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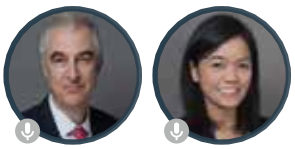
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ITI Implant Nexus Study Club Hong Kong



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Clinical Associate Professor in Oral and Maxillofacial Surgery

BDS (SJTU), MDS (SJTU), PhD (SJTU)

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CASE REPORT

Comparative Clinical Accuracy of Extraoral and Intraoral Photogrammetry and Palatal Scanbody System for Full-Arch Implant Capture



Dr. Chan Fuk Shing, Brian

BDS (HKU), MSc (Lond), DPDS (Brist), MFGDP (UK), DImplantDent RCS (Eng), MFDS (Glasg), MFDS (Edin)

- *Global Educator of BlueSkyBio*
- *Co-Founder of Harvard Digital Dental Studio (One-Stop Digital Solution for Full Arch Implant Rehabilitation); Chief-In-Charge of in-house CAD-CAM Center*

Introduction

Accurate digital transfer of implant positions is the cornerstone of passive-fit, long-term successful full-arch implant rehabilitation. Photogrammetry, a technique using triangulated images of coded scanbodies, is widely regarded as the gold standard for capturing the three-dimensional spatial arrangement of multiple implants in complex, full-arch cases [1,2]. Extraoral photogrammetry (EPG) systems such as ICam4D and Micron-mapper have demonstrated outstanding accuracy and reproducibility in both laboratory and clinical studies [3-6]. Intraoral photogrammetry (IPG), a more recent advancement, integrates photogrammetry directly into an intraoral scanner (Shining 3D Elite), combining soft tissue and implant capture in a single workflow and potentially offering similar accuracy and workflow simplicity [7-10].

Palatally oriented scanbody system (ioConnect) represents a unique approach: by bringing all scanbodies to a more central location to facilitate easier, more concentric intraoral scanning, theoretically reducing stitching errors that plague traditional intraoral scanning [11,12]. The ioConnect workflow involves scanning only the hex and retrieving implant positions with proprietary software, aiming to streamline data capture in the clinical setting.

This case report presents a real-world, clinical comparison of two extraoral photogrammetry systems (ICam4D, Micron-mapper), one intraoral photogrammetry system (Shining 3D Elite IPG), and the ioConnect palatal scanbody system for full-arch implant capture in a senior colleague with seven maxillary implants, some placed in challenging far posterior and closely packed positions. The case is unique in that it was conducted entirely in vivo, using the same patient, clinician, and independent examiner, with all verification jigs tested intraorally for passive fit using the Sheffield test.

In this case, a further dimension was added: bite accuracy testing. After four months with a provisional prosthesis, three different intraoral scanners (3Shape Trios 5, Medit i700, Shining Elite) were used to scan the provisional prosthesis, and these data were combined with photogrammetry records to design multiple 3D-printed prototypes. Each prototype was checked for bite and occlusal accuracy intraorally.

Materials and Methods

Patient Overview

A senior dentist presented for maxillary full-arch rehabilitation. Four new implants were placed to complement the three existing implants (Figure 1).



Figure 1A. *Preoperative panoramic X-ray showing failing dentition with existing implants*



Figure 1B. *Preoperative intraoral frontal view*

Implant Capture Methods

Four digital systems were compared for capturing implant positions (Figure 2A) and the scanbodies used with each system (Figure 2B).

- **ICam4D (EPG):** Extraoral photogrammetry using proprietary scanbodies.
  When scanbodies were too close together or positioned far back, it was not possible to mount and scan all at once. In these cases, some scanbodies were removed and replaced in stages, requiring several partial scans to ensure every implant was captured. This process involved repeated screwing and unscrewing of scanbodies and merging the separate scans in the software.
- **Micron-mapper (EPG):** Extraoral photogrammetry with its own scanbody system. The same staged approach and need for multiple partial scans was required whenever scanbodies blocked each other or were in hard-to-reach positions (Figure 3).
- **Shining 3D Elite (IPG):** Intraoral photogrammetry system capturing all implants in a single intraoral scan, regardless of their position or proximity, using coded scanbodies.
- **ioConnect:** Palatally oriented horizontal scanbody system, also allowing all implants to be captured in one intraoral scan without obstruction; scanning focuses only on the hex for MUA position calculation.

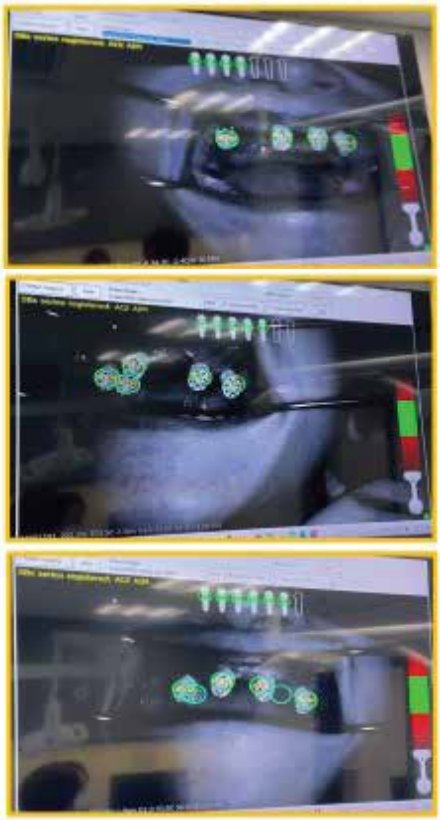


Figure 3. *Repeated removal and replacement of scanbodies to prevent obstruction during multiple scanning sessions using the Micron-mapper system*



Figure 2A. *Four capture systems used in this study: (A) Shining 3D Elite, (B) ioConnect, (C) Micron-mapper, (D) ICam4D*



Figure 2B*. Placement of scanbodies for each system:*
A. Shining 3D IPG scanbodies
B. ioConnect palatal scanbodies
C. Micron-mapper scanbodies
D. ICam4D scanbodies

Testing Protocol

For each capture method, a verification jig (not impinging on soft tissue) was fabricated from the scan data (Figure 4). Each jig was seated in the patient's mouth and secured with one Rosen screw onto the most distal MUA, then subjected to the Sheffield test for passive fit by an independent, blinded examiner. Passive fit was assessed visually and tactilely, with any gaps or misfit recorded and photographed (Figures 5–6).



Figure 4. *Four verification jigs, each labeled by capture method, fabricated using the respective scan data.*



Figure 5. *Sheffield test: Each verification jig is seated intraorally and secured with a single Rosen screw; passive fit and gaps are checked visually and with an explorer.*



Figure 6. *Gap observed on one MUA with the ioConnect jig, indicating lack of passive fit.*

Secondary Test: Intraoral Scanner Bite Accuracy

The patient's four-month-worn provisional prosthesis was scanned with three intraoral scanners (3Shape Trios 5, Medit i700, Shining Elite) (Figure 7). Scanned data was combined with the photogrammetry data, and various prototypes were designed in Exocad using one preoperative wax-up for standardisation. Prototypes were 3D-printed with an Ackuretta printer and Rodin Titan resin (Figure 8A, B), then tried in for bite verification.



Figure 7. *Three intraoral scanners used for the secondary test.*





Figure 8A. *3D printing of prototype with Ackuretta printer and Rodin Titan resin.* ***8B.*** *Prototypes fabricated and packaged, ready for clinical try-in.*

Results

Passive Fit Accuracy Results

- **Shining 3D Elite IPG:** Achieved the most accurate and repeatable passive fit; the verification jig seated passively on all MUAs; no gap visible.
- **ICam4D:** The most posterior implant's MUA-jig connection demonstrated probe catch during verification, though no visual gap was apparent.
- **Micron-mapper:** Accurate in most regions, but mild gap in one position.
- **ioConnect:** An observed gap was noted on one MUA during Sheffield testing.

Bite Accuracy Result

Bite accuracy testing with 3D-printed prototypes showed that the prototype based on Shining 3D scan data provided the best occlusal relationship and required zero adjustment.

After confirming passive fit and occlusal accuracy, the final definitive prosthesis was delivered. (Figure 9A, B). A postoperative panoramic X-ray was also obtained to confirm the passive-fitted prosthesis in place and proper implant integration (Figure 10).



Figure 9A. *Final prosthesis and* ***9B.*** *Clinical outcome with patient smiling.*



Figure 10. *Postoperative panoramic X-ray confirming passive fitted prosthesis in place.*

Discussion

Photogrammetry stands at the forefront of digital implant dentistry for full-arch rehabilitation, offering unmatched accuracy through triangulated image capture of implant scanbodies. Extraoral photogrammetry (ICam4D, Micron-mapper) is widely considered the gold standard for capturing implant positions [1,2,3,4]. However, as this clinical case illustrates, EPG may face practical limitations—especially in far posterior or crowded sites where not all scanbodies can be mounted and visualised at once. In such situations, the scan must be split into multiple parts by scanning accessible implants first, then unscrewing and repositioning scanbodies to blocked sites, and finally merging the scans using shared references. This process, while necessary, introduces extra steps and the risk of alignment errors in the final dataset. These challenges, seen in this case and supported by the literature, highlight that while EPG remains the reference standard, it is not always ideal in every full-arch scenario [10].

The intraoral photogrammetry system (Shining 3D Elite IPG) eliminates these issues by capturing all implant positions in a single scan, without obstruction from lips or cheeks, regardless of implant location. In this case, IPG produced the most accurate and reproducible results, confirmed by passive fit of the verification jig and consistent results across repeated scans—matching the findings of recent studies [7–9,11,12]. Unlike scanbody systems with extensions across the arch, which still inherit the limitations of intraoral scanners—such as the need to stitch together numerous frames, the Shining 3D Elite system operates on a fundamentally different principle. Its coded scanbody technology does not rely on capturing broad surface geometry; instead, it recognizes unique codes and known geometries on each scanbody in just a few frames. This approach overcomes the typical pitfalls of intraoral scanning, resulting in highly accurate and repeatable implant position capture.

The ioConnect system, while innovative and affordable as an open-platform solution, was ultimately limited by the inherent stitching errors of the intraoral scanner. The palatal orientation of the horizontal scanbodies is designed to minimize scanner movement and reduce error, but in practice (and as observed in this case and literature), it remains vulnerable to misalignments if the hexes of scanbodies are not perfectly concentric or if the scanner captures excessive data beyond the hex [13,14]. In this patient, a visible gap was detected on one MUA with ioConnect during the Sheffield test, confirming the limitations of this approach in high-demand cases. Additionally, the number of implants itself impacts accuracy; the misfit observed in the ioConnect group may be partly due to this factor. Recent findings by Pozzi et al. [4] support that as the number of implants increases, deviations—especially in the z-axis—become more pronounced.

Importantly, this report appears to be the first in vivo assessment directly comparing these four digital capture techniques for full-arch implant cases. Unlike in vitro studies, which use reference controls in idealised conditions, real clinical scenarios introduce many variables that cannot be replicated in the laboratory. Benchtop comparisons are valuable, but they may underestimate the practical challenges and variability faced in daily clinical practice.
The bite accuracy test confirmed that the prototype derived from Shining 3D data provided the best bite and occlusal fit. All prototype design and alignment were standardised in Exocad, eliminating the influence of automatic alignment in Shining software and ensuring comparability.

In summary, while the author is a strong advocate and believer in extraoral photogrammetry as the gold standard, this clinical case has shown that it may not be suitable for every situation. The additional cost, complexity, and practical limitations in challenging clinical scenarios mean that alternatives like intraoral photogrammetry (Shining 3D Elite) offer an effective, reliable, and more accessible solution for many practices. ioConnect, while cost-effective, must be used with awareness of its limitations and best reserved for less demanding cases or as a supplementary aid.

Clinical Implications

This case highlights several important lessons for clinicians:

- Extraoral photogrammetry remains the gold standard for full-arch implant capture, but may not be practical or sufficiently reliable in every clinical scenario, especially in crowded or posterior sites requiring repeated partial scans.
- Intraoral photogrammetry (IPG) offers a streamlined, accurate, and reproducible workflow, especially valuable when full-arch case volume or budget does not justify EPG investment.
- ioConnect and similar palatal scanbody systems provide an open-platform, affordable solution, but their accuracy is limited by intraoral scanner stitching errors and perfect scanbody placement is critical.
- For highest-demand cases—especially with pterygoid or posterior implants—photogrammetry (ideally IPG) should be the method of choice.
- The Sheffield test is critical for verifying intraoral passive fit for any verification jig, regardless of capture method.

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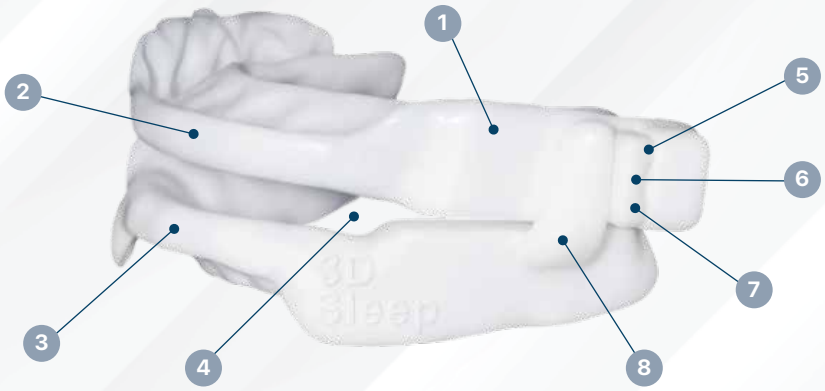
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3 Minimal Anterior Coverage
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4 Maximum Tongue Space
Without significantly affecting the tongue's range of motion

5 Interchangeable Titration Tabs
Allows precise mandibular advancement in 1 mm increments for customised treatment adjustments.

6 Easy-Removal Slot
Designed for secure placement and effortless removal, minimising the risk of handling errors.

7 Exceptional Mandibular Advancement
Provides flexible mandibular advancement from 1 to 5 mm, with 5 pairs of titration tabs included for precise adjustment.

8 Slimline Dorsal Fin
Providing a sense of comfort and naturalness for patients

3D Sleep Appliance VS Traditional Anti-Snoring Appliance



Feature	3D Sleep Appliance	Serene Silensor™	EMA®	MOSES® Elite
Material	3D Printed Nylon	Acrylic	Plastic	Acrylic and Plastic
Thickness	1 mm	2.5 mm	1.5 mm	2.5 mm
Comfort Level	★★★★★	★★★	★★★★	★★★
Durability	★★★★★	★★★★	★★★	★★★★★

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HEEDING THE CALL

Dr Sam Talpis, co-director of 3DSleep in Melbourne, Australia, shares about the opportunities and challenges for the field of dental sleep medicine in Asia-Pacific, and the importance of a collaborative ecosystem for interested clinicians to learn and network.



Dr Sam Talpis

Dr Sam Talpis' story is one of a search for greater purpose. After completing his dental studies and working in general dentistry, he found himself yearning for something more impactful. "Like many general dentists, I reached a point where I did not feel entirely fulfilled," he explained. While he recognised the value of general dentistry, he sought a deeper connection with his patients and their quality of life.

This turning point came when he attended residencies in the US that treated patients with facial pain, temporomandibular joint dysfunction (TMD), and sleep-related disorders.

These cases exposed him to the transformative potential of dental sleep medicine, an area largely overlooked in traditional dental training. The profound changes he observed in patients — from alleviated pain to improved sleep quality — were inspiring.

"The owner of the practice I was working for at the time had suggested that I go to the American Academy of Craniofacial Pain. It was an incredible opportunity to learn from experts like Dr Jeff Okeson, and I really thought that this was an area that I could pursue," he said.

This journey solidified his commitment to focus on dental sleep medicine, marking the beginning of a transformative career shift upon returning to Australia. Dr Talpis' aspirations led him to Sleepwise Clinic, Australia's largest dental sleep medicine practice, where he honed his skills in treating sleep-disordered breathing and related issues. "I really dived deep into sleep studies, working three days a week, seeing about 15 patients a day," Dr Talpis added.

3DSleep was founded in 2020 when Dr Talpis and his fellow co-founders, Dr Harry Ball and Dr Ken Lee, saw the opportunity to provide clinic treatments, training programmes, and manufacturing services for the dental sleep medicine market in Australia, under one brand.

"Our vision and mission are to make this journey more accessible to dentists and give them the skills and the confidence to be able to do it themselves. 3DSleep's established brand will be a key driver to achieve this," he explained.

AN ECOSYSTEM FOR DENTAL SLEEP MEDICINE

The launch of 3D Sleep marked a significant milestone in Dr Talpis's career. Recognising the gaps in dental sleep medicine, he envisioned an ecosystem that seamlessly integrates education, diagnostics, and advanced oral appliances.

"Our training syllabus was embraced by many dentists because it was really something quite unique in the field. Dr Ball and I were also convinced about the physical properties of nylon after attending a conference in 2017. We decided to develop our own product, and after a year spent doing trials and testing, we were thrilled with the results clinically," said Dr Talpis.

3D Sleep's holistic approach includes training programmes that equip dentists with the knowledge and confidence to treat sleep-disordered breathing, diagnostics with streamlined tools and systems for accurate diagnosis and patient management, and manufacturing capabilities with advanced mandibular appliances designed for comfort and durability.



Dr Talpis sharing about 3DSleep's journey at the Asia Pacific Dental Sleep Medicine Fellowship Day in Singapore

This integrated model has been particularly impactful in addressing the unique challenges faced by dentists in the Asia-Pacific region, such as limited access to credible appliances and reliable workflows.

"Raising awareness among dentists and patients is vital. When dentists are confident in their ability to treat sleep disorders, it opens the door to significant improvements in public health," he explained.

Dr Talpis credited the success of 3DSleep to the "maturity" of the dental sleep medicine market in Australia, where the country's illustrious and strong history in sleep medicine makes it a very accepted treatment.

"If we take a look back at history, one of the first pioneering treatments was accidentally discovered in Australia by Professor Colin Sullivan in about 1980, which was the continuous positive airway pressure (CPAP) machine, as well as pioneers like SomnoMed, who were one of the original brands that was created in Australia," he explained.

Dr Talpis highlighted that sleep-disordered breathing is a widespread issue, with up to 40% of adults snoring and 10–15% of men experiencing sleep apnoea. The prevalence of sleep-disordered breathing is also evidenced in over a quarter of a million sleep studies through Medicare in Australia. Despite these numbers, Dr Talpis added that 80–90% of sleep disorders remain undiagnosed, highlighting a critical need for increased awareness and intervention.

By contrast, the US has incorporated sleep medicine screening into mainstream dental guidelines where one in two dentists treat OSA with oral appliances. Established bodies like the American Academy of Dental Sleep Medicine further offer actionable insights in navigating this journey. Dr Talpis sees this as an area ripe for growth in Australia and the broader Asia-Pacific region.

"In Australia, we are very supported by the sleep physicians in the medical fraternity, whereas I know that in many of South-East Asian countries, the field is still quite heavily focused on surgery. The push from dentists as well as availability of evidence-based treatment is key to offer oral appliances credibility for a treatment that is more accepted in Asia," Dr Talpis explained.



Breakthroughs in material science with nylon offer patients new and improved advantages for oral appliances

In dental sleep medicine, more "moving parts" are involved in diagnosing and treating a patient including collaborations with medical specialists. From interpreting sleep studies to managing workflows, the process can feel daunting, which dentists can find overwhelming. Highlighting the ecosystem 3DSleep has modelled, Dr Talpis noted the importance of simplifying this journey. "Our key is the ongoing support for the dentist through the first three to five cases in this dental sleep medicine journey. Once they have done those cases, they would have developed the confidence and be able to autonomously do it within their own practice," he said.

TRANSFORMATIVE ADVANCEMENTS IN TECHNOLOGY

A pivotal moment came in 2017, when Dr Talpis encountered 3D-printed nylon appliances at an international conference. These appliances offered a game-changing combination of durability, thinness, and patient comfort.

"We spent a year testing nylon before rolling them out commercially," he recalled. "Patients transitioning from older models were amazed by the difference. The ultra-thin, lightweight design made compliance much easier."

He continued: "Many of our patients were on their third or fourth appliance after many years. When they transitioned to nylon, they preferred its lightweight and comfort, so we released these products commercially. This helped us realised 3DSleep's path to create an ecosystem offering diagnostics, education, a products lab, and mandibular advancement splints both in and outside of Australia."

The benefits of developing an internal manufacturing capability further allowed 3DSleep to develop and research patented manufacturing processes for features like improved appliance elasticity, stain resistance, and bacteriostatic properties, ensuring safety and longevity.

Beyond materials, 3D Sleep has also collaborated with 3D scanner, 3D materials, and sensor companies to advance research and product development.

One of the most significant barriers in dental sleep medicine is the disconnect between dental and medical professionals. Dr Talpis has worked tirelessly to foster collaboration, recognising that a unified approach is key to improving patient outcomes.

3D Sleep's ecosystem includes a communication portal that connects dentists, sleep physicians, and patients. This system simplifies the process of obtaining and managing sleep studies, ensuring seamless care.

"Traditionally, patients had to navigate a complex, time-consuming pathway involving multiple specialists. Our portal streamlines this, making it easier for everyone involved," said Dr Talpis.

Dr Talpis envisions a future where dental sleep medicine is a standard component of dental practice globally. "The evidence, guidelines, and technology are all in place," he added. "What is needed now is collaboration and education to ensure these resources are utilised effectively."

For Dr Talpis, the mission is deeply personal. He concluded: "Helping patients sleep better does not just improve their nights; it transforms their days. That is the impact we strive for at 3D Sleep." DA

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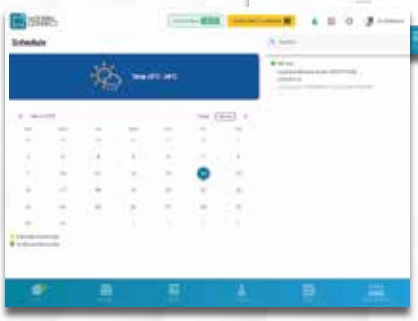
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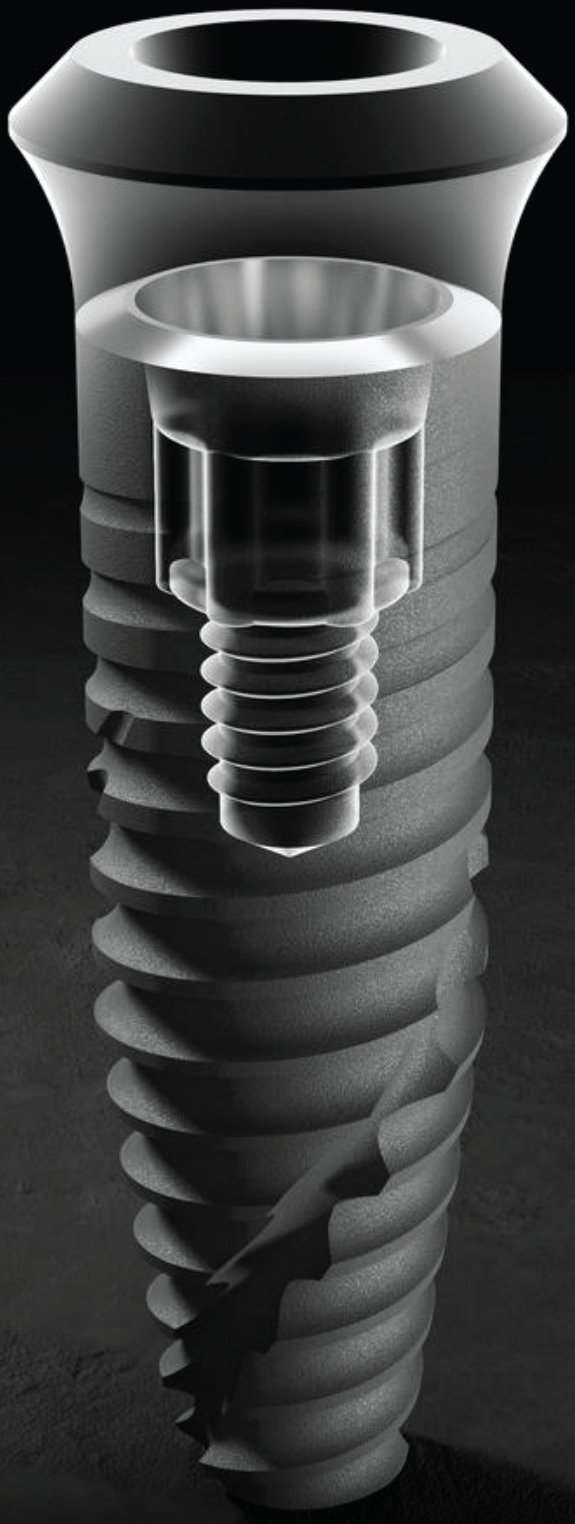
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CLINICAL CASE



Presented by
Prof. Melissa Fok

- *Clinical assistant professor, Periodontology Postgraduate Programme Co-director (European Federation of Periodontology accredited), Deputy Director - Institute for Advanced Dentistry Clinical Research Centre, Assistant Dean (Alumni and External Affairs), Faculty of Dentistry, The University of Hong Kong*
- *Registered Specialist in Periodontology (HK)*
- *International Team for Implantology ITI (Fellow)*
- *PhD, The University of Hong Kong*
- *Fellow of the Hong Kong Academy of Medicine (Dental Surgery)*
- *Fellow of the College of Dental Surgeons of Hong Kong in the Specialty of Periodontology*
- *Membership in Periodontics, Royal College of Physicians and Surgeons of Glasgow*
- *Specialty Membership in Periodontics, Royal College of Surgeons of Edinburgh*
- *MDS in Periodontology (Distinction), The University of Hong Kong*
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FLAPLESS IMMEDIATE IMPLANT IN UPPER AESTHETIC ZONE

> "The apically tapered self-tapping and a coronally conical implant design allow for compression of bone walls in a slightly underprepared osteotomy site, contributing to increased insertion torque and implant stability for immediate placement and restoration protocol."
>
> ***Prof. Melissa Fok***

Patient Information

Gender	Age	Jaw	Health Status	Bone Type	Local Infection	Anatomical Defects	Risk Factors
Female	52	Maxilla	ASA I	Type II-III	Nil	Nil	Aesthetic zone type I placement thin labial bone

Initial Situation



Treatment Planning



Surgical Procedures



Atraumatic extraction at 11 with minimal severing of the gingival tissue.



Static computer-assisted implant surgery.



Full seating of the surgical guide.



Buccal view.



Occlusal view.



BLC SLActive® Ø3.5 x 8mm Implant with a conical coronal portion and an apical self-tapping tapered design. Implant insertion through static guide.



Implant placement. Jumping distance filled with DBBM graft.



Chairside fabrication of immediate restoration (without loading).





1-week post-operation.
Excellent healing of peri-implant tissue.



Post Operation, temporisation stage

Treatment Outcome (Implant loading at 4 months)



Before



After



LOWER MOLAR FLAPLESS IMPLANT PLACEMENT

> “Availability of 4.5mm diameter tissue-level implant with varying heights of polished collars allows flexibility in planning and possibility to avoid GBR in selective cases for posterior indications.”
>
> ***Prof. Melissa Fok***

Patient Information

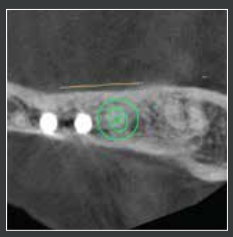
Gender	Age	Jaw	Health Status	Bone Type	Local Infection	Anatomical Defects	Risk Factors
Female	65	Mandible	ASA II, Psoriasis	Type II-III	Nil	Nil	Local mucosal deformity, lack of keratinised tissue

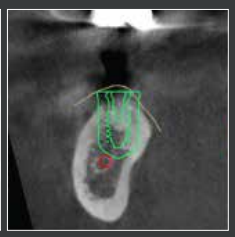
Initial Situation





Treatment Planning







Surgical Procedures



Flapless implant placement with static guide to preserve the attachment of adjacent implants and teeth.



TLC RT Ø4.5 x 8mm SP implant placement. Partial thickness recipient bed preparation, removal of muscle attachment.



A free gingival graft (FGG) was harvested from the palate to augment the buccal keratinised tissue around three implants.

Treatment Outcome



Day 1 loading.



6 months loading.

Before



After



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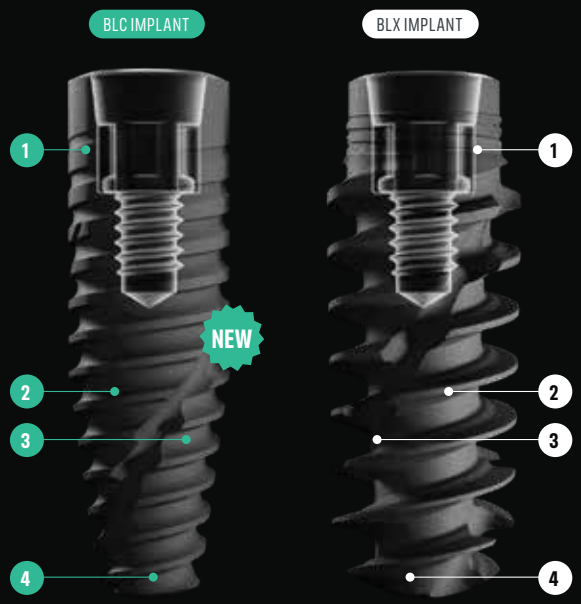


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BLC	✓		✓		✓		✓	✓
BLX		✓	✓	✓	✓	✓	✓	✓
Lengths	8–18 mm	8–18 mm	6–18 mm	6–18 mm	6–18 mm	6–18 mm	6–16 mm	6–14 mm (BLC) 6–16 mm (BLX)

BLC/TLC FEATURES

1. **PRECISE IMPLANT BED**
   Precisely matching drills and profile drills for accurate preparation of the implant bed.
2. **TAPERED DESIGN**
   Enables under-preparation of the bone and ensures high implant stability.
3. **EXTENDED CUTTING FLUTES**
   Self-tapping properties remove the need for tapping.
4. **SLIM APEX**
   For patient's limited anatomy, allows bone compression in undersized osteotomy.



	Ø3.3 mm	Ø3.5 mm	Ø3.75 mm	Ø4.0 mm	Ø4.5 mm	Ø5.0 mm	Ø5.5 mm	Ø6.5 mm
TLC	✓		✓		✓		✓	✓
TLX			✓		✓		✓	✓
Lengths	8–18 mm	–	6–18 mm	–	6–18 mm	–	6–12 mm (TLC) 6–12 mm (TLX)	6–10 mm (TLC) 6–12 mm (TLX)

BLX/TLX FEATURES

1. **SMALL NECK DIAMETER**
   Reduces stress on crestal bone and facilitates slightly subcrestal implant placement.
2. **VARIABLE THREAD DESIGN**
   Thin and progressive thread design for high implant stability.
3. **BI-DIRECTIONAL CUTTING ELEMENTS**
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4. **DEEP APICAL THREADS**
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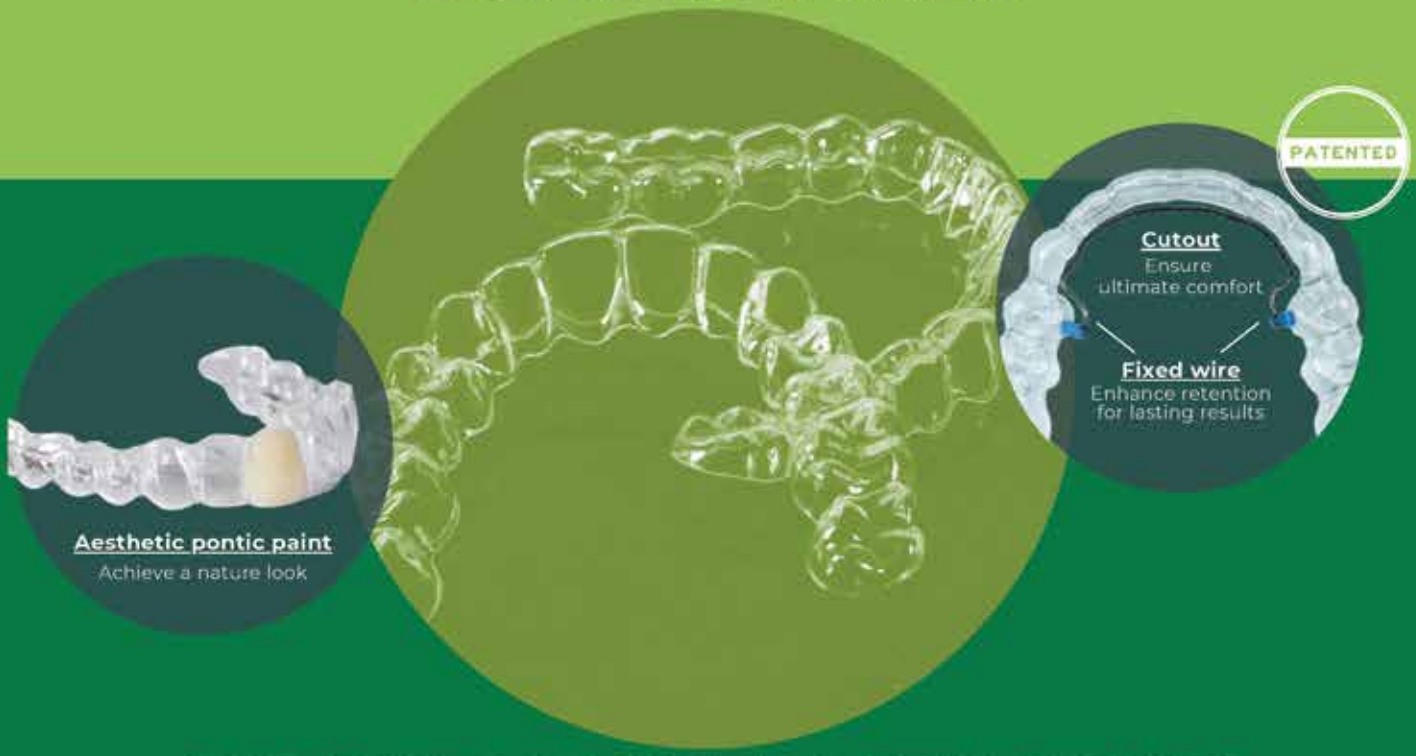
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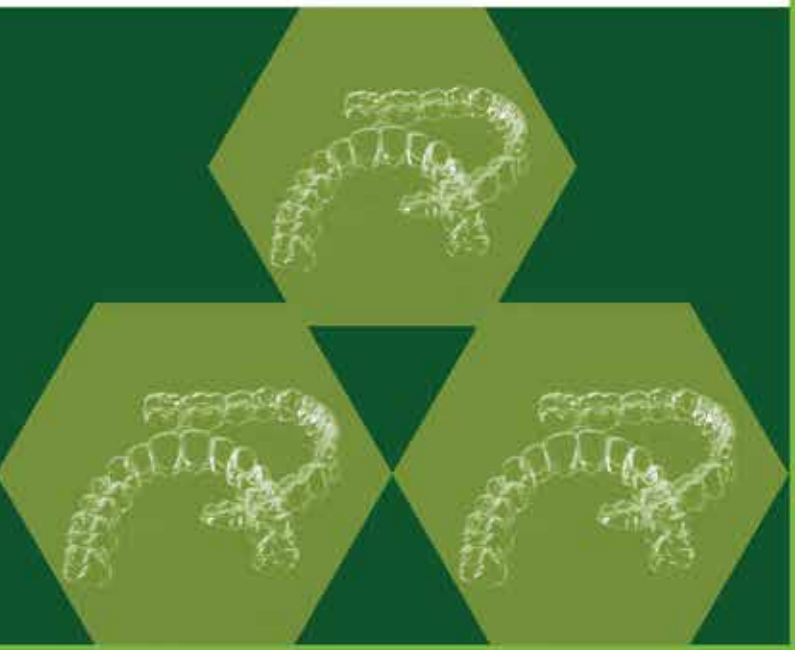
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1 CASE 3 SETS

Computer Assisted Surgery (CAS) Sequential Phasing In Complex Maxillofacial Reconstruction Case Illustration - Oral Dental Smile Reconstruction



Author: Dr. Tak Kun CHOW

FRACDS,FDSRCS(Eng),FHKAM(Dental Surgery),FCDSHK(OMS)

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ABSTRACT

Structural complexity in oral maxillofacial region poses extreme challenge to surgeons managing regional disease and correction of deformities. Until recent decade, practicality of high-resolution CT/MRI imaging, Computer-assisted surgery (CAS) workflow, 3D printing[1,2], virtual reality and perioperative navigation augmented with artificial intelligent AI technologies almost revolutionise the field of oral and maxillofacial reconstruction[3] that offering enhanced precision, safety, and outcomes. This two-part manuscript illustrates the role of CAS sequential phasing in maxillofacial reconstruction by exemplified cases to delineate its application in Part I for oro-dental smile rehabilitation that followed by Part II for mandibular reconstruction and planning for resection of large tumor situation in next issue. This manuscript underscores CAS as a cornerstone of modern oral rehabilitation.

Key Words : CAS Computer-Assisted Surgery, Smile dental rehabilitation, Digital workflow

INTRODUCTION

Oral Maxillofacial dental complex is not solely masticatory function, speech that definitive facial aesthetics greatly influence by the smile anterior dental segment positioning posing unique challenges to reconstructive surgical planning. Conventional freehand techniques for dental implant placement and alveolar reconstruction risk suboptimal outcomes, including malocclusion, implant misalignment, and poor smile cosmesis. Computer-assisted surgery[1,2] (CAS) has emerged as a transformative tool, enabling data-driven planning and execution. By integrating high-resolution CBCT, intraoral scans, and AI-powered smile design software, surgeons can simulate outcomes, optimize implant trajectories, and fabricate patient-specific prostheses[3,4]. The author will elaborate a complex dentofacial secondary cleft deformities patient for comprehensive oral-dental smile reconstruction by detailing how CAS technologies harmonize dental implant placement in osteotomy planning, digital workflow for dental smile aesthetics restoration. We highlight the synergy of preoperative osteotomy planning and implant placement simulation finalized with dental prosthetic fabrication in achieving predictable outcomes.

METHOD & RESULT:

A Case of Complex Oral Dental Smile Reconstruction

Smile restoration should always be the ultimate goal for dentist in frontal dental rehabilitation. However, for some congenital dentofacial deformities such as cleft lip and palate patients that would be extreme challenge. The author will present a complex dentofacial reconstruction sequencing to restore her smile aesthetics with CAS transformation journey.

CAS Sequential Phasing

The role of CAS can be phasing sequentially[1] as

1. *Data acquisition phase -preoperative imaging & clinical information input;*
2. *Planning phase -Joint meetings between surgeon and biomedical engineer/dental technician under the virtual planning software programme;*
3. *Manufacturing phase- computer aided design (CAD) derived 3D models, guides and occlusal splints etc;*
4. *Surgical phase – surgical execution according to the cutting guide & intra-operative navigation;*
5. *Quality assurance phase – intra-operative accuracy verification by either perioperative CT or postoperative CT imaging.*

Clinical Profile

A 27-year-old female born with bilateral cleft lip and palate and multiple congenital deformities such as syndactyly (hand and foot), generalised enamel hypoplasia and lower anterior retained deciduous teeth with diastema. She had primary cleft lip and palate, alveolar bone grafting and maxilla advancement surgeries performed in public hospital. In view of her severe deformed cleft lip nose deformities, anterior cross bite due to former relapse of Le Fort I advancement osteotomy and numbness of lower left mental nerve due to former chin graft harvesting posed her dental rehabilitation almost desperate. She came to see the author for second opinion for radical lip nose and dentofacial reconstruction.

Finalised Treatment Plan Execution by CAS Sequential Phasing

After a thorough dentofacial assessment by full skull 3D Cone Beam CT, intraoral dental scanning and meticulous soft tissue profile analysis ***(Figure. 1)*** a staged reconstruction plan[2] as following:

1. *Radical lip nose reconstruction with 10th rib graft as columella strut to reform nasal tip <June 2023>* ***(Figure. 2)***
2. *Extraction of lower anterior segment due to short roots and non-salvable then perform immediate implant insertion for definitive implant supported bridge <Nov 2023>*
3. *Anterior mandibular segmental setback osteotomy to correct anterior cross-bite for final anterior dental rehabilitation<Dec 2023>*
4. *Anterior 6 units bridge preparation with intraoral scanning for fabrication of Zirconium bridge(multilayering) rehabilitation of her bilateral edentulous cleft dental spacing and Screw retained lower implant bridge<Feb 2024>*
5. *Definitive Smile Line reconstruction by vermillion M-plasty <Aug 2024>*

DISCUSSION

The narrated oral dental rehabilitation journey is well illustrated by the CAS sequential phasing. The distinctive role of CAS started with data acquisition by 3D CBCT and Intraoral dental scanning by using transferring of Digital Imaging Communications in Medicine (DICOM) data to virtual planning software such as DTX™ studio to make qualitative and quantitative analysis of the regional anatomy. Base on this virtual planning tool, the surgeon can assertively decide the best treatment option and incorporate any adjunct procedure. The pre-implant digital planning dictated immediate



Figure 1. Preoperative 3D Assessment - Data Acquisition Phase

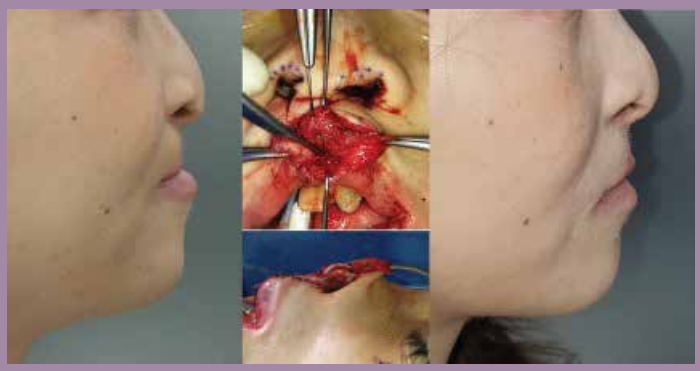


Figure 2. Radical Lip Nose Reconstruction Surgery by 10th Rib strut Graft to reform the Nasal Tip Columella Complex



Figure 3. Virtual Planning to Surgical Phase according to design the implant position and mandibular anterior segmental setback osteotomy to correct anterior cross bite

implant insertion trajectory from thin crestal bone to basal bone to avoid the former para-symphyseal bony defect. ***(Figure 3)***

Preoperative Intraoral scanning **(IOS)** of the severely deformed anterior segment could provide provisional planning of the bridge design and fabrication of the temporary bridge as provisional restoration for the clinician objectively assess the incisal dimension including the lip support and also functional incisal show. High resolution 3 Shape™ wireless intraoral scanner scanned the bridge abutment preparation precisely and instant data transfer to the laboratory as STL file for 3D printing & (CAD) of the master cast for digital planning and fabrication of the zirconium bridge[4]. The dental technician communicates with the clinician via a digital shareware EXOCAD™ to finalise the bridge design and offer any modification after online meeting. ***(Figure 4)*** All the perfect fitting of prosthesis and aesthetic outcome ***(Figure 5)*** are the key parameters of Quality Assurance Phase in CAS digital transformation of Dental Smile Reconstruction.



Figure 4. Virtual Planning & Manufactory Phase by Technician vs Clinician case conference to CAD fabrication of Anterior 6 units zirconium bridge(multilayer zirconium) preparation by intraoral scanning and digital communication

CONCLUSION

The efficacy of CAS sequential phasing facilitated this complex oral-dental smile reconstruction commenced from unifying digital planning, guided surgery till fabrication of aesthetic dental restorations. Both the patient and the clinician could envisage the functional and aesthetic excellence by a secured digital workflow.

Acknowledgement:

This patient's full digital dental laboratory planning and CAD fabrication of the upper zirconium bridge and lower implant retained bridge were under the technical expertise manufacturing by Head Technician Mr. Sean Ho (MacStudio).



Figure 5. CAS Digital Transformation Journey for Dental Smile Reconstruction

DISCLAIMER

The Digital workflow from planning to fabrication of 3D products is a standard of care in author's specialist practice that both patients being informed for the clinical application during their treatment phases. Consent for publication – Patient fully approved the author to publish this manuscript.

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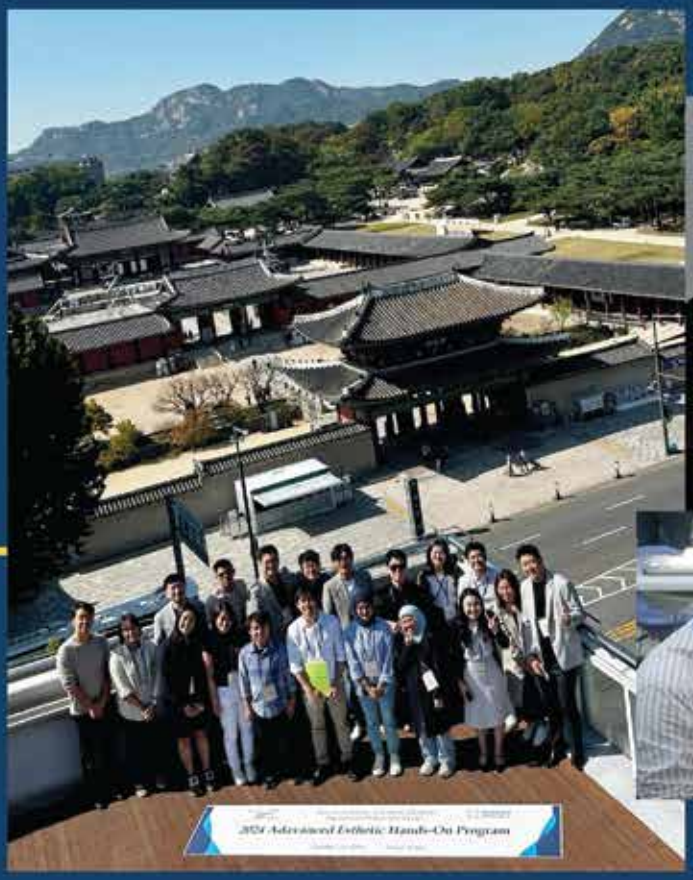
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A standout feature of the program was the hands-on training, where participants engaged in practical exercises for veneer and crown preparation. Guided by Professors Kim and Lee, attendees received personalized instruction, which allowed them to refine their techniques and strengthen their confidence in executing precise and aesthetically pleasing restorations. This experiential learning opportunity was instrumental in reinforcing theoretical concepts, enabling participants to apply their knowledge in a real-world context.

The interactive discussions among peers and instructors fostered a collaborative environment, encouraging the sharing of ideas and best practices in aesthetic dentistry. By the conclusion of the program, participants emerged with enhanced skills and a profound understanding of the principles underpinning predictable restorations. This certification sought to empower dental professionals and raise the standard of care in aesthetics, ultimately benefiting patients who seek exceptional restorative outcomes. Attendees left inspired to implement their newfound knowledge in their clinical practices, ensuring improved treatment success and high levels of patient satisfaction in aesthetic dentistry.

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BY DR JACKY LI

DOCTOR OF DENTAL MEDICINE (D.M.D.), THE UNIVERSITY OF SYDNEY







I attended the Advanced Aesthetics with Korean Academy of Esthetic Dentistry at Seoul National University last year and it was an exceptional experience. The course provided me with the most advanced, cutting edge knowledge, technology and techniques which I can now confidently apply in my practice. Professor Sung Tae Kim, Woohyun Kim and Professor Seung Kyu Lee, Ji Man Pak, Young Dan Cho were outstanding in their teaching approach, making complex topics easy to understand and implement.

The hands-on sessions led by Dr Seung Kyu Lee and Dr Woohyun Kim were particularly valuable, allowing me to improve my efficiency and quality of treatment. The instructors' expertise and dedication to helping participants master the techniques were evident throughout the course.

Since completing the course, I have already implemented the new skills I have obtained. I highly recommend this course to any dentist seeking to advance their clinical skills and broaden their knowledge.

A huge thank you to Dr Woohyun Kim and Dr Jinhwan Kim from Korean Aesthetic Dentistry for delivering such a comprehensive and impactful learning experience.



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Rehabilitation of a Periodontally Compromised Patient Using a Novel Digital Workflow: A Case Report





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Specialist in Periodontology
BDS (HK), MDS (Perio) (HK), M Perio RCSEd, FCDSHK(Perio), FHKAM (Dental Surgery)

Dr. Alex C.H. Cheung
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BDS (HK), MDS (Pros) (HK), MPros RCSEd, FCDSHK(Pros), FHKAM (Dental Surgery)

Abstract

This case report demonstrates the successful rehabilitation of a periodontally compromised patient with multiple missing teeth using an innovative digital workflow. The workflow is characterized by its model-less approach, seamless data integration, and the ability to digitally duplicate the patient's existing prosthesis for planning. The patient received a temporary prosthesis within 24 hours, enhancing both aesthetic and functional outcomes.

Introduction

This case report aims to demonstrate the rehabilitation of a periodontally compromised patient with multiple missing teeth using a current CAIS digital workflow. This digital workflow is unique due to its model-less approach, seamless merging techniques, lack of wax-up try-in, and the ability to copy the patient's existing prosthesis and convert it to digital planning. The process involves photogrammetry and enables the delivery of a temporary prosthesis within 24 hours (Joda et al., 2017).

The value of this digital workflow extends to patients, clinicians, and labs by offering precision, streamlined workflow, and enhanced communication and collaboration between clinicians and technicians (Mangano et al., 2018). Digital workflows in implant dentistry have revolutionised treatment planning and execution, allowing for more predictable outcomes and increased patient satisfaction (González-Martín et al., 2019). Furthermore, the integration of digital technology in prosthodontics has been shown to reduce chair time and minimize errors, contributing to the overall efficiency of the treatment process (Papaspyridakos et al., 2016).

Initial Situation

The patient is a 61-year-old individual. He was referred to Dr. Leung for the management of periodontal disease, presenting with mobile teeth and persistent gum bleeding, which impacted his ability to chew. The patient is a non-smoker with a clear medical history and no reported parafunctional habits. Despite being periodontally compromised with multiple missing teeth, periodontal condition is stabilised and the missing teeth were replaced by a removable partial denture. This denture maintained a stable occlusion and had an edge-to-edge incisor setup.

Periodontal disease is a common cause of tooth loss in adults, and its management often requires a multidisciplinary approach. In this case, the patient's periodontal condition was stabilised, and the missing teeth were initially replaced with a removable partial denture. However, the patient expressed a desire for a more permanent solution, leading to the consideration of a fixed prosthesis using a digital workflow.

Pre-Operative (#32-46)





Pre-Operative photos



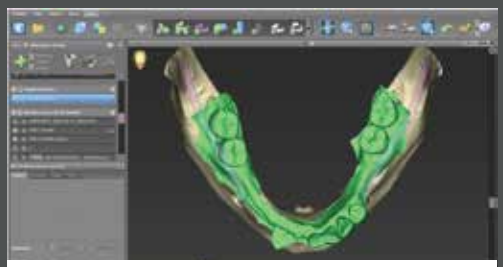


Patient with his existing denture

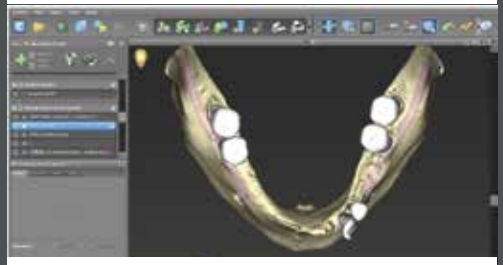
Treatment Planning

Intraoral scans of the upper and lower arches were performed. The existing lower denture was copied into a radiographic stent for implant planning, followed by a CBCT scan using the double scan technique. Implant positions were determined using a prosthetic-driven approach, with the setup of the existing denture teeth as a reference. The surgical guide and location of anchor pins were then designed (González-Martín et al., 2019).

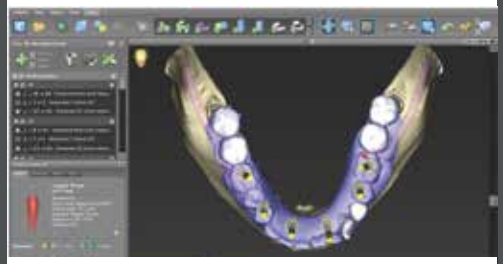
The use of digital technology in treatment planning allows for precise and accurate placement of implants, which is critical for the success of the prosthesis (Joda et al., 2017). By utilizing a prosthetic-driven approach, the implant positions can be determined with the final restoration in mind, ensuring a functional and aesthetic outcome. The surgical guide designed in this process helps to translate the digital plan into the clinical setting accurately.



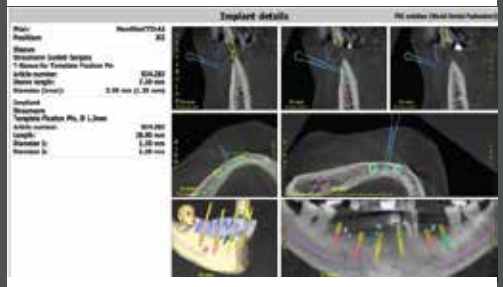
Merging of iOS with DICOM



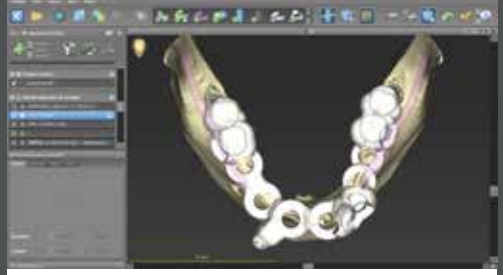
Merged File



Incorporating existing lower denture for implant planning



Implant plan completed together with anchor pins



Design of the surgical guide

Surgical Procedure

The surgery was conducted under local anaesthesia using an open flap technique. A fully guided approach was employed, with four implants placed using a 3D-printed metal guide (Modern Dental Laboratory). This guide reduces the risk of fracture, requires less tooth coverage, facilitates easier checking for complete seating, and includes irrigation holes without increased risk of breakage (Tahmaseb et al., 2014). Employing a fully guided surgical approach ensures the precise placement of implants, which is crucial for the long-term success of the prosthesis.

The osteotomy was prepared according to the manufacturer's instructions, and four BLT implants (Straumann SLA ®, Roxolid®) were placed. Implant positions were verified with a guiding pin, and the insertion torque exceeded 35 Ncm. Guided bone regeneration with Bio-Oss® and Bio-Gide® (Geistlich Bio-Oss®, Bio-Gide®) was performed on the buccal side of sites 32, 42, and 44, where bone was thin. Four zero-degree Screw-retained abutments (Straumann) were chosen and placed.



3D printed metal surgical guide



Implant positions were verified with guiding pins

Photogrammetry (iCam4D Solution)

iCam4D reference markers were placed on the MUAs to capture implant positions using conventional intraoral scans. Subsequently, iCam4D scan bodies were inserted, and photogrammetry data was recorded using the iCam4D solution (Papaspyridakos et al., 2016). The integration of photogrammetry in implant dentistry allows for highly accurate capture of implant positions, which is essential for the design and fabrication of the prosthesis.

Photogrammetry offers several benefits over traditional impression techniques, including increased accuracy, reduced patient discomfort, and shorter clinical times (Papaspyridakos et al., 2016). By capturing precise data on the implant positions, the digital workflow can proceed smoothly, ensuring that the final prosthesis fits accurately and functions well.

Intra Oral Scanning



iCam Refs insertion and take the implant position data by Intra Oral Scanner

Photogrammetry scanning

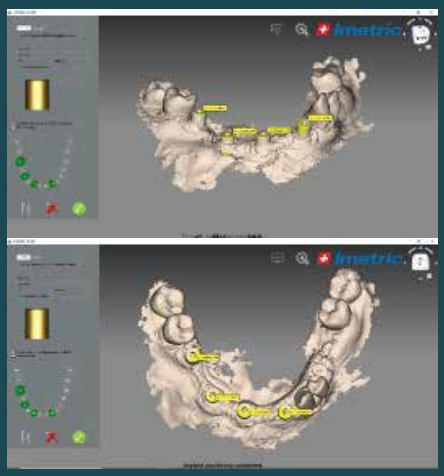


iCam Bodies insertion and take the data by iCam4D

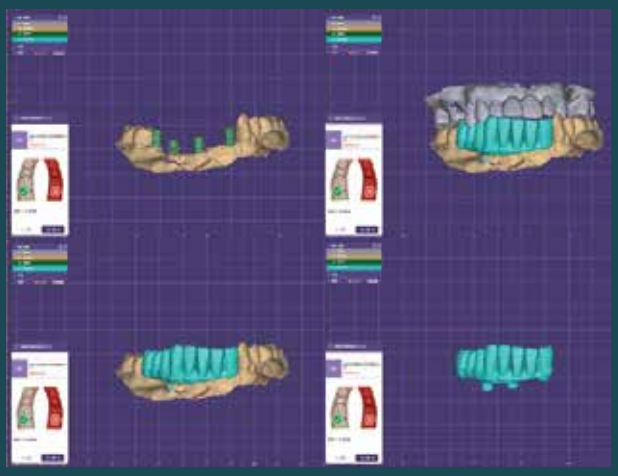
Laboratory Procedures

Using the Imetric 4D software, the intraoral scans of the iCam Refs and the photogrammetry data files were merged to generate a digital working model. The dental technician utilised EXOCAD to position the temporary prosthesis, which was a digital duplicate of the patient's existing denture, onto the MUAs. The implant temporary bridge was then printed and finished (Pozzi & Moy, 2016).

The use of digital technology in the laboratory phase allows for precise fabrication of the prosthesis, ensuring a good fit and excellent aesthetics. By merging the intraoral scans and photogrammetry data, a highly accurate digital working model can be created, which serves as the basis for designing the temporary prosthesis. The use of EXOCAD software allows for efficient and precise positioning of the prosthesis, ensuring optimal function and aesthetics.



Merging the iOS and Photogrammetry data files



Using EXOCAD (model-less solution) to design the temporary implant prosthesis



Finished Implant Temporary Bridge (PMMA + Titanium Base)

Prosthetic Procedures

The implants were restored in immediate function with a CAD/CAM PMMA provisional bridge was delivered 24 hours after the surgery. The old denture data, and the preoperative occlusion data was combined with the postoperative data to create the reference for the manufacturing of implant provisional bridge.

The ability to deliver a temporary prosthesis within 24 hours is a significant advantage of the digital workflow, as it enhances patient satisfaction and allows for immediate restoration of function and aesthetics (Mangano et al., 2018).

Treatment Outcomes and Conclusions

The provisional bridge work was completed as pre-treatment planned. Patient was satisfied with the aesthetics outcome and functionality.

This case report demonstrates the successful rehabilitation of a periodontally compromised patient using a novel digital workflow. The key advantages of this approach include a model-less technique, seamless data integration, elimination of wax-up try-ins, and the ability to digitally duplicate the patient's existing prosthesis for planning purposes. The workflow also enables the delivery of a temporary prosthesis within 24 hours, which can enhance the patient's experience and satisfaction.



Pre OP & Post OP OPG



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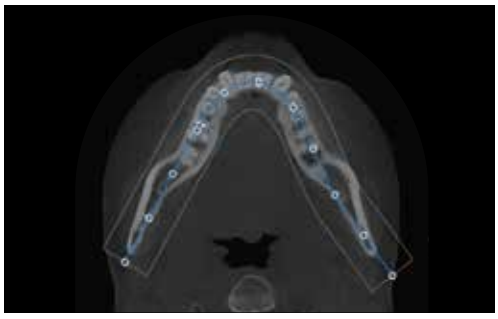
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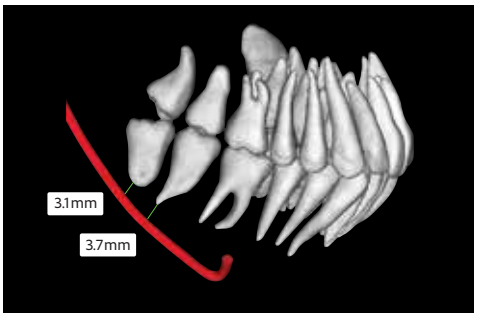
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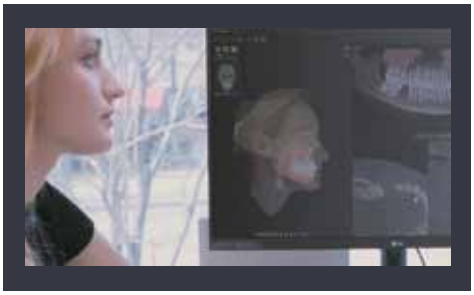
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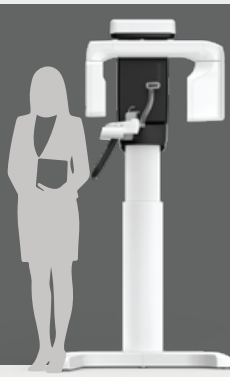
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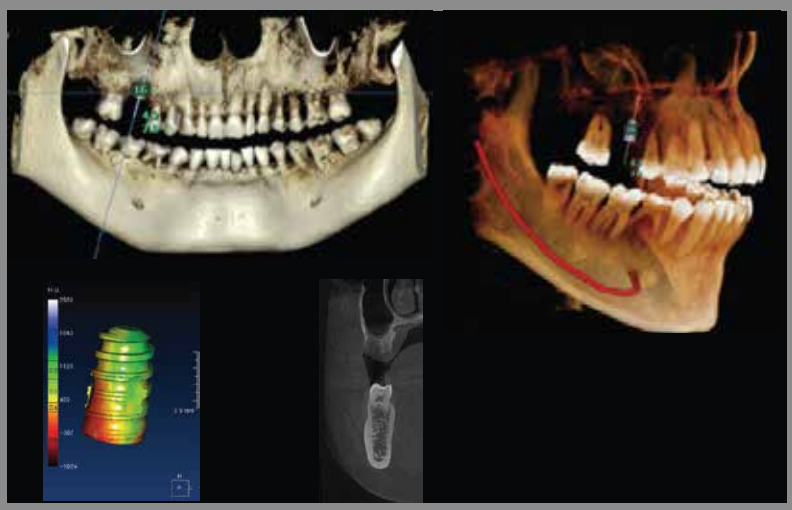
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