first four weeks, thereby providing additional support for early loading – although the amount of new bone was the same after six weeks for both surface types.

The speaker concluded by outlining a paper that had been submitted by him and his co-workers but hadn't been published at the time of the presentation. This described an experimental study using the dog model on the sequential osseointegration of 3D-printed implants, compared with conventional titanium implants. The results will shed light on how 3D-printed implants – which are much cheaper to produce than conventional implants – perform in terms of osseointegration.

SESSION 10

Digital articulation and function

Session summary

The session described a range of digital approaches for assessing articulation and function which are now available in the clinic.

Learning outcomes

Attendees learned how digital devices can be used throughout the treatment workflow in order to measure function and integrate it with other aspects of treatment. They learned about the current thinking on bruxism, along with new means of diagnosing and treating it.

Relevance to daily practice

Assessment of functional aspects using digital technologies significantly improves treatment outcomes, while reducing mechanical risks.

Overview of current technology: virtual face bow, virtual articulation and function, influence on the CAD-CAM design

Guillermo Pradíes (Spain)

The most important process in today's digital workflow is integrating files from different digital devices. STL models need to be merged with 2D JPG images, DICOM radiological files, OBJ files from facial scanners, and XML files that record dynamic jaw motion data.

In the eighties, a debate began about whether there was a need to use articulators and face bows. Recent systematic reviews concluded that prosthesis quality did not vary with or without the use of a face bow. Regarding articulators, dynamic jaw records are required instead of static positions, and these cannot be achieved using conventional articulators. Based on the speaker's experience, virtual articulators are now sufficiently advanced to use instead of mechanical ones.

Facial scanners have moved digital smile design from 2D to 3D. Integrating OBJ files from the facial scanner with the STL files requires landmarks, and these were initially incorporated in virtual face bows. Now, intraoral scanners can automatically integrate the files by capturing facial references, although the future is likely to feature dynamic facial scanners.

Virtual articulators track real jaw movements (Zebris, SICAT JMT+, ModJaw, Trios). They can record the patient's complete range of motion and enable restorations to be designed without premature contacts or interferences.

Until augmented reality and artificial intelligence are sufficiently advanced to solve the current challenges, the industry should facilitate digital protocols that are simple, efficient, and affordable.

Does new technology reduce the risk of wear, chipping or fracturing of implant restorations?

Duarte Marques (Portugal)

New technologies improve communication with patients during treatment planning by enabling them to visualise the entire restoration process with just one click. Thus, smile design applications and facial scanners facilitate the management of patient expectations. Despite their high levels of accuracy, facial scanners currently have a very modest evidence-base to back their use, and integrating them into the treatment workflow is difficult. However, they can facilitate patient profile and lip support analyses.

During the treatment phase, surgical guides increase predictability, with evidence of superior results in fully guided surgery. In single and partial implant-supported prostheses, scanners are as accurate as conventional methods, but more efficient and less time-consuming.

However, achieving a totally digital workflow is still a challenge in full-arch restorations. Scanning completely edentulous arches requires more precision with regard to aspects such as framework passivity, and photogrammetry is currently the best digital approach to full-arch impressions. Recent studies have supported the use of monolithic materials in full-arch rehabilitations to minimise ceramic chipping complications compared to veneered restorations.

During the follow-up and maintenance phase, restorations can be digitally checked for bite force (Teethan®), occlusion (T-scan®), and wear (by merging scanned images and analysing the overlap). These non-invasive digital devices provide complementary data that enables the practitioner to avoid the risk of overload and identify changes that could harm the prostheses over years of use.

Can virtual technology help to manage patients with bruxism?

Daniele Manfredini (Italy)

Over the last ten years, two new definitions of bruxism have been proposed by the IADR (International Association for Dental Research) resulting from consensus papers published in 2013 and 2018. The IADR also contributed substantially to the new Standardised Tool for the Assessment for Bruxism (STAB). Rather than being thought of as a single entity, bruxism is now considered to be multifactorial, with central, non-peripheral aetiology that is unrelated to dental occlusion. Viewed from this neurological perspective, teeth grinding is a result of muscle hyperactivity following nervous system excitation.

The diagnosis of sleep bruxism is traditionally made by polysomnography, and, more recently, certain common features have been observed with sleep apnoea. However, a comprehensive assessment of bruxism requires measuring masticatory muscle activity 24 hours a day, similar to a Holter monitor. Smartphone apps enable causal treatment to be delivered based on a cognitive behavioural approach that focuses on muscle relaxation. An additional benefit is that data from these devices can be collected centrally and analysed using artificial intelligence.

Viewing patients with bruxism from a systemic rather than a dental perspective is changing the treatment paradigm. New technologies help discriminate between different types of bruxers and their particular clinical manifestations.

SESSION 11, BATTLE OF CONCEPTS

Management of molars with an unfavourable periodontal and/or restorative prognosis

Session summary

The session outlined the different treatment approaches for managing a compromised molar.

Learning outcomes

Delegates learned how to choose between periodontal treatment, extraction and placement of a dental implant, and dental autotransplantation when treating a compromised molar.

Relevance to daily practice

Compromised molars are commonly encountered in daily practice, and knowing the different treatment options is mandatory in order to select the most appropriate approach.

The periodontal approach. When to go for periodontal regeneration and when to choose resective approaches

Ulrike Schulze-Späte (Germany)

Evidence-based guidelines are now available that set out treatment options based on the type of periodontal disease presented by each patient[1,2].

When taking the periodontal approach, after completing the first two treatment steps, a re-evaluation is carried out in step three and a decision taken as to which type of surgical treatment is appropriate: access flap, resective, or regenerative surgery.

Periodontal pockets and furcation involvement are significant risk factors for tooth loss, and treating them improves the prognosis. Better results are obtained with space-maintaining defects.

When selecting the biomaterial for grafting an amendable defect, a barrier membrane or enamel matrix derivate, or a combination of both is recommended. In both cases bone derived grafts may be used too.

Treatment guidelines indicate which type of materials to choose in what specific defect configuration and, in general, recommend the use of small access flaps.

Regarding furcations, there are modifying factors (such as gingival recession, the proximity of restorations, and the width or vertical extension of the defect) that can make surgical treatment difficult.

In addition to the regenerative options described in these cases, resective techniques such as osteotomy or root amputation can be considered. Orthodontic therapy is also an option for improving the periodontal situation.

In the long-term, periodontal patients, irrespective of the treatment performed, have diverse risk factors that could compromise the outcome. These include for instance: level of oral hygiene, smoking, diabetes, and degree of compliance with the maintenance programme.

With regard to costs, most literature shows a better cost-benefit ratio for the periodontal treatment of compromised molars, compared to dental implants, however, there might be country-specific differences.

The speaker concluded by emphasising that the specifics of each case should be identified before treating a periodontal patient, including assessment of their degree of compliance; carrying out treatment based on scientific evidence; and communicating effectively with the multidisciplinary team. Following treatment, setting out an individualised maintenance programme is also essential.

[1] *Sanz M, Herrera D, Kebschull M, Chapple I, Jepsen S, Beglundh T, Sculean A, Tonetti MS; EFP Workshop Participants and Methodological Consultants. Treatment of stage I-III periodontitis-The EFP S3 level clinical practice guideline. J Clin Periodontol. 2020 Jul;47 Suppl 22(Suppl 22):4-60. doi: 10.1111/jcpe.13290.*

[2] *Herrera D, Sanz M, Kebschull M, Jepsen S, Sculean A, Berglundh T, Papapanou PN, Chapple I, Tonetti MS; EFP Workshop Participants and Methodological Consultant. Treatment of stage IV periodontitis: The EFP S3 level clinical practice guideline. J Clin Periodontol. 2022 Jun;49 Suppl 24:4-71. doi: 10.1111/jcpe.13639.*

The implant approach. How should we manage the periodontal patient to further receive dental implants? When is it worthy to extract the molar and to place an implant?

Giulia Brunello (Italy/Germany)

Dentists and patients have different perspectives, and as a result their treatment goals can differ. Generally, patients wish to achieve a good level of function and aesthetics, through short and painless treatments provided at a reasonable cost. Factors that are important for dentists include treatment predictability, reduced chair time and lower complication risk.

The speaker presented a case involving a patient with stage IV periodontal disease who had received several dental implants over 17 years. She explained the treatment decisions that had been made at that time, and the basis for subsequent implant therapy. As the patient was missing the third molars, tooth autotransplantation was not an option. Due to the furcation involvements and the presence of infrabony defects, periodontal regeneration was not considered a predictable treatment option. Despite the history of periodontitis, this particular patient ended up having an implant survival rate of 100%.

Although immediate implants in periodontally infected sites present an increased risk, implant treatment is a valid option for stable periodontal patients who receive regular maintenance care, provided that appropriate periodontal therapy is performed before the implant procedure.

Short implants or bone regeneration techniques could be considered where there is insufficient bone.

To conclude, the speaker returned to the range of treatment goals that are important to patients and dentists, and used this to illustrate why placing an implant might be the best option. In this specific case, implant placement was associated with a good long-term outcome. From the dentist's perspective, an implant is likely to be predictable in a stable periodontitis patient and unlikely to lead to patient complaints, while being a satisfying treatment choice from a professional point of view.

Dental autotransplantation. Can the use of digital tools improve the outcome and predictability? Is there any age limit?

Ernest Lucas-Taulé (UK)

Since peri-implantitis is a common disease, alternatives to dental implants are again being considered.

Intentional replantation, apical surgery, surgical extrusion, and autotransplantation are some options to be considered prior to tooth extraction, with the aim of delaying implant placement for as long as possible.

In a tooth with a poor prognosis and where extraction is unavoidable, autotransplantation can be performed if a donor tooth is available. Wisdom teeth with open or closed apices are ideal donor teeth, as are premolars.

The regenerative viability of the periodontal ligament, the degree of apex development, the root anatomy of the donor tooth, and the endodontic technique are the most significant factors linked to the success or failure of the treatment.

A protocol was described in which a replica of the donor tooth is digitally planned and 3D printed in order to enable the alveolar socket at the recipient site to be accurately remodelled prior to extraction of the donor tooth. This approach has survival rates of 96.9% and 93% respectively in open and closed apices after three years of follow-up . However, donor teeth with closed apices are three times more susceptible to inflammatory root resorption and twice as susceptible to ankylosis.

The likelihood of success does not seem to be affected when the recipient site is damaged, as may occur after the extraction of a tooth with a vertical root fracture in which the buccal bone wall is involved. No statistical differences have been found in terms of survival and success rates compared to intact sockets .

The speaker then illustrated an autotransplant in a healed site, rather than a post-extraction socket, which used the same approach. This illustrated how the convexity that is initially lost due to the absence of teeth is recreated in the vestibular area.

Digital planning, 3D printing, and guided surgical protocols are the key tools in current dental autotransplantation techniques.

SESSION 12

Digital vs conventional technologies in the fabrication of restorations

Session summary

The session reviewed a range of alternative restoration materials, along with associated processes for fabricating prostheses, with an emphasis on 3D printing.

Learning outcomes

Attendees learned about the evidence base for the clinical use of monolithic zirconia in implant-supported prostheses, the different features of 3D printing and milling, and the indications for and limitations of promising new restorative materials.

Relevance to daily practice

Due to the speed of change in the field of restoration materials, practitioners need up-to-date information on the different materials available for implant reconstructions, along with different manufacturing techniques.

Digital fabrication procedures (3D printing and milling) - where are we today?

Marta Revilla León (Spain)

At the start of her presentation, the speaker invited the audience to 'think beyond the print button', explaining that two aspects should be considered in order to capitalise on the advantages of the printing technologies: the printing strategy and the clinical application.

Additive production involves two steps: printing and post-processing. For predictable printing, both the manufacturing trinomial and the printing strategy must be considered.

The manufacturing trinomial is comprised of the type of technology, the type of printer, and the type of material used. All three influence the accuracy, composition, colour and mechanical properties of the printed device, whether it is made of polymer, metal or ceramic.

The printing strategy defines the parameters that correspond to the type of technology being used, along with the supportive material and the slicing methods. The strategy directly influences the accuracy, surface roughness, fit discrepancies, mechanical properties and microbial adhesion of the printed devices. Optimisation of the printing strategy should be based on the manufacturing trinomial (technology, printer and material), combined with the clinical application.

For example, some studies have concluded that the most favourable printing angle for obtaining optimal mechanical properties in temporary resin crowns is 0° (perpendicular to the load direction). By contrast, other research shows good results when crowns are printed at different angles, including 30° or 45°. However, all studies concluded that a print orientation of 90° should be avoided.

As one printing parameter will influence more than one physical factor, it is necessary to adjust the parameters based on the intended clinical application of the component to be printed. There is currently no scientific evidence to underpin a single, definitive printing configuration.

Recent research indicates that post-processing, which also depends on the manufacturing trinomial, directly influences the material's mechanical properties. Rinsing type and rinsing time both influence the flexural strength of the material being tested. In all cases, artificial ageing following post-processing led to a 20% drop in flexural strength. Printed materials seem to be more porous and prone to ageing faster compared with milled materials.

In terms of clinical applications, there are three main groups of devices: multi-layer, hybrid and customised.

Multi-layer devices are fabricated using two or more materials, combining the mechanical properties of the different materials. These include indexes and mock-ups composed of between one and four pieces, each of which provides complementary information, as well as dual-material night guards with a resilient material on the inside and a more rigid type on the outside.

Hybrid devices combine milling and printing technologies to harness the benefits of each process. For example, the speaker illustrated a printed framework with screw-retained milled cones used as a manufacturing verification bar to facilitate an accurate intraoral scanning in a full-arch implant-supported maxillary rehabilitation. A second

example illustrated a two-part magnet-retained resin structure with a hybrid fabrication. It consisted of a ground eggshell resin used to make the temporary prosthesis and a printed support part used to accurately place the structure on the palate. This was used to rehabilitate an entire maxillary jaw and was designed to allow both parts to be positioned in a reproducible way, with the parts connected using magnets.

Customised devices have been printed for specific clinical applications, for example, to record jaw movement or to facilitate facial scanning and the creation of virtual patients. A technique was illustrated that combined facial scans with intraoral scans, using a custom-printed scan body to position the scans of the teeth accurately. The person's lip motion was then tracked and recorded using specialist motion software, enabling the creation of a virtual copy of the patient.

New restorative materials and their indications and limitations

Burak Yilmaz (Turkey)

The session began by comparing milling and 3D printing when making restorations using a variety of different materials. While milling had been confirmed and validated in clinical practice for most of the materials being discussed, the picture for 3D printing was less clear.

Accuracy studies comparing 3D printing with the milling of wax, resin crowns and bridges show similar results, although with slight deviations in the 3D printing group, which could lead to additional chairside adjustments.

The speaker went on to discuss whether the fabrication accuracy, wear behaviour, colour stability and surface roughness of printed and reinforced milled resin crowns could be established for prolonged, even permanent, use.

In a recent study, similar fabrication accuracy and wear behaviour results were obtained with milled PMMA, milled graphene-reinforced PMMA, milled reinforced composite resin and 3D-printed composite resin crowns. However, the printed resin group required more chair-side adjustments and showed lower colour stability and roughness after brushing and drinking coffee.

For full-arch restorations, the material type is determined by the number and distribution of implants; their location; the patient's expectations; physical properties, and interocclusal relationships.

Zirconia restorations have become established as a good aesthetic and functional alternative to metal-ceramic for full arches. With monolithic zirconia frameworks, porcelain chipping is also avoided.

To prevent veneering fractures, reinforced PMMA or composite resin CAD-CAM fabricated and cemented on a metal framework, could be an affordable alternative that outperforms dentures.

The material should be selected according to the interocclusal space. In situations of minimal bone loss with a maintained prosthetic space, 6–10 mm, metal-ceramic, zirconia-ceramic or monolithic zirconia can be used. The same materials are suitable when bone loss is mild, 10–12 mm, but in this case, the prosthesis should mimic the lacking soft tissue. In cases of severe bone loss (more than 13 mm), zirconia with pink ceramic or metal-resin (hybrid prosthesis) is indicated. Milled polymer resin or printed composites can also be used.

Milled polymers such as PEEK or PEKK represent a promising alternative, even improving several patient-centred outcomes, although clinical studies are needed to confirm their long-term success. Printed resins in full-arch restorations are less well-researched and lack long-term evidence of their performance.

Monolithic restorations supported by implants: single unit to full arch

Francesco Mintrone (Italy)

Monolithic restorations, and more specifically zirconia restorations, offer faster fabrication times, lower costs and higher fracture resistance than conventional restorations. Zirconia that includes a greater proportion of yttrium oxide has increased translucency (resulting in better aesthetics), but reduced mechanical strength.

Zirconia discs with graduated levels of yttrium oxide provide an optimal combination of strength and aesthetics, enabling the appearance of a natural tooth to be more closely simulated.

Monolithic restorations are suitable for arches, bridges, single posterior and single anterior applications. However, obtaining a high-quality, mimetic restoration with zirconia in the anterior region is a challenge. Aesthetics in the anterior region can be improved by using the layering approach, but veneering zirconia with porcelain involves a higher risk of chipping, due to a difference in the thermal expansion coefficient between zirconia and porcelain .

One of the main advantages of zirconia is its biocompatibility in the transmucosal area of the restoration. Zirconia and titanium outperform monolithic lithium disilicate in terms of gingival cell behaviour . However, the technician must carefully polish the transmucosal zone during staining and glazing.

For multiple unit partial restorations, the volume of the connectors must be managed during the design stage, with different volumes indicated in the anterior (over 12 mm3) and posterior zones (over 16 mm3). During fabrication, the connectors should be nested in the most resistant part of the zirconia disc, in line with variable concentrations of yttrium oxide described above and its impact on strength.

The speaker provided the following guidelines for full arch restorations:

- check textures and curvatures before sintering
- avoid layering in the incisal third of the tooth. This can lead to an excellent aesthetic result, but is very risky mechanically
- if layering the incisal third of the tooth, restrict the layering ceramic to the buccal side
- during the occlusal adjustment, avoid very rough burs and polish well to prevent wear of the antagonists.
- the most important element for the long-term prognosis is a passive fit

SESSION 13

Can advanced technologies help in the maintenance of implants and implant restorations?

Session summary

The session described technologies that are expected to be available in the coming decades and will help with the maintenance of implants and implant restorations.

Learning outcomes

Attendees learned about a range of approaches that have the potential to address several current challenges in implant dentistry.

Relevance to daily practice

New technologies that will benefit daily practice are on the horizon. The session provided insights on how practitioners can adapt their day-to-day clinical practice to anticipate these.

Overview of technological possibilities for monitoring (intraoral impressions and monitoring software)

Ivo Krejci (Switzerland)

Peri-implantitis, caries and periodontitis are infectious, chronic, incurable diseases with a pandemic-like prevalence in industrialised countries. These three diseases are all linked to biofilms, with local symptoms produced by dysbiosis.

Subclinical site-specific detection and monitoring are crucial to avoid the onset of clinical symptoms and to control their progression.

Classic screening tools used in dentistry and implantology – mirrors, probes and bite-wing X-rays – are inappropriate for detecting subclinical symptoms. New diagnostic methods have to focus on subclinical symptoms because when these diseases advance and become clinical their treatment is inexorably surgical.

A range of modern subclinical, site-specific, radiography-free digital imaging systems are available for detecting and monitoring peri-implantitis. These are based on ultra-high-frequency ultrasound (UHFUS) and optical coherence tomography (OCT). When combined with digital optical scanning and interpreted by deep learning algorithms, they allow disease progression to be monitored at a subclinical level.

If we can detect the first pathological signs, we can carry out site-specific treatment before symptoms become clinically relevant. Subclinical therapies to re-establish symbiosis include guided biofilm therapy (GBT), bacteriocins, probiotics, and photoactivated disinfection (PAD ROS).

Software for risk assessment including artificial intelligence. How to inform patients?

Christoph Ramseier (Switzerland)

Digital technology is already widely used in our daily practice, and will play an increasingly important role in risk assessment. The next development will be the inclusion of artificial intelligence (AI). The relevant question is how to use it.

The global burden of chronic diseases is high (60% of people died of a chronic disease in 2015, and that figure is expected to rise to 77% by 2025), and they have a significant impact on the world's economy (>1,000 billion USD in the next ten years). For this reason, most digital developments focus on tackling the burden of chronic diseases.

Positive behavioural changes, like a healthy diet, physical activity, and avoiding bad habits like tobacco, have been proven to reduce chronic disease progression. In periodontology, there are also risk factors to avoid and a need for behavioural support to reduce them. Electronic support can significantly help with these behaviour changes.

We are living in a digital world. There are more cellular connections on earth than the global population. Therefore, mobile devices can significantly help promote behavioural changes in order to reduce risk. They provide a simple way to reach a massive number of people. eHealth (electronic health) and mHealth (health applications running on mobile devices) are potentially enormously important.

Health apps provide feedback to users allowing closer control of their status. However, the evidence for the diagnostic capability of existing health apps is currently scarce. Web-based patient education is another time- and cost-effective alternative for risk factor management. It has been available for longer than apps, and as a result the public have more experience of using web-based patient education tools.

AI can be used to predict the development of diseases and to inform the patient and professional, including prompting the patient to seek treatment. Accumulation of this data contributes to precision medicine and machine learning, and can allow patients to be categorised according to their risk level, thereby individualising their treatment requirements and communicating with them about their susceptibility and personal risks. Furthermore, AI can update this categorisation as patients implement behavioural changes to improve their health.

How do you think maintenance of implants will be done in the future?

Mariano Sanz (Spain)

A significant trend in dental implant development is the design of 'intelligent implants'. These will have easily integrated surfaces; be able to maintain or even improve bone apposition; and have antibacterial and anti-inflammatory properties. This goal is getting closer already with nano-coating functionalisation of the surfaces. However, safety concerns must still be addressed, since nano-particles may move into the body.

An important issue is the need for a deeper understanding of the aetiopathogenesis of peri-implant diseases. It is well known that biofilm is the main trigger for chronic inflammation that leads to tissue destruction and that several risk factors – modifiable or not – are associated with the development of the disease. The bacteria that are involved in periodontitis and peri-implantitis are usually compared, but the biofilm in each condition differs. A key differential factor is the role of the host response. Inflammation around teeth and implants is similar, but the process is not the same. The inflammatory reaction is deeper and more aggressive around implants in the face of the same bacterial challenge.

Today, the technology exists to, for instance, assess genetic susceptibility to peri-implantitis by looking for relevant single nucleotide polymorphisms. However, research has been unable to identify any that are sensitive and specific enough to be used as biological markers in order to detect the individuals that need our care.

Better knowledge of chronic inflammation will help to understand the pathobiology for diagnostic, preventative and therapeutic purposes.

The future of peri-implantitis treatment is closely connected with precision medicine. Currently, guidelines are based on samples studied in clinical trials. However, what needs to be analysed is data from the individual patient so that specifically identified targets can be used in a targeted therapy exclusively for that patient. To achieve this, we need tools to identify highly susceptible patients, subclinical diagnostic tools to monitor the disease before it manifests, and treatment tools to target the specific diagnosis to the specific susceptible patient. We do not have these tools now, but we will have them in the next 30 years.

The role of the patient is changing too. Today, patients play a more active role and take greater control of their health. Personalised prevention already exists via a variety of health wearables, and personalised medicine will follow. This will be further refined with the development of precision medicine.

PLENARY 3

Does investing in new technology improve patients' and clinicians' lives?

Session summary

The session evaluated the value of digital innovations in daily practice, especially with regard to guided surgery and digital impressions. It looked at the economic, clinical and patient-related factors.

Learning outcomes

Attendees learned about factors that would help them assess the costs and benefits of a range of new technologies, including the length of time required to achieve a return on their investment, benefits for the clinician and patients, and scenarios for which digital technologies are not recommended.

Relevance to daily practice

New technology is increasingly important in dentistry and is here to stay. Practitioners must regularly assess which products and systems to invest in. This presentation provided a picture of what is available at the moment, along with the advantages, disadvantages and limitations of different technologies.

Audience survey:

- more than 80% of the audience used CBCT 'always' or 'most of the time' when planning implant placement
- however, only 27% used computer-assisted surgery.
- 38% rarely or never used an intraoral scanner
- only 3.6% used chairside milling, with 65% of attendees having their restorations made in small local labs

Changing a practice from conventional to digital

Stefan Wolfart (Germany)

Is all the investment into digital technologies worthwhile? Does the technology really improve the lives of our patients and our patient care?

Henri Hagenmüller (Switzerland)

New technologies

The digitalisation of dentistry is accelerating quickly, and there are three main drivers for this. The first is the consolidation of practices into larger groups, with big clinics investing in new technologies to optimise their workflows.

The second driver is patients, who like new technologies as they offer improved comfort and enable them to play a more active role in their treatment. Patients also typically like to be treated at a technology-focused clinic.

The third group driving the uptake of technology is general dentists, who are performing increasingly specialised treatments, such as providing aligners or implants. They are more inclined to invest in technology to facilitate these treatments.

Dentists' preferences for adopting digital technologies vary with age and their level of clinical experience. Having more experience makes them more inclined to be cautious about investing in new technology.

When considering new technology, the outcomes it will deliver should be clearly understood, along with benefits from the patient's perspective. Henri Hagenmüller talked about his belief in value-based healthcare, a concept that is being increasingly widely applied in procuring medical technology. From a value-based healthcare perspective, any new technology should improve treatment outcomes, provide increased patient comfort, improve the workflow and reduce costs. However, this is not always the case.

Digital impressions

While the primary concern of patients is the outcome of their treatment, and while they trust the dentist's chosen approaches and techniques, all things being equal, patients would choose digital impression systems because they are more comfortable than conventional alternatives.

From the dentist's perspective, digital impressions are advantageous because they integrate into the digital workflow, reduce treatment time, and are the best option for single-tooth restorations and short-span bridges. However, when natural abutments are present, and if margin preparation on natural teeth is subgingival, using an intraoral scanner cannot be unreservedly recommended. In multiple edentulism, when there are not enough reference points, intraoral scanning alone is insufficient, and recording intermaxillary relationships requires the additional use of conventional tools. Furthermore, the use of intraoral scanners is still not recommended for implant-supported full-arch prostheses.

Overall, intraoral scanners improve the quality and efficacy of both treatment and the patient experience while fully integrating into the digital workflow. Although cost is the main barrier for many dentists, the time saved will pay for the investment. The amount of time taken to recoup initial costs will, however, depend on the frequency of use and the number of patients treated.

Despite the cost barrier for some dentists, intraoral scanners have captured a growing market share, with penetration as high as 50% of clinics in the US, which is leading the way in their adoption.

Freehand versus guided surgery

From the patient's perspective, guided surgery provides additional confidence in the treatment being provided. From the clinician's perspective, it is a valuable tool for communicating the treatment plan to the patient and obtaining informed consent.

Surgery becomes faster and safer, with computer-guided surgery offering more precision in achieving the preplanned implant positions, thus facilitating the success of the prosthesis. Since the accuracy of static and dynamic systems is similar, but both are significantly more accurate than freehand implant placement, switching to guided surgery is recommended, and the evidence supports it as a worthwhile investment.