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Immediate restoration in the digital workflow

case report
From digital planning to the mock-up and final restoration

cone beam supplement
Dynamic navigation in fully edentulous maxilla
The innovative design of the MIS MGUIDE and its surgical kits simplifies digital dentistry. The use of CAD/CAM, allows for a prosthetically driven, safe and accurate procedure. To learn more about the MIS MGUIDE, go to www.mis-implants.com

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Dear Readers,

The art and science of dentistry has dramatically changed with the advent of digital tools that are currently available for the diagnostic, treatment planning and restorative phases for each patient that we are privileged to treat. While clinicians worldwide predominantly continue to practise as “analogue” dentists, more and more have adopted these technological advances as they understand the benefits of the new digital workflow.

Of course, today in 2018, it is difficult to remain totally within the digital workflow without having some analogue component either in the operatory or in the hands of the dental laboratory technician. Perhaps the workflow starts with the first patient visit, where we can capture the initial clinical presentation with a video or still picture with either a sophisticated camera or our smartphone—all digital. If the patient will require dental implants, crown and bridgework, or porcelain laminate veneers, it is always necessary and desired to capture the pre-existing intraoral condition with either an analogue impression or intraoral digital scan. However, a physical impression or poured stone cast will require conversion to a digital file. This process has become the foundation of our digital universe, via the standard triangulation language or STL file. What happens next is crucial to the ultimate success of any case: the diagnosis and treatment planning phase through a merging of technology, combining the skill of both the clinician and the dental laboratory technician. It is the correlation of the different data sets with sophisticated software applications that provides the foundation for success.

Currently, we can create an analogue or digital wax-up to analyse and assess and compare the before to the desired after before ever touching the patient with a drill or a scalpel. In order to accomplish this task, we must have the technical knowledge of the software applications that are available today for both the clinician and the laboratory technician. Whether creating a CAD/CAM restoration for a natural tooth preparation or a surgical guide for implant placement, the workflow has forever changed through our digital tools. Therefore, the question of whether to merge or not to merge may be completely transparent to many clinicians, but an essential and necessary part of the digital workflow equation today. It is the goal of this publication to expose our readership to state-of-the-art concepts and applications to enhance the everyday practice of dentistry. Happy New Year to all, and enjoy the articles contributed by expert clinicians from around the globe.

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2018—Changing the way we communicate

Chris Barrow, UK

It is always simultaneously tempting and dangerous to make predictions about the future of dentistry. A recent personal review of the articles I have written over the years revealed that I seem to get things right half the time. The challenge is figuring out which half! So, looking at 2018, what does the landscape look like?

I am conscious that you, dear readers, are an international community and so I will resist the temptation to have a good old-fashioned moan about post-Brexit Britain moving into the Dark Ages while our politicians attempt to leave the EU without leaving it. Or, for that matter, riffs and rants about dictatorial pothead leaders playing dice with our futures to further their own agendas, whether that is in politics, media or sport.

Actually, what I want to talk about is us, you and me, ordinary folk going about our business, pursuing careers, raising families and trying our best to make sense of the world around us. What I want to address is how I think our lives are going to change in the next 12 months, as dental practice owners, managers and team members, but also as members of the public.

The Internet of things

The smartphone has changed the way we live (Apple-manufactured or otherwise), and the most dominant economic forces on earth are no longer nation economies; they are Google, Microsoft, Amazon, YouTube and Facebook (and let us not forget WeChat—the largest social media platform in China). The figures for the combined revenues of and cash mountains owned by these organisations are mind-boggling, and the way in which those financial reserves are reinvested will have the biggest impact on the world we live in by Christmas this year.

Globally, figures for e-commerce over Christmas 2017 were a record, and as we learn to purchase every conceivable commodity online, the high street trembles, looking at those real estate and staff costs under the watchful eye of their investors and accountants.

There is more to it than just e-commerce though. We are learning to live online, reading, watching, listening, reviewing, commenting, liking and connecting to an extent that our parents could never have imagined. Buying more and more.

India is registering 40 million new smartphones every 12 weeks and is representative of a connective revolution that is gender, age, religion and socio-economically egalitarian—everyone is getting online.

With over 75 per cent of website visits to my clients’ dental sites now taking place via smartphones, how your website looks on a desktop no longer mat—
ters. How it looks and performs on a smartphone is what counts.

Dentistry is going to have to learn how to communicate with patients online to a greater extent than ever before. I am already seeing tech start-ups looking at the dental space and thinking about how best to keep patients informed of their oral health and how to make their patient experience seamless.

Wearable technology

This brings me to how that communication will take place (between patient and dentist and vice versa) as the year unfolds. The start-ups I mentioned are developing electric toothbrushes that send data back to an application that monitors not just brushing technique but also simple issues around patient health. Data is analysed and then sent back to the patient’s smartphone to provide dental health education.

Notwithstanding the issues around the confidentiality of that data and its storage, we are seeing the beginning of wearable tech playing a major role in healthcare generally. E-zines and blogs like those published by Dr Bertalan Meskó (the Medical Futurist) show that progress is exponential. Cue the watch that can feed back dental health information, allowing both patient and dentist to predict problems before they occur.

Getting attention

The science and technology are compelling for early adopters and frightening for laggards. Any debate as to the future of digital dentistry has long since left the late adopters behind, and I am seeing many of my clients racing to keep up with change. However, independent dentistry is a business whose purpose is to solve patients’ problems, but whose objective has to be to make an ethical profit, so we cannot ever afford to be distracted from the focus on attracting the right type of new patient and from charging the right price for what we do. These are the challenges that occupy the majority of my time with clients, and the changes I have referenced in the first part of this article have to be embraced in order to survive and prosper in business.

Prices

The interesting irony here is that digital dentistry, once we have moved from the innovation stage of the adoption cycle, through early adopters to the late majority, will actually have the effect of reducing the cost of providing dental healthcare and treatment. I have clients right now who innovated in digital dentistry and are seeing a consequent improvement in their bottom line profit as costs of sales reduce. That may not sound like great news for laboratory and materials suppliers, but that is the inevitable consequence of technological progress.

I am also realistic enough to agree that little of that cost-saving is being passed on to the patients at the moment. That is because we are still in the early stages of the digital adoption cycle, and the pressure on prices will not occur until much later in that cycle. It is time, indeed, for the innovators to make hay. Prices will stay firm in 2018; costs can reduce.

An interesting year ahead

2018 will see the continued acceleration of the impact that digital communication and commerce will have on our lives. The dental practice of the future will fully embrace not only digital dentistry but also the way in which they connect with their patients online. The smartphone will be the place that happens, until smartphones are replaced by the next generation of wearable devices.

contact

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Immediate restoration in the digital workflow

Drs José Eduardo Maté Sánchez de Val & José Luis Calvo Guirado, Spain

Endosseous implants have consistently achieved high success rates in partially and completely edentulous patients. Clinicians have therefore begun to offer selected patients immediate and early implant placement options. The long-term success of immediately loaded implants has been investigated in animals\textsuperscript{1,2} and humans,\textsuperscript{3} with encouraging results. However, most of the studies were performed with implants placed in the anterior mandible, where primary implant stability is easily achieved.

In the anterior maxilla, clinicians seeking to load implants immediately must be concerned not only about achieving adequate implant stability, but also about fulfilling patients’ desires for aesthetic results that resemble the natural dentition. To achieve this, it is essential to maintain as much of the bone height around the implant neck as possible, controlling the biologic width.\textsuperscript{4}

Bone loss around the implant always occurs when an abutment is connected to a dental implant at the crestal level. It has been demonstrated that the gap between the implant and the abutment has a direct effect on bone loss, regardless of whether the two parts are connected at the time of integration of the implant or later.\textsuperscript{5} This phenomenon occurs whether the implant is loaded or not and appears to be unrelated to the type of implant surface.\textsuperscript{5,6} Hermann et al. demonstrated that crestal bone remodels to a level about 2.0 mm apical to the implant-abutment junction (IAJ),\textsuperscript{5,7,8} while Lazzara and Porter reported crestal bone levels about 1.5 to 2 mm below the IAJ at one year after restoration.\textsuperscript{2} Tarnow et al. documented a horizontal component that results in 1.3 to 1.4 mm of resorption from the IAJ to the bone in a horizontal direction.\textsuperscript{5,11} When the biologic width is in the wake of such osseous changes, the soft-tissue architecture, including the appearance of the papillae, is affected. The interproximal bone influences the interdental papillae by acting as a guidepost for the soft-tissue contours.

In addition to several ideas aimed at limiting crestal bone resorption, the concept of platform switching appears to be promising. Platform switching refers to the use of a smaller-diameter abutment on a larger-diameter implant collar. This type of connection shifts the perimeter of the IAJ inward toward the central axis of the implant.\textsuperscript{12,13} The time limitation in implant treatments is an important bias when it comes to planning and developing rehabilitation therapies. In this sense, the inclusion of new materials that allow for immediate loading in a single session without having to replace prosthetic components facilitate optimal results in terms of gingival attachment and minimize peri-implant bone loss after prosthetic abutments have been manipulated. Ceramically reinforced PEEK is of great interest as it allows a single attachment to be retained in place throughout the entire treatment and avoids handling-related overload. Its mechanical and physical properties have been tested in animal experiments and in humans, showing the material to be ideal for one-step Xprotocols.

The physical and mechanical properties of the prosthetic components govern the success of the long-term restoration. Resistance to occlusal loads such as masticatory movements and parafunction should be adequate to allow denture survival. The modulus of elasticity and bending resistance of the material should be adequate to prevent undesirable fractures or micromovements.\textsuperscript{13}

Furthermore, components used require a high degree of biocompatibility to prevent the occurrence of abnormal tissue reactions such as initial peri-implant inflammation and mucositis, which may result in more severe complications such as peri-implantitis.\textsuperscript{14} Polyetheretherketone (PEEK) is a polymer from the polyaryletherketone family, a relatively newly developed family of high-temperature thermoplastic polymers having of an aromatic backbone interconnected by ketone and functional ether groups.\textsuperscript{1} In medicine, PEEK has been found to be an excellent substitute for titanium in orthopaedic appli-
cations and has been used in dental implants, provisional abutments, implant-supported bars, or clamp material in removable dentures. PEEK is biocompatible and has a natural tooth-coloured appearance, unlike metal reconstructions.

Ceramically reinforced PEEK materials were developed to improve the mechanical properties and the colour of dental restorations. One of these materials is BioHPP (bredent medical, Senden, Germany). In abutments, the BioHPP is directly injection-moulded to a titanium base and forms a monolithic hybrid abutment called “elegance” abutment, with a screw seat in titanium for long-term stability plus a resilient body made of ceramically reinforced PEEK.

To shorten procedures and eliminate intermediate prosthetic steps, digital technologies were developed that allow the intraoral scanning of models and attachments with a high degree of precision and reproducibility. Chairside CAD/CAM systems such as CEREC (Sirona) allow direct scanning of the abutments and the realization of immediate crowns. The ceramically reinforced hybrid abutments with a PEEK body and titanium base are easily scannable, yielding restorations of high quality with a good prognosis. Problems caused by removing and reinserting different prosthetic components—such as loss of soft tissue or early marginal bone loss—are reduced or eliminated. This article demonstrates the reliability of the single-session protocol using digital methods for scanning and producing crowns complemented with platform switching and evaluates the peri-implant soft-tissue seal.

Material and methods

Animal protocol

An animal experiment was conducted to evaluate an implant placement protocol with immediate loading using PEEK and CEREC and to assess the peri-implant soft tissue. Forty-eight blueSKY implants (bredent medical) were placed in healing bone. Thirty-two SKY elegance abutments (bredent medical) were used in the test group and sixteen titanium abutments in the control group (Fig. 1).

A randomization scheme was generated using the website www.randomization.com. The Ethics Committee for Animal Research of the University of Murcia, Spain, approved the study protocol, which followed the guidelines established by Directive 2010/63/EU on the protection of animals used for scientific purposes. Six American Foxhound dogs approximately one year of age, each weighing approximately 13–15 kg, were used in the study.

Day 0 (first stage)

The animals were pre-anaesthetized and taken to the operating theatre where, at the earliest opportunity, an intravenous catheter was inserted into the cephalic vein and propofol was infused at the rate of 0.4 mg/kg/min as a slow constant-rate infusion. Conventional dental infiltration anaesthesia was administered at the surgical sites. Premolar and molar extractions (P2, P3, P4, M1) were performed in both mandibular quadrants of each dog.

Figs. 2a–c: Animal study protocol with immediate loading. Figs. 3a & b: Linear measurements (in mm): peri-implant mucosa (PM), buccal bone crest (BC), lingual bone crest (LC), top of the implant shoulder (IS), bone crest (BC), distance from the implant shoulder at buccal bone crest (IS-BC), distance from the implant shoulder at lingual bone crest (IS-LC).
Day 0 (surgical planning and protocol)

A full-thickness incision was made with a No. 15c blade, combining an intrasulcular with a crestal incision in the palatal area. A full flap was reflected using a periodontal blade, combining an intrasulcular with a crestal incision. The manufacturer’s implant placement protocol for blueSKY implants (bredent medical) was followed. After placement, the site was closed using 4/0 polypropylene single sutures.

- Postsurgical care: All patients received anti-inflammatory treatment (NSAID), ibuprofen 3 x 400 mg/day for three days and two chlorhexidine 0.12 % rinses per day for two days.
- Implants: Ten blueSKY implants (bredent medical) 3.5–4 mm in diameter and 10–12 mm in length were randomly assigned and placed crestally in the premolar zone (P1 or P2) of the maxilla.
- Abutments: Ten BioHPP SKY elegance abutments (Fig. 4) were connected at the time of implant placement (immediate loading). The SKY elegance is a hybrid abutment with a body made of BioHPP moulded directly onto the titanium base without a gap. These abutments are used for single-session immediate-restoration treatments, since they combine the properties of a temporary and a definitive abutment, i.e. it is not necessary to change the abutment. All crowns were realized using the CEREC system (Sirona, Bensheim, Germany) with IPS Empress CAD CEREC/InLab (Ivoclar Vivadent, Schaan, Liechtenstein) feldspar ceramics. The crowns were cemented with Relyx self-adhesive cement (3M ESPE, Neuss, Germany). All implants were loaded using a platform-switching protocol.

Analysis

- Radiographical analysis: Standardized radiographs were taken on the day of placement and at one, three and five months using a one-position paralleling system. The analysis was performed with the ImageJ software (Wayne Rasband, NIH, Bethesda, USA). The distances between the platforms and the points of first bone contact were recorded.
- ISQ stability analysis: Stability measurements were made on day 0 to assess the primary stability of the implant required for the immediate-loading protocol. An ISQ of 65 was defined as the minimum value needed (Osstell Mentor; Osstell, Göteborg, Sweden).
- Mucogingival analysis and clinical findings: The bleeding index was recorded one, three and five months after implant placement by means of a special peri-implant probe. Moreover, any post-insertion loss of peri-implant mucosa or height were recorded. Bleeding on probing (0 = absent, 1 = present) was measured at one, three and five months. The insertion length was measured with a conventional plastic probe by one examiner per examination period and six measurements for each implant. The results were presented as means of six measurements.

Day 60 (second stage)

After drilling, the sequence of placement of four implants by hemi-mandible was randomly planned (using randomization as mentioned). The implants were inserted in healed bone at the sites of the mandibular premolars and molars (P2, P3, P4, M1), with an insertion torque of 30 Ncm or more (Figs. 2a–c).

Analysis (eight weeks after implantation)

- Histological and histomorphometric analysis of the bone-to-implant contact area (BIC) with linear measurements in millimetres: peri-implant mucosa (PM), buccal bone crest (BC), lingual bone crest (LC), top of the implant shoulder (IS), bone crest (BC), distance from the implant shoulder at buccal bone crest (IS-BC), distance from the implant shoulder at lingual bone crest (IS-LC)(Figs. 3a & b).
- Primary stability was evaluated by measuring the ISQ by Osstell Mentor at the time of placement.
- The radiological analysis was performed using a standardized protocol.

Human protocol

The research protocol called for recruitment of subjects among patients referred to the Department of General Dentistry, University of Murcia, Spain, during an 18-month period. All those in need of anterior oral rehabilitation that would include single-implant placement were invited to take part in the study, which was overseen by the institutional review board.

Additional criteria for inclusion in the study included sufficient bone height and width to allow the placement of implants with a minimum diameter of 4.1 mm and a minimum length of 10 mm and an occlusal pattern that allowed for bilateral stability. All subjects needed to have at least 3 mm of soft tissue (vertically) to allow for bilateral stability. All those in need of anterior oral rehabilitation that would include single-implant placement were invited to take part in the study, which was overseen by the institutional review board.

Implants: Ten blueSKY implants (bredent medical) 3.5–4 mm in diameter and 10–12 mm in length were randomly assigned and placed crestally in the premolar zone (P1 or P2) of the maxilla.

- Postsurgical care: All patients received anti-inflammatory treatment (NSAID), ibuprofen 3 x 400 mg/day for three days and two chlorhexidine 0.12 % rinses per day for two days.
- Implants: Ten blueSKY implants (bredent medical) 3.5–4 mm in diameter and 10–12 mm in length were randomly assigned and placed crestally in the premolar zone (P1 or P2) of the maxilla.
- Abutments: Ten BioHPP SKY elegance abutments (Fig. 4) were connected at the time of implant placement (immediate loading). The SKY elegance is a hybrid abutment with a body made of BioHPP moulded directly onto the titanium base without a gap. These abutments are used for single-session immediate-restoration treatments, since they combine the properties of a temporary and a definitive abutment, i.e. it is not necessary to change the abutment. All crowns were realized using the CEREC system (Sirona, Bensheim, Germany) with IPS Empress CAD CEREC/InLab (Ivoclar Vivadent, Schaan, Liechtenstein) feldspar ceramics. The crowns were cemented with Relyx self-adhesive cement (3M ESPE, Neuss, Germany). All implants were loaded using a platform-switching protocol.

Analysis

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- Statistical analysis: Values were recorded as mean ± standard deviation (SD) and median. The non-parametric Friedman test was applied to compare sample values. The level of significance was set at p < 0.05.

The success of immediately placed implants has been investigated in various studies with encouraging results already. But what is rather simple in the anterior mandible needs more attention when it comes to the anterior maxilla. Here, clinicians are oftentimes concerned not only about achieving adequate implant stability, but also about fulfilling patients’ desires for aesthetic results that resemble the natural dentition. To shorten procedures and eliminate intermediate prosthetic steps, digital technologies were developed that allow the intraoral scanning of models and attachments with a high degree of precision and reproducibility.

Rationale for immediate restoration

Research has shown that, for two-stage implants, marginal bone loss occurs primarily during the first year following placement and that this has mainly been attributed to the establishment of biologic width adjacent to the implant. Some studies have shown that bone remodelling can be biologically ascribed to bacterial colonisation of the microleakage present in a two-stage implant system and subsequent inflammation. The crestal bone loss around implants has both horizontal and vertical components. Following abutment connection, crestal bone has been shown to recede from the implant/abutment junction microgap by 1.3 to 1.4 mm, measured horizontally.

Animal study

Immediate implant placement and restoration minimise the harmful contamination of the peri-implant biological space and the resultant bone resorption. Immediate loading requires that certain prerequisites are met. The best way to objectively quantify the feasibility of immediate loading clinically is to analyse implant stability either by measuring the insertion torque, recommended at above 30Ncm, or using the Osstell Mentor ultrasonic stability measuring device that returns ISQ values, which if above 65–70 allow us to load immediately with some confidence (Tab. 1).

Changes in the peri-implant tissue can be quantified by histomorphometry and histological evaluation in experimental studies (Tabs. 2 & 3). The radiological results of the animal experiments are documented in Figures 5a & b and Table 4. The histological connection between the soft tissue and the SKY elegance abutment is tight. In combination with platform switching, this produces a high level of bone stability at the implant collar (Figs. 6a & b).

## ISQ value

<table>
<thead>
<tr>
<th>Insertion</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean ± Sd</strong></td>
<td><strong>Median</strong></td>
</tr>
<tr>
<td>BioHPP abutment</td>
<td>74.46 ± 4.55</td>
</tr>
<tr>
<td>Titanium abutment</td>
<td>74.19 ± 4.29</td>
</tr>
</tbody>
</table>

Tab. 1: Friedman test of ISQ analysis and measurements at initial day. Results as mean and medians. No significant differences with p < 0.05 were found.

## BIC (%)

<table>
<thead>
<tr>
<th>Titanium</th>
<th>PEEK</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean ± Sd</strong></td>
<td><strong>Median</strong></td>
<td></td>
</tr>
<tr>
<td>PM-BC</td>
<td>2.74 ± 0.41</td>
<td>3.11 ± 0.26 *</td>
</tr>
<tr>
<td>PM-LC</td>
<td>2.91 ± 0.03</td>
<td>3.71 ± 0.18 *</td>
</tr>
<tr>
<td>PM buccal-IS</td>
<td>2.35 ± 0.87</td>
<td>2.95 ± 0.53 *</td>
</tr>
<tr>
<td>PM lingual-IS</td>
<td>2.65 ± 0.43</td>
<td>3.57 ± 0.38 *</td>
</tr>
<tr>
<td>IS-BC</td>
<td>2.04 ± 0.11 *</td>
<td>1.53 ± 0.21</td>
</tr>
<tr>
<td>IS-LC</td>
<td>1.93 ± 0.14 *</td>
<td>1.41 ± 0.19</td>
</tr>
</tbody>
</table>

Tab. 2: Friedman test of BIC values. Comparison between titanium and hybrid PEEK-Ti abutments. Follow-up eight weeks after implant placement. Data shows mean, Sd and medians. No significant differences with p < 0.05 were found.

## Linear measurement in millimetre:

- PM-BC: distance from the peri-implant mucosa to the buccal bone crest; PM-LC: distance from the peri-implant mucosa to the lingual bone crest; PM buccal-IS: distance from peri-implant mucosa to the implant shoulder in the buccal aspect; PM lingual-IS: distance from peri-implant mucosa to the implant shoulder in the lingual aspect; IS-BC: distance from the top of the implant shoulder to the first bone-to-implant contact in the buccal aspect; IS-LC: distance from the top of the implant shoulder to the lingual bone crest. Values as mean ± Sd and median.
Rationale for platform switching

The switch in implant platform diameter prevents apical migration of the epithelial attachment and soft-tissue in growth at the top of the platform by reducing bacterial migration and, consequently, of soft-tissue ingrowth and peri-implant bone loss. Marginal bone loss is drastically reduced and the objective criteria for peri-implant inflammation are greatly improved.22

Human study

Table 5 lists clinical parameters from human studies at one, three and five months. Figures 7a to h show radiological findings at one, three and five months. Figures 8a and b show the customisation of a SKY elegance abutment.

Rationale for single-stage treatments

Successive insertions and reconnections when restoring an implant according to conventional protocols provoke bacterial invasion and colonisation of the biological space and mark the onset of marginal bone loss. Offering treatment in a single session provides the biological benefits described and saves time and money, increasing patient satisfaction.23

Titanium and PEEK values

<table>
<thead>
<tr>
<th></th>
<th>Titanium Mean ± Sd</th>
<th>Titanium Median</th>
<th>PEEK Mean ± Sd</th>
<th>PEEK Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buccal bone</td>
<td>1.96 ± 0.21 *</td>
<td>1.96</td>
<td>1.43 ± 0.11</td>
<td>1.43</td>
</tr>
<tr>
<td>Lingual bone</td>
<td>1.78 ± 0.33 *</td>
<td>1.78</td>
<td>1.28 ± 0.43</td>
<td>1.28</td>
</tr>
</tbody>
</table>

Tab. 4: Radiological analysis of bone first contact distance to the implant shoulder. Values as mean ± Sd and median. Non-parametric Friedman test analysis. (*) Significant differences with p < 0.05.
Intraoral scanning

Fabricating a CEREC crown requires a step prior to intraoral scanning, namely the adaptation of the prosthesis support. The SKY elegance abutment can be cut and customised in the mouth, more or less like dentine, which means a reduction in time and cost. Also required are a delicate surface polish and preparation of the pro-

<table>
<thead>
<tr>
<th></th>
<th>1 month</th>
<th>3 months</th>
<th>5 months</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First bone contact to platform (mm)</td>
<td>0.50 ± 0.41</td>
<td>1.07 ± 1.12</td>
<td>1.17 ± 0.87</td>
<td>0.044</td>
</tr>
<tr>
<td>ISQ value (%)</td>
<td>68.10 ± 4.93</td>
<td>69.34 ± 1.22</td>
<td>71.43 ± 3.01</td>
<td>0.12</td>
</tr>
<tr>
<td>Bleeding on probing (0–1)</td>
<td>0.21 ± 0.01</td>
<td>0.16 ± 0.05</td>
<td>0.06 ± 0.02</td>
<td>0.014</td>
</tr>
<tr>
<td>Insertion length (mm)</td>
<td>3.64 ± 1.02</td>
<td>4.19 ± 1.05</td>
<td>4.11 ± 1.02</td>
<td>0.029</td>
</tr>
</tbody>
</table>

Tab. 5: Human study, values as mean ± Sd. Non-parametric Friedman test. Values of bleeding on probing (0 = no bleeding on probing and 1 = bleeding on probing).

Intraoral scanning

Fabricating a CEREC crown requires a step prior to intraoral scanning, namely the adaptation of the prosthesis support. The SKY elegance abutment can be cut and customised in the mouth, more or less like dentine, which means a reduction in time and cost. Also required are a delicate surface polish and preparation of the pro-
files to be recognised by the intraoral scanner. The restoration margins should be well-defined and prepared to the gingival or subgingival level. The SKY elegance abutment anatomy allows to create a proper emergency profile that can be customised for each patient (Fig. 9). The next step is to obtain relative isolation, with any hint of moisture removed, to ensure a good intraoral impression. The savings in terms of time and money are evident, as is the increase in patient comfort.

**Fabricating a CEREC crown**

The choice of restorative material to use on an implant requires familiarity with the way masticatory forces are transmitted via the crown and abutment to the bone-to-implant contact area. Biomimetics is the study of the materials that allow us to adapt prosthetic elements to their intended proper function, based on similarity to the receiving environment. Knowing how forces are transmitted is essential to avoid loads that can lead to bone loss or implant failure.

The SKY elegance is a hybrid abutment with a titanium base and a ceramically reinforced PEEK body, so the transmission of forces from the crown to the implant proceeds gradually and progressively. This helps avoid crown fractures due to internal or external tension between a ceramic crown and an all-ceramic abutment.

Using a hybrid abutment approach, there is a choice of resin or ceramic base materials, from feldspar ceramics to ceramics with a silicate base. This still leaves the interface to consider; here, the crown is best connected to the abutment using a resin-based composite cement that facilitates the gradual transmission of forces; also, these cements are more stable biomechanically than ionomer cements or derivatives (Figs. 10a & b).

**Conclusion**

The establishment of a stable peri-implant seal to maintain gingival health around implant-supported restorations must be a primary objective of any implant treatment. The single-stage approach allows the establishment of an initial peri-implant soft-tissue attachment that will be preserved as the abutment is not removed; hence, no violation of the biologic space will occur, allowing for greater tissue stability and yielding better aesthetics and an improved bone and soft-tissue stability.

The integration of digital technology (CEREC) in the implant/restorative process shortens the treatment time and reduces the cost for the patient. The SKY elegance abutment helps treat patients with predictable results.

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

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Anterior no-preparation ultrathin veneers

Drs Feng Liu & Xing Liu, China

Introduction

No-preparation ultrathin veneer is one of the most minimally invasive restorations. Its thickness ranges from 0.3 to 0.5 mm. In the right circumstances (Figs. 1 & 2) it can show excellent aesthetic appearance, and provide long-term stability and health of soft- and hard-tissue.

The overall structure of ultrathin veneer is flexible, in that its neck can gradually change from thick to thin, and the border can be knife edge-like or thin round-convex (Figs. 3 & 4).

Manufacturing inlays, onlays, crowns and veneers chairside with a CAD/CAM system has become established in most dental offices. This technique can produce immediate scan, design, milling and restoration quickly and conveniently. It is the same for the no-preparation ultrathin veneer. For chairside CAD/CAM systems, CEREC is the most developed system.

The biocopy mode, which is widely used for restoration design, has target contours such as wax-up. In this mode, the operator should scan the original tooth shape in the mouth or on the model first, then wax up and re-scan the wax-up shape into the CEREC system. Both optic impressions will transfer into the virtual model, and match to each other to obtain the restoration contour information. Depending on the 3-D data, chairside milling can be complete in few minutes. Post-milling processes usually contain shaping and polishing. In some conditions, it may be necessary for additional staining and glazing.

Fig. 1: No-preparation veneer is adapt to the teeth with flat surface. Fig. 2: When the teeth have apparent curvature, no-preparation veneer may have weak contact area. Micropreparation veneer is more appropriate.

Fig. 3: Ideal gradual thinning no-preparation veneer. Fig. 4: Acceptable round-convex no-preparation veneer margin with a little thickness.
Case report

A 57-year-old female patient presented, whose dentition had apparent colour changes and abrasions that had occurred gradually over time. These problems resulted in an unaesthetic smile and made her appear older than her age. She also made a request for a highly comfortable and minimally invasive treatment plan, and expected an improvement in the colour and shape of her upper anterior teeth, which would rebuild her smile and self-confidence (Figs. 5 & 6).

It was found that due to the abrasion which had occurred over several decades, the labial surface was plane and flat, the incisors had been worn to a straight line and also had abrasion-associated defects (Figs. 7 & 8). The no-preparation veneer that would occupy the “outer space” of the teeth would eliminate the slight wrinkles around the lips. These effects were part of the patient’s expectations and the treatment plan was accepted.

Taking the treatment requirement and oral condition into consideration, the patient was prepared for the ultra-thin no-preparation veneer. Digital Smile Design (DSD) was done based on the pre-operation photos (Figs. 9 & 10), and the patient was satisfied with the aesthetic appearance of the design.

The patient wanted her teeth colour to seem natural and to disguise the discoloration. The treatment plan was confirmed as CEREC designed and manufactured Mark II (VITA) veneer of 0.3mm thickness, 1M1 shade, and the material was chosen for its excellent aesthetic performance and translucency.

The manufacture of no-preparation veneer could depend on the precise wax-up of pre-operation. This step could save the patient’s chairside waiting time; the biocopy technique can simplify the design process; milling the restoration with a 0.5mm original thickness and polishing after milling will decrease the risk of milling defect.

The exact process can be concluded as:
1. Obtain a precise pre-operation impression, and make the model. Use a CEREC scan to obtain information about the abutment teeth (Figs. 11 & 12).
2. Depending on the DSD result, make a wax-up on the pre-op model. The thickness of wax-up should be from 0.3 mm to 0.5 mm. Get the biocopy scan of the wax-up model, and match accurately with the pre-op model (Figs. 13–15).
3. Setting the margin of the abutment teeth, the marginal edge line is not fixed because of the no-preparation technique. The direction of insertion should be defined first, which can cover most areas of the labial surface, incisor edge and adjacent surfaces. The border of the covered area should be the margin of the restoration (Fig. 16).
4. Shape formation of the restoration: Copy the target shape of the biocopy model, the restoration should be calculated automatically. If there is any defect, it can be adjusted and corrected by the tools. If there are any areas not thick enough for 0.5 mm, it should be added to 0.5 mm to avoid fractures during the milling process (Figs. 17 & 18).
5. Modification and polishing of the initial restoration to 0.3 mm thick after milling. And fine polishing of the final restoration (Figs. 19 & 20).
6. Intraoral try-in, fine adjustment and cementation (Figs. 21–24).
Fig. 11: Precise pre-operation model.

Fig. 12: Pre-operation scan.

Fig. 13: Wax-up based on pre-operation model.

Fig. 14: Biocopy model.

Fig. 15: Biocopy optic model accurately match with pre-operation model.

Fig. 16: Setting the insertion direction and margin of the restoration.

Fig. 17: Finished restoration design.

Fig. 18: Designed restoration prepared to mill.

Fig. 19: Ready veneers before cementation.

Fig. 20: The thickness of the finished restoration is 0.3 mm.

Fig. 21: Try-in: frontal view of upper anterior dentition.

Fig. 22: Try-in: incisal view of upper anterior dentition.

Fig. 23: Try-in: lateral view of smile.

Fig. 24: Try-in: lateral view of smile.
7. Four-year follow-up and recheck. The restorations are as excellent as before and the margins are tightly sealed, the colour is stable, there is no margin colorised or whole colour changing. The patient is very satisfied with the aesthetic performance and function. A charming smile appearance has given her more confidence and vigour (Figs. 25–32).

Conclusions

The no-preparation veneer is a kind of restoration with high precision requirement and manufactured difficulty. It is usually finished in laboratory. Getting benefit from chairside CAD/CAM techniques, immediate restorations in one appointment can be achieved; dentists can invite the patients to observe the process of restoration design and manufacture, and even get involved into the design. Patients may feel that they are participating in the treatment, establishing an emotional connection with the restoration, which may also make them more easily accept and love their restoration. The value of increasing the satisfaction should not be ignored.

Biocopy design is the combination of traditional aesthetic design and digital virtual design. It is also the most convenient and fast technical route. Nowadays, 3-D virtual technique is becoming more and more established. Using 3-D techniques directly to make a virtual design may also get wonderful restoration performance, it can be predicted that this pattern will become the mainstream of digital aesthetic design in future.

about

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From digital planning to the mock-up and final restoration

Presentation of a modern work concept on the basis of a veneer fabrication

Dr Cyril Gaillard & Jérôme Bellamy, France

Introduction

The demand for cosmetic treatments is also increasing in dental practices. The Internet provides patients with virtually limitless access to a wealth of information on this topic. And with it comes an increase in expectations. This can pose a conundrum to the dentist: patients want to be promised the desired results, yet, they should not be given undue expectations in the run-up to the treatment.

The challenge

One of the challenges in day-to-day dentistry is the fact that the mock-up presented to the patient is produced from a wax-up, and is often not consistent with the final outcome of the treatment (e.g. ceramic veneers). Several research studies have been initiated to overcome this problem. The SKYN concept is a result of this research.

The solution

The SKYN concept is based on a unique approach: it uses natural tooth shapes to create a mock-up directly in the patient's mouth. A wax-up is created on the basis of tooth shapes that reflect the anatomy and morphology of natural teeth in terms of height, width, curvature and surface texture. The predictability of the result is ensured by using CAD/CAM technology to scan the mock-up, make adjustments in the oral cavity, and then mill the veneers to achieve lifelike results. The reproducibility of the mock-up and the accuracy of the result arise from, among others, the performance of the CAD/CAM system, allowing the expectations of the patient to be met both promptly and effectively.

CAD/CAM technologies have brought about a revolution in dentistry. They enable the efficient manufacture of customised ceramic veneers with high accuracy and within a short period of time.

Figs. 1a & b: Initial situation. Severely stained restorations in the upper anterior region (a). It does not bother the patient that her upper lip is asymmetrical and her gum line is visible when she laughs (b).
Furthermore, the restorations present an accurate copy of the aesthetic wax-up. The different working steps involved in the SKYN concept are demonstrated in the following clinical case.

Case report

Initial situation
The patient visited the practice with a request that mainly concerned aesthetic criteria. She felt that her anterior restorations looked too yellowish and their shape did not fit in. The restorations had been in her mouth for several years and the patient wanted to change them.

First, a series of digital pictures was taken to examine the situation more closely. The patient had a high smile line. However, the fact that her gums were visible when she smiled and her upper lip was asymmetrical did not bother her (Figs. 1a & b). The periodontal apparatus was healthy. The soft tissues did not show any signs of abnormalities either.

Treatment planning
We recommended the patient to have the anterior region restored with veneers stretching from teeth 15 to 25, and advised her to have the premolars included in the restoration to achieve a harmonious appearance. The patient agreed with our proposal. We drew up the following treatment plan:
- Wax-up using composite veneers to reproduce the natural shape and texture of the teeth.
- Mock-up according to the SKYN concept using a light-curing nanohybrid composite (IPS Empress Direct).
- Intraoral digital data scan of the mock-up.
- Preparation of the teeth with the help of the mock-up.
- Digital impression of the preparation using an optical camera.
- Fabrication of the temporaries.
- Machining of the glass-ceramic veneers (IPS Empress CAD).
- Incorporation of the veneers.

Fabricating the wax-up
The aim of the ceramic veneers was to give more volume to the teeth. The teeth should appear stronger and longer. Adjusting the dental proportions was requisite to creating a harmonious appearance between the teeth and the smile on the patient’s face. To create the wax-up, we used the SKYN models (“Anterior Model Set” by Dr Jan Hajtó) as reference (Fig. 2). This is a reproduction of natural teeth. Upon request by the patient, tooth selection was performed with the help of both the Digital Smile Design programme and the VisagiSMile design and visualisation software.

Fig. 2: SKYN models (according to Dr Jan Hajtó) for the fabrication of the wax-up. Fig. 3: The composite (IPS Empress Direct) is applied into the silicone key. Figs. 4a & b: The composite veneers created with the help of the silicone key show a natural shape and surface texture on the model. Tooth 11 (a). Teeth 15 to 25 (b). Fig. 5: The mock-up is placed in the mouth. The surfaces are being reworked slightly. Fig. 6: Completed mock-up. Photos and videos are used to assess it. Figs. 7a & b: The surfaces of the mock-up are being reworked slightly. Side view (a). Front view (b). Fig. 8: Targeted preparation of the teeth with the mock-up in place. Fig. 9: Close-up of the prepared anterior teeth.
Transfer to the mock-up

We created a silicone key of the vestibular surfaces with the help of the wax-up and applied a thin layer of composite material into the key using a spatula (IPS Empress Direct; Fig. 3). Once light-cured (Bluephase with Polywave LED), the resulting composite veneers for teeth 15 to 25 were placed on the model and stabilised with wax (Figs. 4a & b). Once the wax-up was finalised, it was duplicated and cast in stone. We created a silicone key from this model to assist the dentist in the preparation of the teeth. The silicone key was created in two steps using two different silicone materials, one with a high hardness (Silico Dur, Cendres+Métaux) and the other with a low hardness (3M ESPE Express). The silicone key served to create the mock-up and the temporaries.

Tooth preparation and data transfer to the lab

The mock-up was inserted with the help of the silicone key and the surface texture was reworked using a polishing system (Astropol; Fig. 5). The aesthetic effect was validated with photographs and videos. The patient could also inspect the pictures (Figs. 6 & 7). Then, the teeth were prepared using a ball-shaped bur whilst the mock-up was in place (Galip Gürel 2003) (Fig. 8). This procedure meets the requirements of minimally invasive dentistry. An impression of the prepared teeth (Fig. 9) was taken using an intraoral scanner and the temporaries were fabricated with the help of the silicone key.

At this point, the dentist is required to take two optical impressions: first, an impression of the prepared teeth and, second, an impression of the temporaries in the mouth. In addition, a conventional silicone impression of the prepared teeth is taken. The dental technician will use this impression to produce a physical model to check the fit and contact points of the milled ceramic veneers.

Creating the final restoration

For the CAD construction, the two data sets (temporaries, prepared teeth) were superimposed in the software (Fig. 10). Subsequently, the shape of the temporaries was matched to the preparation margins. Each component was examined (preparation margin, thickness, contact points, etc.) separately before the data was transmitted to the milling unit for machining (Fig. 11). For the fabrication of the veneers, we decided to use the IPS Empress CAD Multi blocks, which feature a lifelike shade transition from the dentine to the incisal. We selected a block in shade A1. Each veneer was positioned in the block in such a way that the translucency of the incisal area matched our requirement. Once the veneers were milled, we checked their fit on the prepared dies of the model and assessed their contact points with each other. The surface texture was lightly reworked (Fig. 12). To achieve a highly aesthetic result, we additionally characterised the veneers with Stains and Essence materials (IPS Ivocolor) before we glaze-fired them (Fig. 11).
Seating the ceramic veneers

At the try-in, the shade and fit were checked. All ten veneers showed an excellent fit in the mouth. The next step was adhesive bonding. Prior to the bonding procedure, a rubber dam was placed to isolate the treatment field and to keep it dry. As the natural teeth were not discoloured, we were able to use a translucent luting composite (Variolink Esthetic) to insert the veneers (Fig. 13). The veneers were seated using the following protocol:

- The restorations were etched with hydrofluoric acid for 60 seconds, rinsed under running water and dried with compressed air.
- The veneers were then conditioned with silane. A universal primer (Monobond Plus) was applied, allowed to react for 60 seconds and dried.
- The prepared teeth were etched with 37% phosphoric acid gel (Total Etch) and rinsed.
- Fluoride-releasing Excite F DSC adhesive was applied (without light-curing).
- The veneers, which were coated with luting composite, were seated.
- The luting composite was tack-cured for 1 to 2 seconds (Bluephase with Polywave LED) to facilitate the clean-up of excess luting composite.
- Final light-curing of all veneers for 40 seconds.
- Removal of the rubber dam and occlusal check. At the last step, the restorations were polished.
- The ceramic restorations show an appealing aesthetic appearance in the mouth and harmonize beautifully with the smile of the young patient. The planned situation was accurately transferred to the final restoration (Figs. 14–16).

Conclusion

Modern materials in aesthetic dentistry allow pleasing results to be achieved with considerably more ease than before. It may be considered a substantial progress that the resulting restorations meet not only high aesthetic requirements, but also essential functional criteria. State-of-the-art planning tools, digital auxiliaries, CAD/CAM-supported manufacturing and promising materials lead to excellent results and ensure high patient satisfaction. However, regardless of the relatively new CAD/CAM technologies, the skills and experience of a seasoned dental technician will remain indispensable.

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Fig. 14: Close-up of the veneers after seating. Fig. 15: Texture and tooth shape look natural and harmonise with each other. Figs. 16 a & b: Lip appearance (a) and portrait picture (b) with the completed restorations. The expectations of the patient have been met.
Digital workflow: From planning to restoration

Drs Jan Kielhorn, Siegfried Hoelzer & Björn Roland, Germany

High-quality treatment results that are individual to each patient can be drawn up for the edentulous jaw in the combination of innovative procedures for implant surgery and reasoned prosthetic concepts. In this article, the authors describe the digital workflow for the tried-and-tested immediate restoration concept SKY fast & fixed and discuss the possibilities of transverse screwing, amongst others.

Introduction

Digital technologies help simplify the process involved in implantology and often accelerate the process, whilst at the same time offering a high level of accuracy. High-precision results can be achieved in an efficient manner by combining the digital production of the superstructure. In addition to digital know-how, proven fundamentals are promising factors. This includes patient compliance, a sound dental and dental technical knowledge, surgical and manual skills, the perfect materials and products and close consultation within the treatment team. On the basis of this, modern computer-guided procedures offer an optimum basis for re-interpreting tried-and-tested implant prosthetic concepts such as the SKY fast & fixed (bredent medical). This article shows the digital workflow using a patient case as an example.

Anchoring

The “fixed” treatment option has become important for edentulous jaws and jaws that are becoming edentulous. Many patients state that they are not satisfied with the classic removable total prosthesis; in particular, if they lose the last few teeth they still have. They want an aesthetic, functional implant prosthetic restoration. However, areas of limitation, such as suboptimal anatomical circumstances, are often encountered. In order to be able to avoid bone augmentation, measures where
possible in these cases, as well as problematic implant positions and limited aesthetics, suitable implant prosthetic solutions are sought. The SKY fast & fixed concept is one of those.

In principle, a distinction is made between screwed and cemented prostheses in fixed implant prosthesis. In an edentulous jaw, we generally prefer a screwed reconstruction. In contrast to cementing, the main benefit is the fact that the restoration can be removed from the implants without problems. For example, if an abutment were to loosen or a repair be required, the restoration can be carried out with ease. What is more, hygiene measures are simplified, which is an important aspect, particularly with regard to professional implant aftercare.

The treatment concept

In the SKY fast & fixed therapy, the implants are inserted in the local bone in such a way that they can be restored immediately after insertion with a fixed temporary bridge. Osseointegration is supported by means of primary interlocking. In order to be able to insert the implants into the jaw without augmentation measures where possible, meticulous preoperative investigations and an implant component especially designed for use in this situation are pre-requisites. This objective can generally be achieved by means of angled insertion of the posterior implants. The immediate temporary restoration is guaranteed by means of screwing onto the implants, resulting in stable interlocking. The pre-fabricated interim restoration is made from plastic. Due to the relatively low elasticity module, the load application on the implants can be cushioned during the healing phase. Following successful osseointegration, several prosthetic configurations lead to the desired result. The primary requirement of the restoration is the tension-free fit on the implants.

Transverse screwing

Due to the type of screwing of the dental prosthesis, a choice can be made between two variants in the described concept. In addition to occlusal screwing, a bonding element is also offered for the transverse (horizontal) screwing. This offers an aesthetic benefit in many situations. Orthograde screwing—screw channel emerging occlusally, often especially means a compromising solution in the anterior region in terms of aesthetics. The seal of the screw channel in the visible region of the front teeth limits the dental technician with regard to the aesthetic design. Adequate alternatives include normal bonding elements in the region that is not visible.

The SKY fast & fixed abutment with horizontal circumferential groove is available for this and is restored using a pre-fabricated transverse screwed coping. This type of screwing involves bolting in the true sense of the word. The thread for the bolt screw is located in the bridge framework. The bolt screw and the cylindrical surfaces form a unit (Fig. 1). Fixation is carried out as three-point fixation, which prevents tilting. Thanks to the slightly inclined position of the bolt screw, the prosthetic coping is “pressed” onto the abutment platform without showing a gap once it is tightened. The treatment team benefits from the transverse bonding of the dental prosthesis with the implants with excellent aesthetics and a complete lack of tension.

Patient case

The 48-year-old patient came for a consultation in the practice due to an unsatisfactory removable dental prosthesis in the maxilla. Teeth 11 to 23 were still present, but
severely damaged periodontally. A fixed restoration was requested. The high mobility grade of the teeth would not permit a stable anchoring of a new dental prosthesis. Therefore, following a discussion with the patient, extraction of the teeth and immediate implant prosthetic restoration was planned in accordance with the SKY fast & fixed concept.

Planning

As a planning base, a situation model was initially produced (Fig. 2). This was digitalised in the laboratory scanner (D800, 3Shape) and an STL data set was created. In order to validate the implant positions, the two-dimensional X-ray image only yielded limited information about the available bone (Fig. 3). A three-dimensional image (DVT) was therefore compiled, without a scan template being required for this.

Thanks to the allocation of space for the anatomical structures, a detailed analysis of the jaw was now possible. Using the planning software (coDiagnostiX, Dental Wings), six implants were planned in the local bone based on the visualisation of the anatomical structures and the digital set-up (ideal position of the prosthesis; Fig. 4). By angling the distal implants, anatomically vital structures were circumvented and augmentation measures avoided.

The angle of the implants is between 30 and 45 degrees for the SKY fast & fixed concept. In addition to the individual surgical components, special prosthetic superstructures are integrated in the complete concept. A drilling template for the navigated implant insertion and a temporary restoration were created from the planning software for the immediate restoration (Figs. 5 & 6). In order to guarantee accurate positioning in the mouth, both objects were designed with a palate, whereby the temporary dental prosthesis is produced with target fracture sites, in order to guarantee a palate-free design of the screwed bridges (Figs. 7 & 8).

Implantation and immediate restoration

At the time of the surgical procedure, the existing teeth were extracted atraumatically and six implants (blueSKY, bredent medical) were inserted with the help of the drilling templates. The implants were inserted in a primary stable manner with a torque of between 30 to 45 Ncm (Fig. 9). The abutments were applied and the area sutured. The pre-fabricated temporary restoration was inserted without an impression needed. The palate provided support in order to ensure the reliable referencing of the mouth. The temporary restoration was bonded with the abutment for a tension-free intraoral adhesion and lining. The temporary restoration was then processed and produced (Figs. 10 & 11).
Manufacture of the final restoration

The postoperative progress was free of problems. The patient was able to participate in social activities without restriction during the healing phase. Osseo integrated implants and stable hard- and soft-tissue conditions were seen after three months. Following a pick-up impression, the temporary restoration was removed and the implant situations were modelled using an individual tray (Figs. 12–14). A screwed restoration was also planned for the final dental prosthesis. The framework made from non-precious-metal alloy (NEM) should be veneered using a high-quality composite material. In order to give the aesthetic design ample space, transverse screwing (bolting) of the dental prosthesis with the implants was considered. In principle, a restoration screwed onto implants places a high demand on the framework fit. In complex restorations of this type, this involves a considerable challenge in the production procedure. Due to the implant’s rigid bond with the bone, even a low amount of force can cause considerable displacement of the implants.

The highest level of precision is required from both the dentist and the dental technician. Digital manufacturing technologies come into play here. These offer a perfect framework fit and a high material quality—the icing on the cake is that production is also efficient. In the CAD software, the data relating to the pick-up impression is superimposed on the data relating to the implant master model (matching) and a framework is constructed in a smaller anatomical crown shape. In the software, the bonding elements for the transverse bolting were integrated in the framework (Figs. 15–17). CAM milling of the NEM framework was carried out in the laboratory’s own high-performance milling machine. The thread for the transverse bolting was then incorporated within the cavity incorporated in the bridge framework (Fig. 18).

A framework try-in in the mouth confirmed that this was the perfect fit. The individual veneering of the restoration was carried out using pre-fabricated veneers (novo.lign, bredent medical). The multiple-layer veneers (high-impact PMMA composite) and the light-curing composites support the simple manufacture and the individual aesthetic characterisation. In order to achieve efficient progress, the cushioning properties against chewing pressure of the composite are combined, which are important to consider, particularly in implant prostheses.

Figs. 12–14: The implant model for manufacturing the final restoration (transverse screwed bridge).

Figs. 15: CAD construction with the bonding elements for the transverse bolting.
Fig. 16: Digitalised set-up.
Fig. 17: Construction of the framework in a smaller, anatomical crown shape.
Insertion and aftercare

The bridge was fixed using the prosthetic copings (SKY uni.cone transverse prosthetic coping) and bolting in the practice. As this was carried out as three-point fixation, tilting or rotation of the dental prosthesis can be ruled out. Thanks to the slightly inclined position of the bolt screw, the prosthetic coping is “pressed” onto the abutment platform without showing a gap once it is tightened. This elegant type of fixation combines high-quality aesthetics with a tension-free position. The “screw channels” are located in the palatine region of the cervical area, which does not lead to any aesthetic or functional impairments. Following final fitting, the functional, aesthetic and periodontal hygiene factors were subjected to a final check and the patient was discharged from the practice with an aesthetic, fixed restoration (Figs. 19 & 20). The superstructure was designed in such a way as to ensure optimal hygiene was guaranteed.

The patient was given comprehensive instructions in this regard. An important pre-requisite for the long-term success and therefore for a stable periodontal situation is aftercare in the practice. For the first year after treatment with an implant, in particular, a continuous, specific recall system is recommended. The patient had a consultation in the practice every three months. Once the superstructure was removed, professional cleaning and disinfection of the components of the dental prosthesis bearing the implant were carried out. The peri-implant soft tissue remains exemplary to date (Fig. 21).

Summary

The success of a total concept such as SKY fast & fixed is based on a coherent procedure. From the surgical components to the prosthetic materials—the philosophy is to combine the components in an optimal manner. This requires a high level of cooperation between the practice and laboratory, which can be experienced more intensively and effectively in the digital workflow. Various concepts are offered for the final prosthetic restoration and the individual details are therefore taken into consideration. In order to rule out an aesthetically compromising solution, in this case orthograde screwing of the dental prosthesis—screw channel emerging occlusally—was avoided. A normal bond was achieved in the region that was not visible by means of transverse bolting. The access to the bolting, which was easily achieved, made it possible to easily remove the dental prosthesis in the practice.

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Drs Massimo Frosecchi, Eugenio Longo & Alessandro Certini, Italy

Initial situation

The patient was a 53-year-old male non-smoker at the time of treatment, although had a history of heavy smoking for many years before treatment (Figs. 1–3). General health conditions were good, but the patient suffered from severe chronic periodontitis, probably with a juvenile onset (Figs. 4a–c). A periodontal chart and X-ray periodical status were checked to assess the severity of the periodontitis and the therapeutic prognosis (Figs. 5a–n). Only nine teeth were remaining in the maxilla after previous extractions. Mobility, migration of teeth, and lack of vertical dimension of occlusion were observed. Most of the maxillary teeth were splinted to improve function (Fig. 6). The mandible was in a better condition, with the preservation of all natural teeth, no restorations, and with minor mobility and migration (Fig. 7). Before any implant-borne reconstruction was considered, periodontal treatment was provided in order to obtain the necessary biologic condition and patient compliance for long-term implant survival. The treatment was finalised in 2016 (Figs. 8 & 9).
Treatment planning

The treatment plan included the placing of six implants in the maxilla (Straumann BLT, 4.1 mm diameter, 12 mm length, Roxolid SLActive), followed by full reconstruction of the entire jaw (Figs. 10–13). The planned implant placement modality was type 1 (immediate, postextraction) and the planned loading modality was immediate loading. Lab staff received treatment planning in preparation for surgery.

Surgical procedure

Prior to the surgery, the patient was instructed in intraoral professional hygiene and in a mouth rinsing protocol. Antibiotic prophylaxis (amoxicillin 800 mg and clavulanic acid 200 mg) was also prescribed. Next, all the remaining teeth in the maxilla were extracted (Fig. 14), and a prosthetic guide was used to check its stability and correct orientation and congruity with the lower jaw (Figs. 15 & 16). A full-thickness flap was raised to expose all recipient sites. A bone remodelling procedure was performed to remove thin parts of alveolar bone from the extraction sockets. Using the prosthetic guide, implant beds were prepared according to the pre-surgical planning (Figs. 17 & 18). Next, six Straumann BLT implants (Roxolid SLActive) were placed (Figs. 19 & 20). Two tilted implants in the posterior maxilla were specifically used to avoid a sinus lift procedure and achieve very high primary stability. There was no need to use any biomaterials or bone grafting procedures. After implant placement, titanium bridges and a temporary abutment were placed, and primary closure of the flaps was obtained with a single suture (Fig. 21).

Prosthetic procedure

In accordance with our immediate loading protocol, a prosthetic surgical guide was used as an impression tray. This atypical impression was made directly using a titanium temporary abutment as an impression transfer. A self-curing resin was injected to block abutments to the guide (Figs. 22 & 23). A full-arch temporary bridge was then delivered and stabilised in the patient’s mouth (Figs. 24 & 25). The patient was recalled after three days, one week and one month for suture removal, adjustment of occlusal contacts, and a general check-up (Figs. 26 & 27).
Final result

After a period of osseointegration (about six weeks) (Fig. 27) and complete soft tissue remodelling and stabilisation (Figs. 29 & 30), the temporary denture was removed and replaced with the final one. The final restoration was produced based on the data acquired for preparation of the temporary bridge (Figs. 31–35). Occlusion, aesthetics, phonetics and hygienic maintenance possibilities were investigated at the moment of final restoration and confirmed to be appropriate (Fig. 36). A final panoramic radiograph with a final prosthetic superstructure in place was also recorded to serve as a baseline for the follow-up controls (Fig. 37). At the 12-month follow-up visit, the patient was checked with regards to the general hygienic maintenance of the denture, any bone resorption, phonetics, function and aesthetics. A new periapical radiograph was also taken to investigate the periodontal and peri-implant situation (Figs. 38–41).
Conclusions

No complications or adverse situations were observed at any time during the treatment, from the planning to the final prosthetic installation. The patient was extremely satisfied with his new denture. Overall, the treatment required a relatively low number of appointments, with just a single surgical session. An immediate replacement of natural dentition in the upper jaw with an implant-supported full-arch bridge was achieved in a controlled and planned way, minimising the risks and potential patient discomfort. The patient appreciated the immediate loading approach, since it enabled him to maintain a “fixed teeth” situation and avoid a removable denture stage during the osseointegration period.

about

Dr Massimo Frosecchi
In November 2017, QAdental, a new dental consultation portal, won the Innovation Award at the Finnish Dental Congress and Exhibition in Helsinki. Developed by Dr Mikko Nyman and Teddy Grenman, Chief Dentist and Chief Engineer at NUOVO NORDIC Healthcare Services, respectively, the platform offers dental professionals the opportunity to e-consult with dental specialists, serves as a database for learning material and patient cases, and enables forum discussions. Dental Tribune International spoke with Nyman about this pioneering solution and the expertise it brings to remote areas and developing countries.

Congratulations on winning the award. How did this come about?

This has been quite a year. We piloted QAdental in Namibia this spring. It wasn’t easy to obtain permission from the local ministry of health and it wasn’t easy to get people excited about something totally new. We visited the country twice. However, we managed to conduct the pilot successfully. In summary, this win feels very good and motivates us all to continue developing QAdental.

Did you have a team to support you in the development process?

QAdental was developed by a team. Teddy Grenman and I were the main architects, but without the rest of the team—CEO Jani Korpela, Chief Medical Officer Jarkko Saramäki and Project Coordinator Teemu Tanninen—we wouldn’t have been able to conduct the pilot successfully in Namibia. Steve Jobs’s famous quote applies to QAdental also: “Great things in business are never done by one person. They’re done by a team of people.”

With the success of the platform, will something change for you personally?

My focus will be completely on QAdental and I’ll pass over most of my other duties in the company [NUOVO NORDIC Healthcare Services] to my colleagues. This applies to Teddy also.

How do the features of QAdental help practitioners in particular?

In Finland and many other countries, specialist services are not available in remote areas. This means dental professionals located there are obliged to work beyond their scope. QAdental brings them advanced knowledge and a supporting community via the Internet. This way, clinicians can perform more challenging procedures more safely and discuss patient cases with their peers. The growing international database of questions and answers and learning material is available for all members. With the help of the advanced search function—or maybe artificial intelligence in the near future—clinicians may find answers to their questions from previous questions and answers.

What sets QAdental apart from other dental community platforms?

This kind of consultation or support service might be very significant in enhancing patient safety and healthcare quality. Our plan was to export Finnish or Western expertise to developing countries. One challenge was that these countries cannot afford to pay for Western dental specialist consultation. That’s why we wanted to develop a way to share the knowledge. The solution was quite obvious: we had to create a place where all consultations, answers and learning material are available for all members so that the learning experience wouldn’t be limited to one person.

During the pilot project, we learnt that there’s a need for specialist e-consultations also in Finland, especially in remote areas. In Finland, there’s no tele-consulting platform where information and learning experiences are shared with several practitioners at the same time, so QAdental serves as a kind of reverse innovation when it comes to Western countries. Compared with other dental forums, QAdental focuses solely on consultation and learning material. There’s always a dentist on duty taking care of maintenance, and to make sure that the appropriate QAdental professional answers to the corresponding consultations. The officer on duty is also the quality controller when it comes to official answers.

Will your product be globally available or only for the Finnish market?

QAdental is open to all dental professionals globally and membership is free. Dentists can register at www.qadental.com.

Thank you very much for the interview.
The innovative design of the MIS MGUIDE and its surgical kits simplifies digital dentistry. The use of CAD/CAM, allows for a prosthetically driven, safe and accurate procedure. To learn more about the MIS MGUIDE, go to www.mis-implants.com

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Dynamic navigation in fully edentulous maxilla

Preoperative planning is the most important part of a successful implant rehabilitation and requires multiple parameters to be considered for the precise placement of implants. The implants should be placed not only within anatomical boundaries but also be strategically located to support a prosthesis that will fulfil both functional and aesthetic requirements.

3-D virtual images are being used through computer software, which transforms CBCT scans into 3-D virtual models. However, after a precise planning or virtual realisation of the treatment, the osteotomy should also be executed precisely according to the plan and would likely require guidance of the drills and the implant.

For years, stereolithographic static guides have been used successfully for implant osteotomies, using detailed information implemented through 3-D virtual images.\(^1,2\) Static guides on the other hand present several disadvantages. The loss of tactile feeling during osteotomy and the fact of being limited to the predesigned drilling trajectory are considered to be their major drawbacks.

Real-time navigation

A recent technology, which provides dynamic guidance through real-time navigation for implant osteotomy, offers not only accuracy, but also additional valuable advantages during an operation.\(^3,4\) With this technology, the

Fig. 1: Patient wants a screw-retained fixed prosthesis. Fig. 2: Radio-opaque tooth set-up for prosthetic planning. Fig. 3: Scan prosthesis at try-in to check its fit, aesthetics and maxilla mandibular relation. Figs. 4a & b: Navident H-Arm (a) and V-Arm (b).
location and diameter of implants can be modified and a flap can be incised intraoperatively whenever needed.

Furthermore, dynamic navigation enables the surgeon to adjust the surgical plan during surgery. In case of an unexpected low bone quality, an additional implant could be planned with the software and placed additionally. Moreover, one of the most significant benefits of dynamic navigation is the ability to use it also for alveoloplasty and reshape the alveolar crest’s topography during the same surgery, together with the implant placement.

The precise location of implants is case-specific and determined by different factors. If an edentulous case is to be restored with an implant-supported screw-retained fixed prosthesis, implant locations should be critically examined whether they can provide screw access holes within occlusal or palatal/lingual parts of the restoration. Frequently, alveolo plasty is required for the recontouring of the ridge in order to obtain sufficient bone thickness at the level of the implant’s collar.

This crestal trimming of bone may also be necessary in order to increase the inter-arch space and provide a sufficient volume for the restorative material, since den- togingival prostheses are frequently required to enhance aesthetics. In such cases, dynamic guidance can be used to level the alveolar crests as planned on virtual images, followed by precise multiple osteotomies.

**Case report**

The following case report describes the treatment of a 65-year-old male with an one-year history of maxillary partial edentulism (Fig. 1). He was discontent with the stability of his prosthesis and expressed that through the unstable prosthesis situation he has lost social self-confidence. In the initial appointment he thus stresses his need for a “fixed solution”.

His medical history did not reveal any specific systemic disease or condition that contraindicates oral surgery. The patient’s soft tissues on the edentulous ridges were healthy and panoramic X-rays showed expanded sinuses at both sides and irregular alveolar ridges. The treatment plan, carried out for a maxillary screw-retained fixed prosthesis, included two implants at the pre-maxillary region and two tilted in the posterior maxilla to avoid a sinus lift surgery.

**Stent placement**

In order to acquire both anatomical and prosthetic information prior to the surgery, a scan prosthesis was manufactured by duplicating the maxillary denture (Fig. 2). It is important that the scan prosthesis has the same aesthetic and functional information as the complete denture or set-up. Thus, the scan prosthesis was checked for its fit, aesthetics and maxilla mandibular relation (Fig. 3). The scan prosthesis was then used together with a Navident Edentulous Kit for CBCT imaging.

The Navident edentulous protocol consists of a SDI (Small Diameter Implant of 2.2 mm or 2.5 mm diameter), which is inserted into the alveolar ridge of the arch to be operated, prior to the acquisition of the CT scan. This temporary SDI serves as a mount for the CT marker and for the Jaw Tag used for the registration of the CT scan to the patient and for tracking the patient’s jaw during surgery.

The SDI can be placed either in a vertical position or in a horizontal position in relation to the alveolar crest. A special plastic arm with a proprietary aluminium bracket is then used for the connection of the CT marker and Jaw Tag to the SDI. Two types of arms are available: one for a
vertically placed and another for a horizontally placed SDI (Figs. 4a & b). In the presented case, the SDI has been placed vertically to achieve the required stability (Fig. 5).

The CT marker, containing the fiducial marker used for the registration of the CT scan to the patient, was attached to the V-type arm on the fix-plate at one end. At the other end, the assembly was placed over the SDI’s square head and secured to it using a setscrew which was embedded in the aluminium bracket, with this creating a complete “NaviStent” (Fig. 6).

The scan prosthesis was then modified to accommodate the aluminium bracket before it was placed over the maxillary edentulous ridge (Figs. 7 & 8). For accuracy purpose, it is imperative that the scan prosthesis is stable, while at the same time it should not interfere with the NaviStent.

CT scan
The following CBCT imaging protocol for Navident dynamic navigation was applied during CT imaging. Before the scanning procedures, both the modified scanning prosthesis and the NaviStent had been placed into the patient’s upper jaw (Figs. 9 & 10).

A CT marker was then connected to the NaviStent. A scout view had been acquired prior to the actual scan to verify the presence of the CT marker in the CT scan. In order to allow for accurate registration, at least three corners of the fiducial marker must be present in the scan. In order to maintain a high level of accuracy during navigation, it is mandatory that the slice thickness must not exceed a maximum of 0.4 mm. In this case, the slice thickness had been set to 0.3 mm. Afterwards, the scan was exported in DICOM format, then imported into Navident.
Osteotomy planning

When the CT scan is imported into Navident, a proprietary algorithm detects the fiducial’s image in the scan, then registers it with a mathematical model of the fiducial that is stored in the computer memory. This enables Navident to map the Jaw Tag, which is the tag mounted onto the patient, to the CT image during navigation.

For this case, Ankylos dental implants had been selected. The implants with a diameter of 3.5 mm and a length of 11 mm were planned on the locations 15, 12, 22 and 25 using the Navident planning software (Fig. 11). The following parameters were considered when osteotomies were planned:

1. Alveolar ridges, though they had a sufficient bone height, were narrowing at the crestal 1/3. Without waiving or compromising the restorative information, the implant locations were planned to be deeper where at least 2 mm of buccal plate thickness could be achieved.
2. Straight implants were placed at 12 and 22 and tilted ones at 15 and 25.
3. Angulated distal implants were planned 1 mm mesially to the sinus wall.
4. The angle of distal abutments was planned to be 30 degrees to the occlusal plane to have the retaining screws access holes placed in the denture’s occlusal aspect since screw-retained abutments have 30 degree joints.
5. The plane of the implant collars was planned to be parallel to the occlusal plane.

Surgery

Before surgery, the CT marker was disconnected from the NaviStent Arm and replaced by the Jaw Tag, which is detected by the Navident camera. A Drill Tag was installed onto the handpiece (Fig. 12). Together with the Jaw Tag, they provide real-time feedback during surgery, enable the surgeon to communicate with the software and place the implant as planned.

A crestal incision was made at either side. Pilot drills were used to start osteotomy followed by the Ankylos dental implant drilling protocol. All drills were navigated according to the planned trajectory, until real-time feedback confirmed that its tip has reached the apical end of the planned osteotomy. The alveolar crests were levelled by a rongeur (Fig. 13). Between each trimming attempt, the pilot drill was touched to the trimmed surface of the crestal bone and its level was checked on the virtual image.

The trimming of the bone was completed under the guidance of dynamic navigation and the pilot drill was again touched to the newly formed alveolar crest. Implants were inserted in the osteotomies as planned (Figs. 14–16), the gingival tissue placed back and sutured with coated poly-galectin 910 sutures. The patient was medicated with antibiotics and chlorhexidine mouth rinse and was released with NSAID’s.

Conclusion

The Navident navigation surgery system achieves a successful guidance both in alveoloplasty and implant osteotomies in the edentulous maxilla (Figs. 17–19). In the presented case, the proposed protocol was highly efficient in gathering 3-D prosthetic and anatomical information for the planning. Dynamic navigation provided a precise guidance in the execution of the planned osteotomies through a flexible surgical operation.

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

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“Good design will pay off”

by DTI

Just as in dentistry in general, where aesthetic aspects are becoming ever more important, dentists today are pursuing intentional design of their dental practices. With the launch of four new design lines, Dentsply Sirona Treatment Centers presents dentists with the opportunity to enhance workflows and treatment efficacy through clever and cutting-edge solutions while conveying their individual style. DTI spoke with German dentist Dr Marcus Riedl and Dr Mona Patel from the US, both of whom have ensured careful design of their practice environment based on their needs and preferences with a Dentsply Sirona line, about the role of aesthetics in daily dental practice.

Design can convey emotions and distinguish a dental practice from others. In your opinion, what relevance does design have in this regard?

Dr Mona Patel: In the US market, it has not played an important role for a long time. Now, with the newer generation of dentists, design is increasingly significant. I think it is just as important as the type of equipment that one purchases or the insurance one carries, because image is everything. In my opinion, the design of the practice is a direct reflection of how one provides care as a dentist. This correlation was not present in previous generations, but it is now.

Dr Marcus Riedl: I can speak for Germany and I think design aspects were mostly neglected in the past. Now, the influence of design in our practices is increasing. One has to consider that we spend almost half of our lives in our practice, so we should feel comfortable. For example, I love the mountains, skiing and the atmosphere of the Alps. Incorporating this love for nature into the design of my practice gives me a holiday feel at work.

When deciding on a particular design or the overall look of your practice, what did you put special emphasis on?

Patel: Dental anxiety is a huge component of what we have to manage, so we need to create an environment that first and foremost has a calming, spa-like feel and reduces our patients’ anxiety when they walk through the door. Secondly, in my practice, I wanted the design to be evidently smart, because that reflects my meticulous per-
sonality. I equipped the whole office with Dentsply Sirona products—in fact, it was the first all-Dentsply Sirona office in the US. I wanted to showcase the high-tech equipment and design a nice, simple office around that—not to compete with the equipment, but to enhance it.

Riedl: For many of our patients, the design aspect is just an outer shell, since they come to us for the content. We designed our practice for patients to feel at home. When they come into the office, they do not see any units at first. As for dental phobia, in my opinion, reducing anxiety mainly is the responsibility of the staff. However, a calming atmosphere is a great support, of course.

Patel: In healthcare, whole-body awareness and preventative health are becoming ever more important. A practice today is not just about treating tooth pain, but about establishing a dental home, creating a place where patients can establish a relationship with their dentist and their hygiene team.

Dentsply Sirona has developed four different design worlds: Embellished Elegance, Cheerful Patterns, Honest Materials and Pure Shapes. Which one did you decide on and why?

Patel: We chose Honest Materials because our practice has all this enhanced digital technology, which can be intimidating. I wanted to balance this digital aspect of our practice with natural and organic materials. We have a lot of birch and wood—clean, sleek, simple and balanced materials that hopefully move the focus from the equipment. My design in general is very monochromatic, nothing too messy or cluttered.

Riedl: We too choose Honest Materials, mainly because I like nature. In our previous office design, we used...
the colours white, grey and green. In order to preserve our corporate identity, we wanted to keep these and combined them with a lot of wood and glass, because we wanted to convey the nature aspect to our patients. Technology is cold and patients do not want to be confronted with it directly, so we created the look of a mountain lodge. Our floors are even called “valley station”, “middle station” and “mountain station”, for example.

Do you feel that patients appreciate the effort?

Riedl: Some do, some do not. Patients who share the same values as we do feel more comfortable than those who think the design is unnecessary for dentistry or think it makes the cost of their care more expensive.

Patel: Good design does not have to be expensive. Nevertheless, for some reason, if one puts a great deal of effort into the design of one’s practice, it is perceived as though one put a lot of money into it, which is not always the case.

Would you say that the investment in the design is also reflected in the success of the practice?

Patel: In the US, many things are based on return on investment. It is easier to convince oneself to invest in a CEREC or CBCT device, because one sees an immediate return on investment. However, trying to convince oneself to invest in the design with nicer cabinetry or floorplans, where there is not a direct return on investment, is more difficult. But, I am a firm believer that if one works in a beautiful and happy place, it reflects one’s standards and that is the greatest return on investment. Patients see that. If one sees that love is in every detail, the financial aspect fades in importance;
the design fulfils one as a person and one’s patients appreciate the resulting work.

Riedl: Sometimes, it is about the little things. For example, my wife puts fresh flowers in every corner of the practice, which I love. However, design polarises. It divides our patients into at least two groups. Those who are interested in and impressed by our design appreciate it, of course. Others do not. I believe that treatment units and high-end equipment establish a sense of professionalism, quality and exclusivity. No patient can judge a dentist’s quality and knowledge at first sight, but, in the eyes of the patient, design and technology often are equivalents for quality, so good design will pay off.

There are countless treatment units on the market and they differ a great deal. What did you consider when deciding on a system?

Riedl: The treatment units are our workbenches—very expensive ones (laughs), but workbenches nonetheless. It has to be stable, easy to use, intuitive, ergonomic and comfortable for the patient, as well as for the dentist and the assistants—and, of course, easy to clean. It has to aid our treatment and therefore our daily work as a dentist. It is like the assistance systems in one’s car or a smartphone. A good design, of course, is welcome too. That is why the Teneo was our system of choice.

You both use Teneo. What sets the unit apart from those you have used before?

Riedl: As a dentist, I have always worked with Sirona, now Dentsply Sirona. Therefore, there was no question of the brand I would choose. In our previous office, we used the M1 for almost 30 years—I, of course, used it only for about ten years—and I did not want to change my habits and movements during treatment. Comparing the M1 with the Teneo is like comparing an old Mercedes-Benz with a new one. It is the same quality. The Teneo might be not as solid as the good old M1, but has more features that are useful.

Patel: I was designing a new office, so I had a clean slate to work with. I did a great deal of research and comparisons. For me, the look and the design were important, as were functionality, integration, longevity and being able to sanitise it easily. I was instantly drawn to Teneo, because, as I said, I do not like clutter. The fact that everything was integrated was an instant attraction to me. I found solutions to all my wishes in the Teneo. It was an easy decision to make and we designed the office around the units.

Thank you very much for the interview.
The European Parliament has voted to implement two new regulations concerning medical devices with the aim of improving safety in medicine and dentistry. The regulations were proposed in 2012 by the European Commission and experienced several delays before being officially endorsed at the begging of 2017. They will be applied after a transitional period of three years from publication for medical devices and five years for in vitro diagnostic medical devices. Publication is expected to take place shortly in the Official Journal of the European Union.

Though the rules regarding the safety and performance of medical devices were standardised throughout the EU in the 1990s, significant progress in technology rendered these standards in need of updating. In addition, manufacturers could interpret the three existing directives on medical devices—which will be replaced by these regulations—in different ways, thereby creating inconsistencies in adherence to these rules. The new regulations aim to remedy this by ensuring that this progress and innovation continue in a way that is beneficial to the safety of all involved. At the same time, smaller and medium-sized companies are facing the challenge of meeting the new requirements for clinical data, new legal requirements and certifications for all dental products.

Some of the main elements of the regulations include:

- Stricter measures on the quality, safety and performance of devices released into the marketplace, with a particular emphasis on perceived high-risk devices.
- A scrutiny mechanism for Class III implants and Class IIb active products.
- The introduction of a comprehensive database for medical devices sold in the EU (EUDAMED), to be set up by 2020 at the latest.
- Higher requirements for clinical data and technical documentation before and after placement of the respective product on the market.
- A universal device identification system that will permit medical devices to be traced more easily.
- An implant card that will be given to patients so that they, along with medical professionals, have access to information about any implants they receive.
- A set of guidelines for providing appropriate financial recompense to patients for faulty products (the payment will vary according to the risk class and type of device, as well as the size of the company that manufactures the device, and will ideally expedite the remunerative process).
- Guidelines for manufacturers of substances that are carcinogenic, mutagenic or toxic for reproduction, as well as substances that can disrupt the endocrine system, to provide alternative and less harmful products.

The regulations will be applicable in each of the EU member states and aim to provide a clearer framework regarding device standards to patients, professionals, and relevant domestic and international regulatory bodies. A Medical Device Coordination Group, formed of experts from member states and chaired by the European Commission, will be established to help organise and enforce the correct implementation of these regulations.

In addition, conformity assessment procedures by notified bodies—intranational organisations that evaluate medium- and high-risk devices—will continue to be performed through joint assessments conducted with the assistance of other member states.
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US dental prosthetic market set to grow with digitalisation

Salma Mashkoor & Jeffrey Wong, US

Digitalised dental products, whether produced by additive or subtractive technologies, are expected to disrupt the US dental prosthetic market for the foreseeable future, according to a report by international market research and consulting company iData Research. This will be especially true in the denture market. With increasing innovations, emerging competitors, and Food and Drug Administration (FDA) approvals, the digital market is expected to grow substantially over the next several years. As digital products are offered at higher prices, their growth will drive the total dental prosthetic market at a compound annual growth rate (CAGR) of 1.4 per cent.

“The digital dentistry market had an estimated value of nearly $650 million in 2017 and is expected to grow at a CAGR of 5.6 per cent through 2024.”

The report highlighted recent milestones in digitalisation of the US dental prosthetic market (which encompasses crowns, bridges, inlays, onlays, veneers and dentures) beginning in 2015, when DENTCA received FDA approval for the first resin material used to 3-D print parts of dentures. Later in 2017, EnvisionTEC received FDA approval to sell its E-Denture material, providing both dental laboratories and offices with the ability to fabricate pink denture bases. Currently, AvaDent holds the majority of the nontraditional complete denture market, as it is the only company with a fully digitalised denture product. AvaDent has a proprietary method of milling both the pink base and white teeth from a single puck, whereas other competitors mill out the pink denture base only and it is then integrated with teeth by a technician in the laboratory.

In their overview of the digital dental industry, consisting of CAD/CAM systems, CAD/CAM materials and rapid prototyping systems, report authors iData Research analysts Salma Mashkoor and Jeffrey Wong said they are expecting that market growth will result from innovative product applications, such as the increasing user base of intraoral scanners or even new indications for innovative rapid prototyping systems. Unfortunately, competitive price cuts and inexpensive solutions are reducing potential market growth. This is especially true for rapid prototyping systems, which have an unsaturated market relative to that of CAD/CAM materials and systems. The digital dentistry market had an estimated value of nearly $650 million in 2017 and is expected to grow at a CAGR of 5.6 per cent through 2024.

Since the rapid prototyping system market is relatively new in comparison with the other digital dentistry markets, new indications for printers will continue to emerge, such as 3-D temporary prostheses. Stratasys recently received FDA approval for its VeroGlaze material, which can be used in the mouth on a temporary basis for up to 24 hours. Its biocompatible PolyJet photopolymer has also been medically approved for temporary in-mouth placement. Printers are currently too costly for an in-office setting and the technology is still advancing in this regard. Once these barriers are overcome and the necessary FDA approvals are acquired, the use of 3-D temporary prostheses will grow, stimulating sales of in-office printer units.

CAD/CAM systems too are experiencing an uptick of new applications, as demonstrated by intraoral scanners, Mashkoor and Wong noted. In the past, the intraoral scanner market was entirely reflective of use by general practitioners. However, in recent years, the user base has expanded to include orthodontists and other specialists, a trend that is expected to continue in the future. Orthodontists and dental surgeons are quickly adopting the technology, as general practitioners are now sharing scanners in multipractice organisations.

As the user base for intraoral scanners expands, unit sales will increase, thereby encouraging growth of the total CAD/CAM system market. Similarly, the increasing applications of rapid prototyping systems will boost both laboratory and clinical sales.
According to the report, the factor most limiting growth of the US digital dentistry market is the emergence of relatively inexpensive products that create more competition and threaten market growth on a national basis. Low-cost foreign brands have penetrated the CAD/CAM zirconia material market in the US, driving the overall average selling price (ASP) downward. In addition, a number of generic brands produced in the US have captured a sizeable portion of the market through promotional strategies, further resulting in ASP declines. These subpremium solutions have been especially effective in reducing the ASP of zirconia discs, as the ASP for zirconia blocks had already declined rapidly in the past. Inexpensive products have facilitated ASP cuts and competitive pricing in the rapid prototyping system market too.

In 2017, Formlabs engaged in aggressive marketing and educational initiatives regarding its technology and the affordability of its products, attracting a large customer base. As its machines are relatively inexpensive, many potential clients are willing to try them out, thereby decreasing the overall ASP for rapid prototyping systems. As with Formlabs, additional companies are entering the market with affordable solutions, further depreciating the ASP. Furthermore, the competitive landscape is becoming more saturated, encouraging competitive price cuts as a result. Rapid prototyping systems are still gaining acceptance, especially in the clinical setting. Once these systems are widely accepted by various users in the dental industry, the corresponding ASPs will continue to rapidly decline. With regard to CAD/CAM systems, ASPs for both CAD/CAM mills and chairside systems are declining with the competitiveness of the market too. Amann Girrbach and Roland DGA are examples of companies that are introducing new products on to the CAD/CAM mill market alongside printer products. Chairside units, such as the closed milling systems offered by Dentsply Sirona and E4D Technologies, command a premium price over other CAD/CAM systems. It is more feasible for dental offices to purchase a scanner and then outsource or run a separate open-source mill. As a result, pricing, largely set by Dentsply Sirona owing to its market share, has been decreasing in order to remain competitive.

Dentsply Sirona led the total digital dentistry market in 2017 as a result of product successes in the CAD/CAM system and material markets. This was largely due to the diversity of mills offered by the company. Dentsply Sirona continued to dominate the closed chairside milling system market in 2017 through sales of its CEREC chairside CAD/CAM system.

For this report, the authors summarized information from two papers, titled US Market Report Suite for Digital Dentistry Devices 2018 and US Market Report Suite for Dental Prosthetics and CAD/CAM Devices 2018, published in December 2017. The full versions of the two reports can be purchased on the iData Research website.
Non-original abutments are “a lottery that you cannot win”

An interview with Prof. Matthias Karl from Saarland University, Germany, about the results of the research into micromotion at the implant-abutment interface

In a recent study analysing the effect of cyclic loading on micromotion at the implant-abutment interface, the authors found that a quantifiable settling effect seems to be more pronounced in non-original abutments. In the in vitro study, the NobelProcera implant-abutment interface showed the lowest initial micromotion and minimal settling effect.

Why is it important for clinicians to know about micromotion in general regarding the implant-abutment assembly?

Prof. Karl: From a prosthodontist’s perspective, the interface between the implant and what goes on top of the implant is, in my opinion, the most critical interface in implant dentistry. To my knowledge, it’s still impossible to manufacture two parts that fit perfectly. Perfect means zero micrometres of gap, but there is always a certain amount of component interplay. This is also needed by the implant manufacturers, because different parts from different batches have to match each other. As a consequence, during dynamic loading and mastication, there will be some micromovement between the abutment and the implant. This may cause fatigue over time.

What were the findings of your study?

We studied different abutments for Straumann tissue level implants. In particular, we analysed the implant dentistry. To my knowledge, it’s still impossible to manufacture two parts that fit perfectly. Perfect means zero micrometres of gap, but there is always a certain amount of component interplay. This is also needed by the implant manufacturers, because different parts from different batches have to match each other. As a consequence, during dynamic loading and mastication, there will be some micromovement between the abutment and the implant. This may cause fatigue over time.

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In particular, we analysed the impact of third-party abutments on a major implant brand.

We did this investigation twice with the status of the abutments as received from the different manufacturers and after some dynamic loading in our masticatory simulator. These micromotion measurements showed that with NobelProcera Abutments there is hardly any difference in abutment seating before and after dynamic loading, which is indicative of the fact that the NobelProcera restoration is in its final position. Once it’s screwed in by the dentist it stays there. If you have settling it means that the preload of your retention screw is basically gone and this does not happen with NobelProcera Abutments.

Are there any other implications that these findings might have for clinicians in practice?

If you’re not sure whether the implant-abutment is fully seated or whether it might experience some settling, you may need to go back after a couple of weeks and retighten the abutment screw. If you have cemented your crown on top of the abutment, then it’s a major inconvenience to take off the crown. I prefer abutments that I can seat correctly the first time.

You talked a little bit about NobelProcera. Compared with the other abutments in your study, how did NobelProcera Abutments perform?

The advantage of NobelProcera Abutments over other third-party abutments is that they’re precision-engineered individualised CAD/CAM abutments. Although it was a Straumann implant that was used as a basis for testing, we could demonstrate that NobelProcera Abutments showed less micromotion compared with standard abutments from Straumann for cement restorations.

What do you attribute this result to?

NobelProcera manufacturing quality is extremely high. The result of this study is indicative of very consistent and precise manufacturing.

Reference
“A truly open solution”
by DTI

At the latest Greater New York Dental Meeting (GNYDM), global dental imaging technology specialist 3DISC showcased its newly developed Heron IOS scanner. Dental Tribune International had the opportunity to speak with Sigrid Smitt Goldman, CEO and Executive Chairman of the 3DISC group, about the company’s entry into the intraoral scanner market and what sets the device apart from competing products.

After a two-year development process, you showcased the market-ready Heron IOS in New York. What were priorities in the development of the scanner?

The Heron’s lightweight design and ability to update in real time make it an essential tool in the contemporary dental practice. In development, we focused on ergonomics for the dentist and comfort for the patient. Recognising that size and flexibility in scanning are essential, we developed a small, lightweight hand- and mouthpiece with a 360° rotating tip for maximum flexibility and comfort when scanning the upper and lower arches.

Were there any challenges you had to overcome in the development process?

During the development process, we took initial concepts to dentists early on in the design phase and were quite surprised to find that they had very different approaches to some basic things, like how they would pick the unit up. Some used a pen grip, others lifted it from the top. This feedback led to several changes to the shape of the unit and drove the design of the 360° rotating tip that allows the scanner to be comfortably held and used in every situation.

When will the device be available to customers and in which markets?

We open for sales in Europe and USA in the first quarter of 2018 and the first scanners will be in clinics early in the second quarter.

“The 360° rotating tip allows the scanner to be comfortably held and used in every situation.”

Increasingly, dental manufacturers are introducing open solutions. Is Heron IOS compatible with solutions other than those of 3DISC too?

Yes, the scanner output is entirely open, providing both STL and PLY format, and expected to be compatible with most open dental CAD systems.

Our QuantorClinic software is a combination of our own scan software and exocad’s DB software, with dentalshare as the primary laboratory sharing tool. It facilitates order management, scanning, validation, commenting and order submission to the laboratory.

The Heron offers an all-in-one application accessible from one interface—a truly open solution with what we believe is one of the market’s best-optioned CAD integrations.

Have you already planned any updates, such as introducing a wireless Heron IOS version in the future?

Naturally, the development of the solution does not end with the upcoming launch. We primarily expect updates on the software side, such as improvements to the free QuantorClinic software license that comes with the scanner. This means that dentists that order the first-generation software now will automatically get the updates with their software at no extra charge.
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