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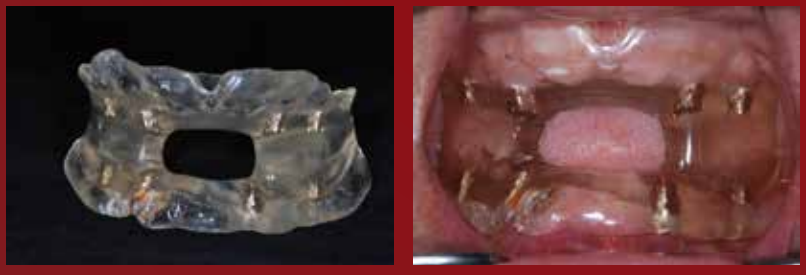

Oral appliance for obstructive sleep apnea patient. Page 16 Fig. 10

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E-mail：field.design@msa.hinet.net **傳真**：(02)3234-5491

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Journal of Prosthodontics and Implantology

Editorial

Journal of Prosthodontics and Implantology is the official journal of the Academy of Prosthetic Dentistry, ROC, Taiwan. The first issue of this journal was launched four years ago. Despite the Editor-in Chief, Prof. Shiau, has been exhausted in attracting manuscripts, this new journal has been difficult in collecting enough good quality papers to be published. Without new strategy from the Academy, this journal will have difficulty to survive.

Nevertheless, four manuscripts featuring three case reports and one review article are included in this issue. The review article was written by Prof. Shiau, which briefly but elegantly summarized the nomenclature, symptoms, etiology, classification, differential diagnosis of the temporomandibular disorders. A method of treating an edentulous patient of obstructive sleep apnea-hypopnea syndrome (OSAHS) with implant retained oral appliance was introduced. The retention and stability of the oral appliance was greatly improved by the implants and so was the effect of OSAHS treatment. Prostheses supported by mandibular subperiosteal implants have been used in mandibular rehabilitation for several decades. With the development of CAD/CAM technology, the treatment can be applied more easily. In this issue, a case was reported by rehabilitating with a simplified surgical protocol involving CAD/CAM technology and a screw-retained denture supported by a tripodal subperiosteal implant. Another case report described the successful outcome of a multidisciplinary treatments of a 28-year-old female with severe hypodontia. An interdisciplinary cooperation is indeed needed in treating such a comprised dentition and a prosthodontist should show great foresight and lead the team in achieving the final rehabilitative results.

We appreciate the efforts of all the authors and reviewers to make this issue possible.

Li-Deh Lin, DDS, PhD
Associate Chief Editor

Review Article

What is "Temporomandibular Disorders"?

Yuh-Yuan Shiau, D.D.S, M.S., F.I.C.D.
Professor Emeritus, National Taiwan University School of Dentistry, Taipei, Taiwan
Chair Professor, China Medical University Taichong, Taiwan

Corresponding author:
Yuh-Yuan Shiau, D.D.S, M.S., F.I.C.D.
National Taiwan University Hospital, Department of Dentistry, Taipei, Taiwan
Tel: +886-2-2312-3456 ext. 66849
Fax: +886-2-2312-3456
E-mail: shiauyy@ntu.edu.tw

Abstract

Pain and dysfunction at the orofacial area, or more specifically at the masticatory system are fairly common complaints of modern humans. There are many names applied for this problem, but the term "temporomandibular disorders (TMD)" is most often used. Based on information of recent publications related to the nomenclature, symptomatology, etiology, classification and diagnosis of TMD, the author tended to provide readers, especially dental health providers, a reference for better understanding of patients with orofacial pain complaints, and then more reasonable diagnosis and treatment.

Keywords: TMD, nomenclature, etiology, symptomatology, diagnosis

The nomenclature of temporomandibular disorders

"Temporomandibular disorders(TMDs)" or "temporomandibular disorder (TMD)" are terms used for a disease involving two specific parts of the anatomy, namely, the temporal and mandibular portions of the head. The abbreviation of this disease is more often TMD than TMDs in the literature. Therefore, in this article, TMD is used to represent either TM disorders or TM disorder. The word "joint" is not included in this term because it refers not limited to the temporomandibular joint (TMJ). The term was first seen in the 1960s, and replaced the term "Costen's syndrome," which was coined by Dr. J.B. Costen, who described a so-called "syndrome" related to a number of problems involving the ear and TMJ area, including hearing impairment, tinnitus, headache, and pain at or near the TMJ. Many other names for this type of disease were proposed subsequent to Costen's coinage based on the understanding of the anatomic parts, as well as the pain and/or functional disturbances involved. Among these other names, the term "temporomandibular arthrosis"[2] referred to TMJ disturbances without evident pain with inflammation. "TMJ pain-dysfunction syndrome," a term described by Schwartz[3], included of the TMJ area with pain and functional disorders. Schwartz also used the term "disorders of the temporomandibular joint," which indicated his emphasis on the TM joint itself, although he did not exclude muscle pain from his defini-

tion. Meanwhile, "myofascial pain-dysfunction syndrome," a name suggested by D. Laskin[4], focused more on the muscles of the head, face, and neck. However, Laskin's definition of myofascial pain does not meet the definition of myofascial pain generally used in the physical therapy field of general medicine. Moreover, the implied definition of "syndrome" in his designation is also different from the generally accepted definition of "syndrome," which refers to a series of symptoms and signs caused by a single disease. In fact, TMD is now generally believed not to be caused by a single factor and is thus regarded as a multifactorial disease. In 1958, Shore[5] used the term "temporomandibular joint dysfunction" to refer to disorders of the TM system, and while he was primarily concerned with the joint itself, he noted that these disorders were often accompanied by complaints of muscle pain and dysfunction. In 1995, Ramfjord and Ash used the name "temporomandibular joint and/or muscle disorders"[6] to describe problems at or near the TMJ while specifically pointing out that these disorders are not exclusively localized at the TMJ. Their nomenclature is no longer used now, but its definition is similar to that of the presently accepted term "temporomandibular disorders", or TMD.

The term "temporomandibular disorders" was first used by W. Bell in 1982[7]. This term covered pain and dysfunction in both the muscles and joints of the temporal and mandibular areas of the head. Prior to Bell's definition, the American Academy of Craniomandibular Disorders (AACMD) [8], which was founded in 1975, used the term "craniomandibular disorders," which referred to disorders involving the whole head rather than the temporal area alone. Subsequently, in 1982, the aforementioned academy changed its name to "the American Academy of Orofacial Pain (AAOP)", and went on to provide "Diagnosis Guidelines for Orofacial Pain" [9] in 1993. Thereafter, the terms "orofacial pain," "CMD," and "TMD" have all frequently been used by different academies and authors to describe roughly the same problems of the head, face, and neck areas. In 1996, the US National Institutes of Health (NIH) held meetings of experts on TMD and, led by Okeson, published a book titled "Orofacial Pain, Guidelines for Assessment, Diagnosis, and Management"[10]. This book subsequently became the most important reference for clinicians and researchers when dealing with orofacial pain and TMJ problems.

The symptomatology of TMD

The complaints most commonly raised by TMD patients consist of pain in unilateral facial areas including the ear, eye, temporal area, cheek, mandibular angle, and neck. Such pain is typically exacerbated by jaw movements made when eating, speaking, yawning, or clenching. Characteristically, TMD pain is neither severe nor continuous, but because of the pain, the movement of the jaw is limited or altered. The pain is deep in nature, and again, is most often related to jaw movements. As such, a patient's willingness or ability to open the mouth may be limited because of pain in the muscles or joints. Some patients also complain of noise from the TM joint when opening or closing the jaw, with or without mouth opening limitation. Nonetheless, ankylosis of the TMJ due to bone destruction such as rheumatoid arthritis is not regarded as a typical symptom of TMD. Meanwhile, the occurrence of joint noise may be accompanied with deflection in the jaw opening and closing path. Limitation or luxation of the jaw without evident pain[9] is occasionally mentioned as a symptom of TMD in addition to joint noise. Such joint noise can be sub-divided into clicking and crepitation, depending on the characteristics of the joint disc displacement, with or without destruction of the condyles, discs, or temporal bones.

The etiology of TMD

Most clinicians and researchers agree that TMD is a multifactorial disease. Therefore, a given TMD cannot be regarded as a "syndrome" because a syndrome is defined as a series of symptoms found in many parts of the body due to one cause. TMD was once thought to be related in a broad sense to rheumatic diseases[11], especially in Europe. For those who were more concerned with muscle problems related to muscle spasm, pain, and tenderness to systemic fibromyalgia or myofascial pain in the head and neck muscles[12-14]. In 1934, Costen related ear pain, tinnitus, dizziness, headache, and hearing impairment to the compression of the auriculotemporal nerve by TMJ posterior displacement resulting from the loss of posterior teeth[1]. In 1948, however, H. Sicher was unable to find evidence of auriculotemporal nerve compression due to condylar posterior displacement in autopsy cases and questioned Costen's mechanical compression hypothesis. Nevertheless, posterior compression was still thought to be related to clicking of the joint and muscle pain without concern-

ing compression of the auriculotemporal nerve.

Masticatory muscle pain was regarded to occur as a consequence of muscle fatigue and muscle spasm. Such fatigue is caused by excessive muscle activity due to bruxism and clenching, which are non-functional jaw movements that can occur for either dental or non-dental reasons.[16]

Occlusal factors such as centric interferences were first related to bruxism and masticatory muscle pain by S. Ramfjord in 1960. He reported on occlusal interferences and muscle pain in bruxers and found that through the adjustment of such interferences, pain and bruxism could be reduced[16]. His report suggested that occlusal interference in the centric and eccentric jaw positions is the primary cause of muscle pain and joint displacement. However, later reports questioned the relationship between dental occlusal interferences and bruxism and TMD. Clinical reports regarding new crown insertions for bruxers found that they were subjected to no more grinding at night in the first 2 to 4 nights[17]. In another study, the positions of the teeth and interocclusal relationship were changed suddenly and vigorously by orthodontic measures, yet bruxers engaged in less bruxing during the first few weeks after such changes[18]. Those findings questioned the importance of occlusal factors in causing bruxism. However, acute occlusal interferences such as those caused by new restorations or orthodontic tooth movement were found to be associated with a higher possibility of masticatory muscle pain[19]. In addition to the so-called centric occlusal interference, balancing side premature contact is often mentioned as an important factor related to the occurrence of TMD[20-22]. Working side interferences or premature contacts caused by ill-fitting restorations may alter the proper jaw movement, but such alterations may often be adapted to if the patients are not bruxers or suffering from emotional stress[23,24].

It is interesting to note that in one epidemiological survey, more than 40% (specifically, 40 to 70%) of a population reported having 1 or more signs of TMD, yet, much less frequent (5-10 %) in population asked for medical or dental treatment[25]. Moreover, most of the members of the population with positive findings were aged between 20 and 50 years old. After 50 years of age, the incidence of TMD symptoms and signs has been reported to decrease with age, and the existing symptoms often becoming less evident[25,26]. These findings are seemingly inconsistent with the fact that the aging process is often associated with a decrease in tooth number and changes in occlusal form. Therefore, occlusal factors and TMD cannot logically be correlated.

Recent reports on facial muscle pain have often mentioned that individuals who report such pain often have mental, emotional, or personality-related problems. However, seldom have any reports directly pointed out the occurrence of orofacial pain caused solely by mental problems – that is, in the absence of any concomitant occlusal factors. "Stressors," i.e., the environmental factors or experiences that result in an individual feeling a sense of pressure, tend to be relieved via either "internal release" or "external release"[27]. Internal release may lead to psychophysiological disorders, such as peristalsis-related problems in the intestines, high blood pressure, asthma, cardiac arrhythmia, or hypertonicity of the craniofacial muscles[28]. "Stress" and "anxiety" are purely psychological phenomena, and yet they demonstrate physiological effects on many parts of the body. If such effects impact the head and neck muscles only, occlusal factors may be related as a "confounding factor," a "triggering factor," or a "perpetuating factor," in spite of not being a "predisposing factor."[29]Therefore, the etiology of a given TMD may be psychological, but its treatment has to be dental occlusion-related; thus, dentists are unavoidably responsible for such treatment.

Recent advances in joint biomechanics, neuromuscular physiology, autoimmune disorders, musculoskeletal disorders, and pain mechanism studies have changed some of our understandings regarding TMD etiology. For example, genetic factors affecting chronic TMD patients may have effects on their reactions to and processing of pain[31,32], and gender differences, such as estrogen-related factors, may be related to the difference in TMD incidence, among other findings[32-34]. Such connections are gene-related, and cannot be explained by occlusal or local dental factors.

In cases of so-called internal derangement of the TMJ, joint noise during jaw movements (with or without pain) is the main complaint. This type of TMJ disorders is now emphasized as an expression of collagen diseases, which in turn are gene-related. Hypermobile joints in some children or teenagers have been found more often in patients with Marfan syndrome, Ehlers Danlos syndrome, and

Down syndrome[35]. Englebert et al. compared children with generalized joint hypermobility (as indicated by Beighton scores) and muscle pain with muscle pain-free children, and found higher skin extensibility, lower bone density, lower systolic and diastolic blood pressure, and higher levels of urinary collagen degradation products (hydroxyproline) in the muscle pain group[36]. This finding emphasized that TMD is a gene-related collagen disease demonstrated in both the joints and muscles of the masticatory system.

The classification of TMD

TMD is classified as a subtype of "Secondary Headache Disorders" in the International Headache Society (IHS) classification definition[37]. The AAOP, meanwhile divides TMD into "articular disorders" and "masticatory muscle disorders"[38] (Table 1). Therefore, any diagnosis of TMD should first determine whether the given TMD involves joint problems or muscle problems. According to Table 1, clinicians can easily classify a patient as having a joint-type TMD or a muscle-type TMD just based on the patient's history and a physical examination. It should be noted that joint problems can indicate muscle disorders as well,

Table 1. Temporomandibular Disorders: (adapted from the guidelines of the American Academy of Orofacial Pain) (de Leeuw, 2008)

I.	Articular disorders
1.	Congenital or developmental
	First and second branchial arch disorders: hemifacial microsomia, Treacher Collins syndrome, bilateral facial microsomia
	Condylar hyperplasia
	Idiopathic condylar resorption (condylysis)
2.	Disc-derangement disorders
	Displacement with reduction
	Displacement without reduction (closed lock)
	Perforation
3.	Degenerative joint disorders
	Inflammatory: capsulitis, synovitis, polyarthritides (rheumatoid arthritis, psoriatic arthritis, ankylosing spondylitis, Reiter's syndrome, gout)
	Non-inflammatory: osteoarthritis
4.	Trauma
	Contusion
	Intracapsular hemorrahage
	Fracture
5.	TMJ hypermobility
	Joint laxity
	Subluxation
	Dislocation
6.	TMJ hypomobility
	Trismus
	Postradiation therapy fibrosis
	Ankylosis: true ankylosis (bony or fibro-osseous), pseudoankylosis
7.	Infection
8.	Neoplasia
II.	Masticatory muscle disorders
1.	Myofascial pain disorder
2.	Local myalgia
3.	Myositis
4.	Myospasm
5.	Myofibrotic contracture
6.	Neoplasia

Table 2. Taxonomic classification for temporomandibular disorders (adapted from Schiffman et al., 2014[39])

I. Temporomandibular joint disorders		
1. Joint pain		
A. Arthralgia		B. Arthritis
2. Joint disorders		
A. Disc disorders 1). Disc displacement with reduction 2). Disc displacement with reduction with intermittent locking 3). Disc displacement without reduction with limited opening 4). Disc displacement without reduction without limited opening B. Hypomobility disorders other than disc disorders 1). Adhesions/adherence 2). Ankylosis a. Fibrous b. Osseous C. Hypermobility disorders 1). VDislocations a. Subluxation b. Luxation		
3. Joint diseases		
A. Degenerative joint disease 1. Osteoarthrosis 2. Osteoarthitis B. Systemic arthrides C. Condylysis/ idiopathic condylar resorption		D. Osteochodritis dissecans E. Osteonecrosis F. Neoplasm G. Synovial chondromatosis
4. Fractures		
5. Congenital/ developmental disorders		
A. Aplasia	B. Hypoplasia	C. Hyperplasia
II. Masticatory muscle disorders		
1. Muscle pain		
A. Myalgia 1). Local myalgia 2). Myofascial pain 3). Myofascial pain with referral		B. Tendonitis C. Myositis D. Spasm
2. Contracture		
3. Hypertrophy		
4. Neoplasm		
5. Movement disorders		
A. Orofacial dyskinesia		B. Oromandibular dystonia
6. Masticatory muscle pain attributed to systemic/ central pain disorders		
A. Fibromyalgia/ widespread pain		
III. Headache		
1. Headache attributed to TMD		
IV. Associated structures		
1. Coronid hyperplasia		

such as TMJ hypermobility with jaw opening muscle pain, or myofascial pain with jaw motion limitation or condylar compression. In 2014, Schiffman et al. proposed a "Taxonomic Classification for Temporomandibular Disorders" that clearly divided TMD into the following types: I. Temporomandibular joint disorders, II. Masticatory Muscle Disorders, III. Headache (headache attributed to TMD), and IV. Associated structures (coronoid hyperplasia) (Table 2). Again, this article also emphasized that when dealing with so-called TWD patients, the separation of joint problems from muscle problems should be done before any treatment is given.

Additional diagnostic tools

The identification of a joint origin or muscle origin of a given TMD should first be based on careful examination and history taking. Furthermore, image examinations, including examinations of transcranial X-ray, panoramic X-ray, computerized tomography (CT) and magnetic resonance imaging (MRI) images, may help in the differential diagnosis of TMD. MRI is now recognized as the best diagnostic tool for identifying condyle or disc displacement, joint fluid accumulation, and non-osseous ankylosis among other problems. An arthroscopic TMJ examination is a minimally invasive examination procedure, and through a small window, a clinician can see the internal structures of the TMJ more directly and accurately[40]. The power of diagnosis in terms of disc displacement, deformation, adhesion, and condylar surface destruction is high. Moreover, treatments of such problems can also be done with the arthroscope. However, for the purpose of making a diagnosis, arthroscopic examinations have become less important than MRI, mostly because the former is somewhat invasive and carries the possibility of injury[41,42]. An arthrographic technique can be applied to the TMJ with a contrast medium, and this is a good way to demonstrate the disc position and any disc perforation. However, because it is highly technique-dependent and could cause radiation exposure, this technique is no longer popular and has generally been replaced by MRI unless surgical treatment of the TMJ will follow.

The differential diagnosis of TMD for dental healthcare personnel

Except TMJ noise, dentists have to make differential diagnosis between dental pain and orofacial pain other than dental origin. Odontogenic pain includes dental caries, periodontal diseases, pulpitis, osteomyelitis, etc., and non-odontogenic pain includes TMD, soft tissue and bone anomalies, inflammation, and primary and secondary new growths occurring in the head, face, and neck areas. Patients having jaw bone tumors, intracranial tumors, brain base tumors, etc., often exhibit orofacial pain similar to TMD pain. Some masticatory muscle pain with trigger points may also be caused by teeth and result in dental pain without evident dental problems. In general, this type of dental pain is often intermittent in nature[43]. In addition, patients with primary or secondary headache, trigeminal neuralgia, and problems of other body parts like cardiac diseases, viral infections, autonomic nerve disorders, diabetes, and temporal area arteritis, among others, often complain of acute or chronic pain in the orofacial area and are misdiagnosed with a TMD as a result. Patients with fibromyalgia, for example, when occurring in the orofacial area, may exhibit allodynia, muscle pain, and reduced pain-inhibiting effects of heterotopic noxious stimulations[43]. Fibromyalgia patients may also have altered neuromuscular control in the masticatory muscles, as well as complaints of jaw movement limitations or alterations[44,45]. As such, it is not easy to distinguish TMD from masticatory fibromyalgia, although the prevalence of fibromyalgia increases with age (the highest incidences occurring in people aged 60-79 years old)[46], while that of TMD decreases after the age of around 50 years. However, joint noise, or internal derangement of the TMJ, is not likely related to fibromyalgia[47] and should be identified more easily and early.

For dental health providers who also take care of TMD patients often confront dental pain, or orofacial pain combined dental pain earlier than other heath providers. Therefore, careful history taking and physical examination are very important before making a diagnosis of TMD and providing treatments, because in some cases, orofacial pain caused by systemic problems is more life-threatening and urgent than TMD. Such treatment for TMD based on a misdiagnosis may delay the necessary treatment of those patients.

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Case Report

Implant-Supported Oral Appliance: A Novel Treatment for Edentulous Patients with Obstructive Sleep Apnea-Hypopnea Syndrome

Pin-Feng Huang, D.D.S.
Resident Doctor, Dental Department
Shin-Kong Wu Ho-Su Memorial Hospital
Taipei, Taiwan

Wen-Chien Chang, D.D.S
Clinical Professor, Taipei Medical University
Visiting Doctor, Dental Department
Shin-Kong Wu Ho-Su Memorial Hospital
Taipei, Taiwan

Po-Ya Yang, D.D.S
Visiting Doctor, Dental Department
Shin-Kong Wu Ho-Su Memorial Hospital
Taipei, Taiwan

Chih-Ling Chang, D.D.S. M.S. PhD.
Assistant Professor, School of Dentistry
National Yang-Ming University Taipei, Taiwan
Director and chief, Dental Department
Shin Kong Wu Ho-Su Memorial Hospital
Taipei, Taiwan

Corresponding author:
Chih-Ling Chang, D.D.S. M.S. PhD.
Director and Chief, Dental Department
Shin Kong Wu Ho-Su Memorial Hospital
Taipei, Taiwan
No.95, Wen Chang Road, Shih Lin Distric,
Taipei City, Taiwan
Tel: +886-2-2833-2211 ext. 2182
Fax: +886-2-2838-9321
Email: cclpyy2001@yahoo.com.tw

Abstract:

Obstructive sleep apnea-hypopnea syndrome (OSAHS) is the most common type of sleep apnea and is caused by obstruction of the upper airway. The literature illustrated that people with healthy dentition wearing the oral appliances (OAs) to treat OSAHS are well when making the right diagnosis. However, patients with edentulous ridges may also require treatment with OAs when they suffer from OSAHS. Implant-supported overdentures have shown better stability and retention than conventional overdentures. As such, if an OA is designed for combination with implants during its fabrication, then the desired stability and retention can be achieved. This case report describes our experiences with using an implant-supported OA in the treatment of an edentulous OSAHS patient.

Key words: Implant-supported overdenture, Oral appliances, Obstructive sleep apnea-hypopnea syndrome.

Introduction:

Obstructive sleep apnea-hypopnea syndrome (OSAHS) is the most common type of sleep apnea and was first described in the medical literature in 1965[1]. It is caused by obstruction of the upper airway, and the symptoms may include loud snoring, restless tossing and turning during sleep, and nighttime choking. Because of the resulting poor sleep quality, an OSAHS patient may also experience excessive daytime sleepiness, problems with memory and concentration, feelings of fatigue, and personality changes. OSAHS is also considered to be one of several potentially treatable contributors to systemic hypertension, and has been associated with coronary artery disease, stroke, congestive heart failure, and atrial fibrillation.[2,3] All of these factors can add up to an increased risk of motor vehicle accidents[4], impaired quality of life[5], and even a reduced life span.

When OSAHS is diagnosed correctly, successful treatment of the disorder may be possible. Continuous positive airway pressure (CPAP) is believed to be the most effective therapy for patients with severe OSAHS. Because of specific aspects of CPAP treatment, such as the use of a mask in-

terface, sealed tubing, and a device connected to a power source, the acceptability of CPAP among patients is somewhat limited, which can lead to suboptimal treatment adherence[1]. Therefore, oral appliances (OAs) have become an alternative treatment for OSAHS.

OAs are designed to reposition the lower jaw slightly forward relative to its natural, relaxed position. This repositioning holds the tongue farther away from the back of the airway, and may thus be enough to relieve apnea or improve breathing.

At the same time, when treating a sleep apnea patient who is also edentulous, it is not only necessary that any dentures but also any OA provided to the patient are satisfactory in terms of meeting the patient's chewing, esthetics, and phonetics needs. In order to achieve the desired retention and stability in such cases, osseointegrated implants may be the optimal option.

Relatedly, while OAs are regarded as an alternative treatment for severe OSAHS in patients who cannot tolerate CPAP, there is still insufficient data regarding the use of OAs to treat OSAHS in edentulous patients. This case report presents an example of the use of an implant-supported OA in the treatment of an edentulous patient with severe OSAHS.

Case report:

A 70-year-old male patient presented to the prosthodontic department of SKH with the following chief complaint: "I have had sleep problems and complaints from my wife about my snoring for many years."

At that time, the patient had been edentulous and worn complete dentures for at least 22 years. He had also received regular dental check-ups for complete denture maintenance. In addition, he had previously been diagnosed with several systemic diseases, namely, severe sleep apnea, hypertension, and diabetes mellitus. The hypertension and diabetes mellitus were under medical control. As for the sleep apnea, however, although the patient's doctors had recommended CPAP therapy, the patient found that he could not tolerate it because he found it inconvenient.

Intraoral examination revealed that the alveolar ridges of the maxilla and mandible were moderately resorbed, especially in the mandible (Fig. 1), while the border and frenum attachments were relatively low and located too

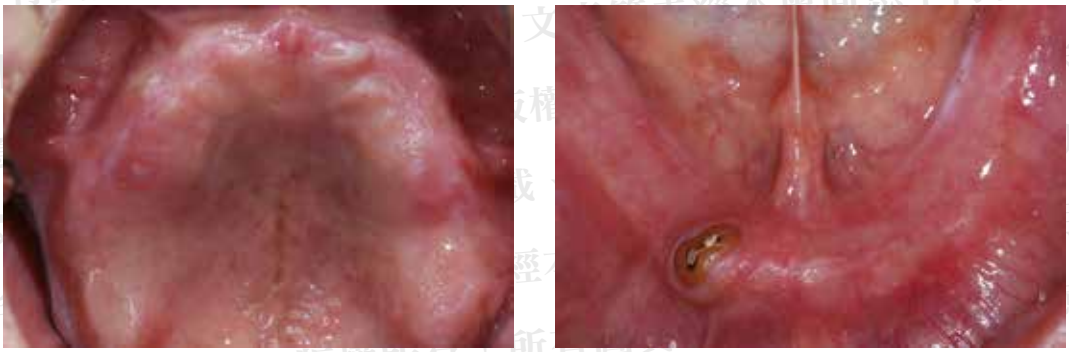

Figure 1: Preoperative view of the patient's maxillary and mandibular edentulous ridges.

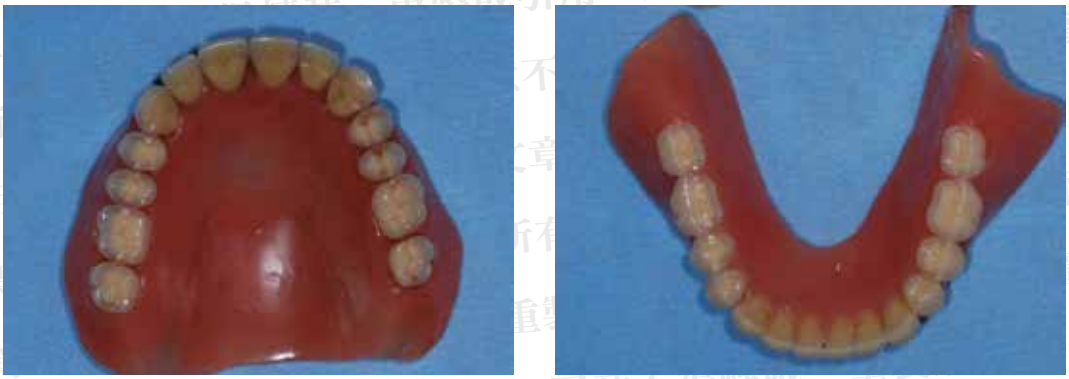

Figure 2: Occlusal view of previous maxillary and mandibular complete dentures

close to the crest of the residual ridges. It was further noted that the maxillary edentulous ridge had an ovoid shape while the mandibular appeared to have a tapered shape with a right canine residual root.

After a panoramic X-ray and dental CT scan (Kodent Dental Systems Co.,Ltd, Taiwan) evaluation and consultation with an oral surgeon, the risks and benefits implant and non-implant therapy were discussed with the patient. A definitive treatment plan using maxillary and mandibular four-implant supported overdentures was suggested and accepted by the patient.

To maintain fundamental functions such as chewing, and for esthetic reasons, the temporary prostheses were the previous denture after the evaluation of the fit of the tissue surface, occlusion and articulation, and fracture of denture base or teeth. The patient was satisfied with this previous complete denture (Fig. 2).

The previous complete denture was duplicated in order to make surgical templates (Ortho-Jet®, Lang, USA) that could be used to determine the optimal implant positions over the right and left canines and molar sites on the maxilla and mandible.

The surgical templates simulated the final dental prostheses and allowed the surgeon to visualize potential technical constraints. Thereafter, a radiological guide derived from the prosthetic model could be obtained. In this case, gutta-percha radiopaque material was used for the initial evaluation of implants along the axis of orientation.

Furthermore, using 3D software (Implant-Max®, Saturn Imaging Inc., Taiwan), additional relevant information regarding the implants was obtained, allowing the implantation process to be planned accurately and securely (Fig. 3). Stereolithography (SLA) is a computer-driven process that creates precise models using lasers and epoxy resin. According to the analyzed 3D positions, the optimal sizes of the individual implants size were selected, and then the surgical guide was prepared from the digital planning data via stereolithography. This ensured the full and accurate realization of the planning in the patient's mouth.

Eight dental implants (Ankylos® C/ implants, Dentsply, USA) were inserted under local anesthesia by one surgeon. The implants were designed to be inserted in the canine and molar regions of the maxilla and mandible. The insertion procedures were carried out using a one-stage technique. Post-operative analgesics, antibiotics, and 0.2% chlorhexidine digluconate mouth rinses were prescribed. Soft liner was applied after selectively relieving the maxillary and mandibular dentures at the implant sites.

The patient also received oral hygiene instructions. Prosthetic procedures were then started after a 3-month healing period. At that time, the patient's periodontal condition was stable, and the implants were all surrounded by healthy keratinized gingiva.

A preliminary impression was taken and

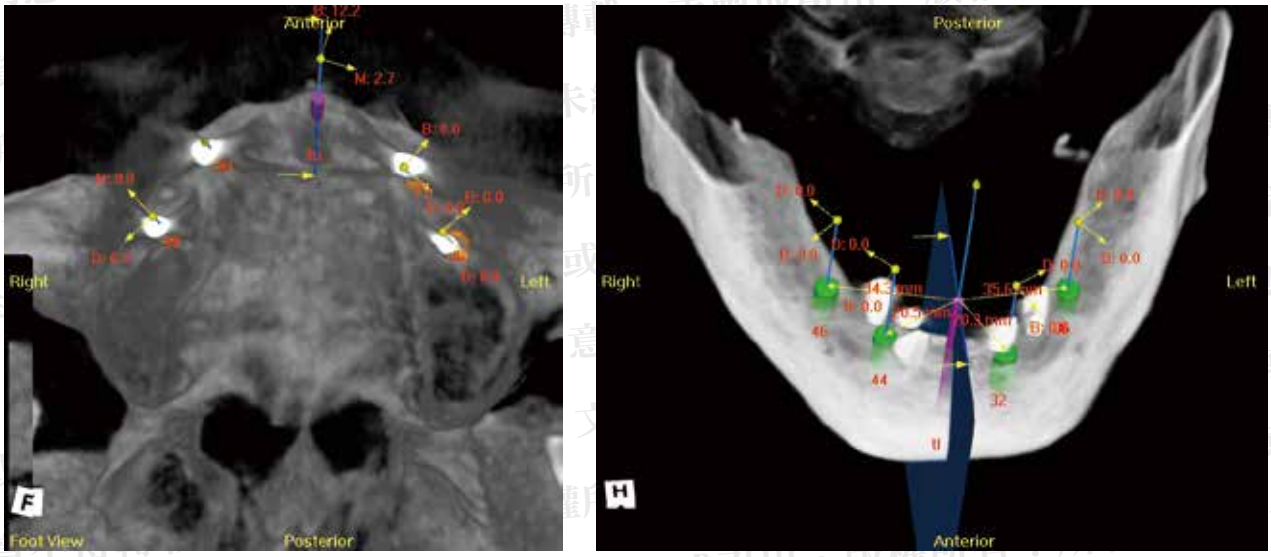

Figure 3: Image used to check the parallelism of the implants, as well as the 3D view used for confirmation

custom resin trays with openings for transfer posts and screws (Ankylos® C/ Transfer Post & Screw, Dentsply, USA) were fabricated. The transfer posts were inserted into the connection taper of the implants and attached with transfer screws of the desired length. The transfer screws were tightened using a hand torque (Fig. 4).

The tray was placed over the transfer posts, and any contact between the post and the tray was avoided to allow the tray to rest firmly on the denture-bearing mucosa. The screw for each post was positioned above the relevant opening in the tray.

The final impression was taken with polyether (ImpregumTM PentaTM Soft, 3M ESPE, USA) material. After the impression material had set, the transfer screws were undone and removed from the impression along with the transfer posts. The transfer posts were connected to implant analogs (Ankylos® Balance C/ implant analog, Dentsply, USA) in the impression tray, and the master casts were then poured.

The overdenture abutments (Ankylos® SynCone C/5° abutments, Dentsply, USA) were selected according to sulcus height and the angulation necessary to compensate for the axial divergence of the implants. To check the parallelism, a parallelization gauge (ANKYLOS® Parallel Gauge for SynCone®, Densply, USA) was placed on all the abutments, and the angled abutments were then adjusted to a common parallel direction of insertion in the parallelometer. Once the abutments had been aligned and attached, a transfer key was fabricated.

A transfer key can be fabricated entirely from quick-curing synthetic material. In this case, however, a custom metal key was provided (Fig. 5). As a clinical step, the abutments were placed into the implants according to the customized transfer key. A pick-up impression was taken for the metal framework combined

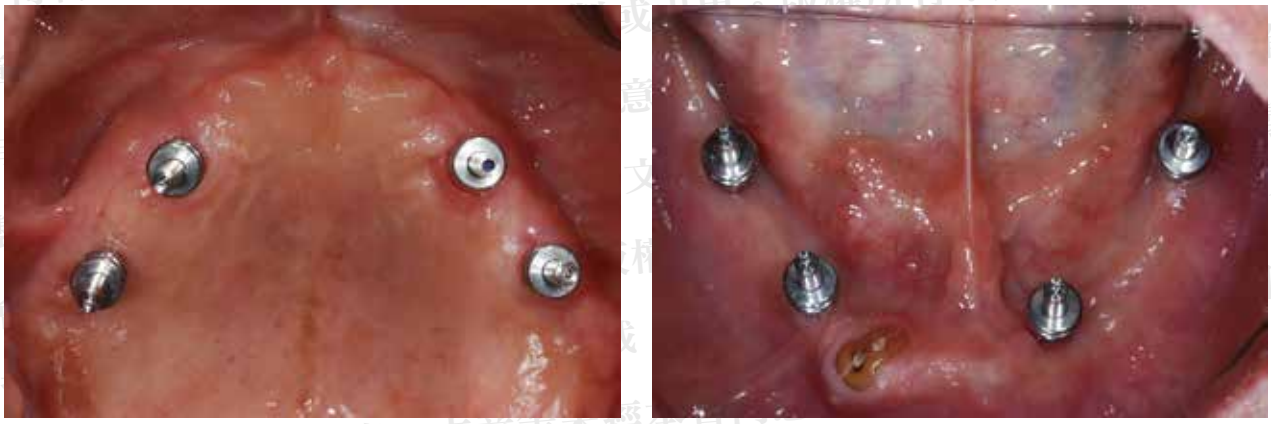

Figure 4: The transfer posts and screws mounted on implants in maxillary and mandibular ridges

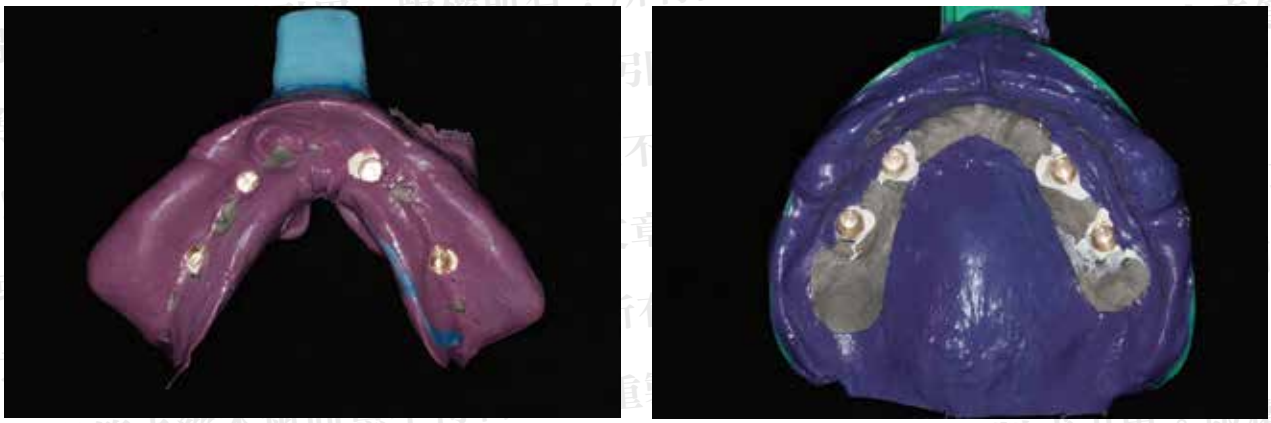

Figure 5: Maxillary and mandibular pick-up impressions of the tapered caps with cast metal frameworks.

with the tapered caps (ANKYLOS® Taper Cap Degulor, Densply, USA). The casts were poured and set, then the tapered caps were removed one by one from the metal framework by removing the temporary cement and embedded in framework with self-cured resin. The definitive prostheses were done by the copy of the previous interim which the patient adapted. During the delivery of the definitive prostheses, the overdenture abutments were placed and tightened to 25 Ncm with a torque controller (Fig.6). After insertion, the adaptation of the base was examined with disclosing material. Once the adaptation had been checked, the occlusion and articulation were also examined.

The patient was taught to remove the overdenture and to clean the prostheses and his intraoral abutments. A few days after delivery, the first check-up was performed, and peri-implant radiographs were taken to record peri-implant bone levels at the outset of the functional period.

The upper and lower four-implant supported removable overdentures provided ideal stability and allowed for easy removal and cleaning of the prosthesis (Fig.7). After finishing the fabrication of the overdentures, the OA could then be constructed. As in the denture making process, individual trays were made and tapered caps were used to cover the abutments. Thereafter, a pick-up impression was

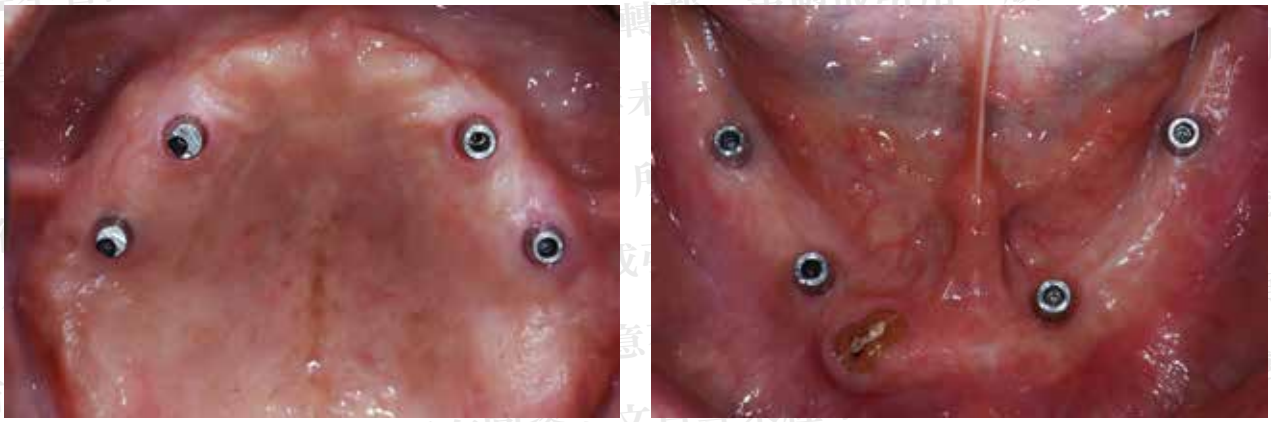

Figure 6: Occlusal view of connected abutments on maxillary and mandibular arches

Figure 7: Finished definitive dentures and extraoral view of the patient with complete dentures

taken to determine the relations of the tapered caps with the implant positions (Fig. 8). The casts were then poured and transparent acrylic resin (Hygenic® Coltene Whaledent, Inc, USA) splints were fabricated and combined together using self-cured acrylic resin(Ortho-JetTM Acrylic Resin, Lang, USA), with a venting hole left in the front side that allowed air to pass through (Figs. 9 and 10). When the OA therapy was applied, the mandible was protruded to approximately 75% of the patient's maximum advancement. In both the maxilla and mandible, the OA was retained by SynCone caps that were incorporated into the duplicate of the overdentures. The patient was instructed to wear the OA instead of his dentures whenever he slept. After three months, a post-operative polysomnographic study (PSG) was performed. The AHI data was decreased from 33 to 3, and the severity was from severe to normal.

Discussion:

Obstructive sleep apnea-hypopnea syndrome (OSAHS) is the most common type of sleep apnea. According to a study by Morgenthaler et al in 2006.[6], the prevalence of OSA, CSA, and complex sleep apnea syndrome, in a 1-month sample, were 84%, 0.4%, and 15%, respectively. However, a lack of awareness among the general public and health profession means that an estimated 80~90% of people with OSAHS are as yet undiagnosed.[7] As a result, a large number of studies have investigated the causes of and treatment options for OSAHS.

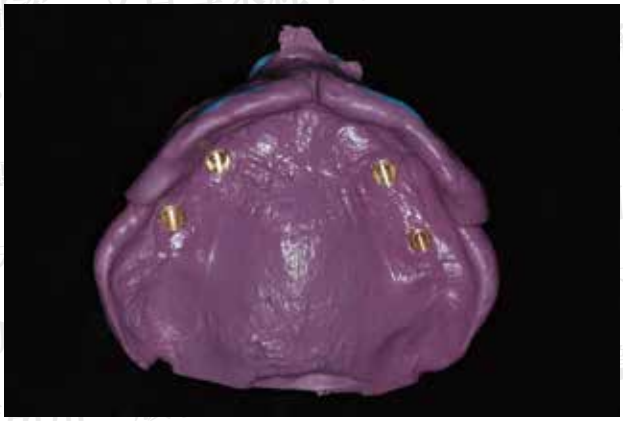

Figure 8: Pick-up impression to catch the SynCone cap

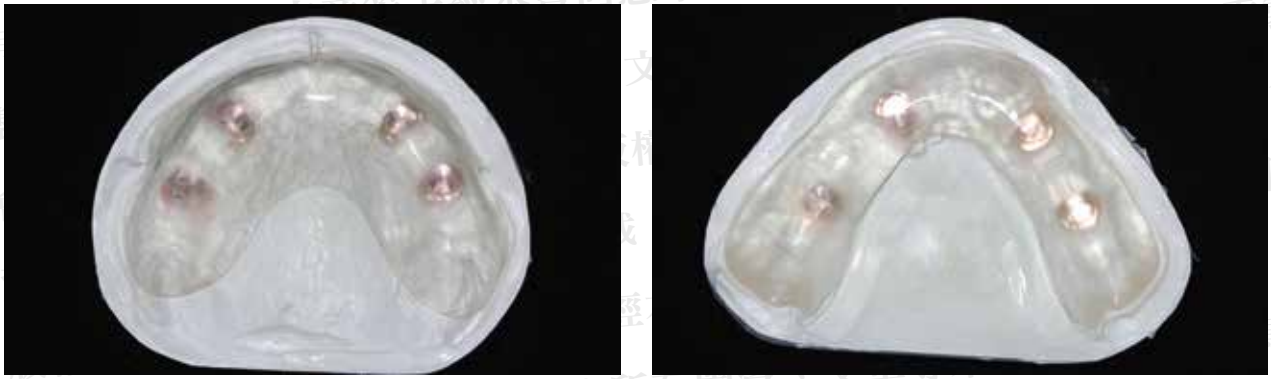

Figure 9: Maxillary and mandibular transparent acrylic baseplates

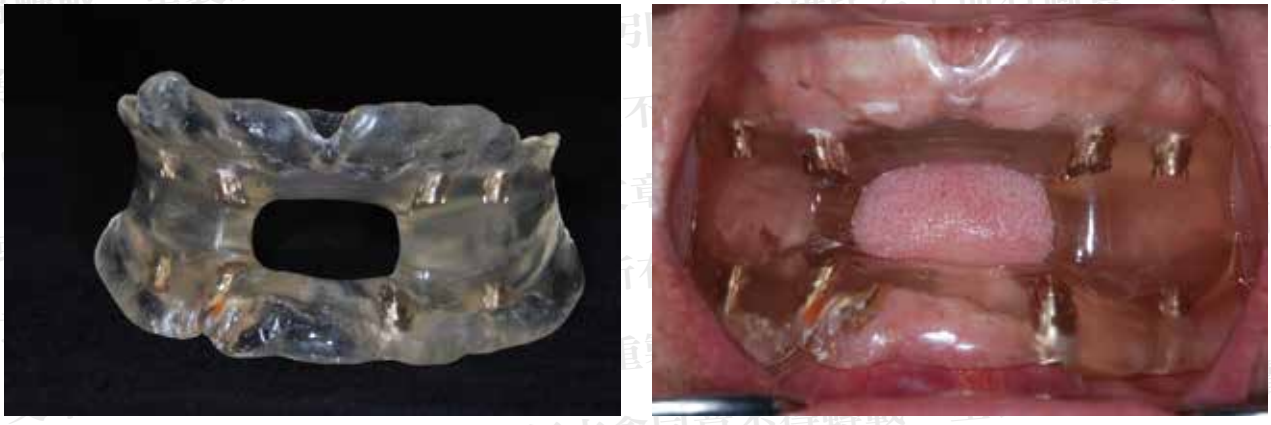

Figure 10: Finished oral appliance and intraoral view of the appliance on maxillary and mandibular arches

The presence or absence of OSAHS must be determined before initiating treatment. Thereafter, a baseline is established in order to determine the effectiveness of any subsequent treatment. In diagnosing OSAHS, the standard process is to use PSG to measure multiple parameters, such as EEG,ECG,EMG, air flow, blood oxygen saturation, apnea, and snoring levels, among others, and then make an appropriate treatment decision.[2] The apnea-hypopnea index (AHI) is an average that represents the combined number of apneas and hypopneas that occur per hour of sleep. The standard severity levels of the AHI are mild (an AHI of 5~15), moderate (an AHI of 15~30), and severe (an AHI of more than 30), respectively. The initial AHI of the patient in this case was 33, indicating a diagnosis of severe sleep apnea.

CPAP therapy is regarded as the treatment of choice for OSAHS, especially in moderate to severe cases. On the other hand, the modification of oropharyngeal patency by OAs that protrude the mandible has been suggested as an effective alternative treatment for OSAHS, especially in mild to moderate cases.

OAs are often preferred by patients but may not be as effective as CPAP. The primary indication for the use of OAs is snoring that has not responded to weight loss or sleep position changes in the context of mild to moderate OSAHS. One study found that OAs had similar treatment efficacy to CPAP for mild to moderate OSA[8]. According to a 2006 study by Kushida, the success rates of OA treatment for mild, moderate, and severe OSA were 81%, 60%, and 25%, respectively, in level I studies. Relatedly, the use of CPAP is indicated whenever possible for patients with severe OSAHS prior to any consideration of OAs. Nonetheless, while the success rate for OA treatment of severe OSAHS is only 25%, it is reasonable to consider using OAs to treat severe OSAHS patients who cannot tolerate CPAP and refuse upper airway surgery[2].

There are also other treatment options that can be used to treat obstructive sleep apnea. For example, avoiding alcohol, smoking, and the use of medications that relax the central nervous system (for example, sedatives and muscle relaxants) is recommended, while weight loss is also recommended to those patients who are overweight. In addition, physical training, even without weight loss, can improve sleep apnea.

Edentulism is a debilitating and irreversible condition and is described as the "final marker of disease burden for oral health". Although the prevalence of complete tooth loss has declined over the last decade, edentulism remains a major disease worldwide, especially among older adults.[9]

Several types of OAs have been developed for the management of OSAHS, including the Herbst appliance, Klearway appliance, Thornton adjustable positioner, and tongue retaining device. However, these appliances have all exhibited poor stability in edentulous patients. As such, in order to improve a given patient's chewing ability and stabilize and retain the given OA in the edentulous ridges, osseointegrated implants may be needed.

According to a 2006 study by Hoekema et al.[10], insertion of the implants in both the upper and lower arches will achieve the desired support. Four unsplinted implants supporting an overdenture can be a treatment option in both the maxilla and mandible, although the use of such implants in the maxilla has little support in the literature thus far. According to a 2007 study by Cavallaro[11], a minimum of four textured-surface implants at least 10mm long and 3.75mm wide may be sufficient to retain overdentures via individual attachments. This case demonstrated that osseointegrated implants can be utilized in an unsplinted manner to retain both a maxillary overdenture with partial palatal coverages and a mandibular overdenture. This was attempted because the patient wanted the palatal coverage to be reduced, although there are no published studies thus far that have compared implant survival rates for full and partial palatal coverage.

According to the previous literature, protrusion bite is taken about six to ten mm of forward distance or fifty to seventy-five percent of the maximum the patient could protrude.[12] The advantage of an increased level of protrusion is a greater reduction in respiratory events, but the disadvantage is a greater level of occlusal change.

For this case, a regular recall system was applied. During overdenture follow-ups, the status of the alveolar process was checked intraorally along with peri-implant-related items such as plaque and calculus accumulation, the condition of the mucosa, sulcus depths, and bleeding. The evaluation of the overdenture included the fit of the tissue surface, occlusion, and articulation, and fracture of denture base

or teeth. At the 1-year follow-up, the patient presented a satisfactory clinical situation and a favorable peri-implant bone level. For the OSAHS follow-up, PSG was performed with the OA in place after final adjustments of fit about 3 months after the initial fitting. The patient's AHI was decreased from 33 to 3, and the bed partner give a more accurate reflection of the improvement in the subjects' snoring and can add further understanding to the improvement in other symptoms, such as moodiness. In previous studies, bed partners have reported that their partners' snoring was improved when using OAs.

Reconstructive implant-supported prostheses and OAs can have a positive effect for edentulous patients. The good final result seen in this case may be attributed to the integrated treatment planning and the obedience to a step by step novel treatment protocol.

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Case Report

The Interdisciplinary Management of Hypodontia: A Case Report

Yueh-Tzu Huang
Resident Doctor, Department of Prosthodontics, Taipei Medical University Hospital, Taipei, Taiwan

May-Show Chen
Attending Doctor, Department of Prosthodontics, Taipei Medical University Hospital, Taipei, Taiwan
Assistant Professor, School of Dental Hygiene, College of Oral Medicine, Taipei Medical University, Taipei, Taiwan

Chi-Yang Tsai
Attending Doctor, Department of Orthodontics, Taipei Medical University Hospital, Taipei, Taiwan
Associate Professor, Department of Orthodontics, College Of Oral Medicine, Taipei Medical University, Taipei, Taiwan

Tine-Kuo Liu
Attending Doctor, Department of Oral and Maxillofacial Surgery, Taipei Medical University Hospital, Taipei, Taiwan

Shang-Lun Kuo
Attending Doctor, Department of Prosthodontics, Taipei Medical University Hospital
Lecturer, School of Dentistry, College of Oral Medicine, Taipei Medical University, Taipei, Taiwan

Hsiu-Na Lin
Attending Doctor, Department of Prosthodontics, Chang-Gung Memorial Hospital, Taipei, Taiwan

Chien-Chih Chen
Director of Dental Implant Center, Cardinal Tien Hospital, Taipei, Taiwan

Hsiu-Ju Yen
Attending Doctor, Department of Prosthodontics, Taipei Medical University Hospital,Taipei, Taiwan

Corresponding author:
May-Show Chen
Taipei Medical University
No.252, Wusing St., Sinyi Dist., Taipei 11031, Taiwan
Tel: +886-2-27372181*3211*5
Email: mayshowc@hotmail.com

Abstract

Severe hypodontia or oligodontia (≥6 congenitally missing teeth) is a rare condition but should not be neglected. It usually causes esthetic and oral function problems, and the treatments are complicated. Even though there are several options for treating hypodontia, a definite treatment plan should be carefully discussed and established by an interdisciplinary team consisting of clinicians of orthodontics, implantology, prosthodontics, and even pediatrics. This case report discribed the successful outcome of the interdisciplinary treatment of a 28-year-old female with severe hypodontia. We applied orthodontic tooth movement to increase the dimension of the edentulous ridge, and followed by implant placement. This approach can create more predictable bone volume than a ridge augmentation surgery procedure.

Keywords: congenital missing, hypodontia, interdisciplinary treatment, orthodontic tooth movement

Introduction

Congenitally missing teeth, also known as congenital absence of teeth, congenital dental aplasia, and tooth agenesis, is one of the most common human developmental anomalies[1]. The prevalence of congenital teeth missing in adolescent Chinese populations with or without orthodontic treatment has been reported to be 6.39%, with congenitally missing teeth being more frequently found in females than in males to a statistically significant degree in both the treated and untreated groups[2]. The definitions of hypodontia, oligodontia, and anodontia differ in terms of the number of missing teeth, on which there is no clear agreement[1]. In most studies, however, the terms "oligodontia" and "severe hypodontia" are used to refer to the condition in which six or more permanent teeth, excluding third molars, are agenetic[3], with the prevalence of oligodontia having been reported to be 0.14%[4,5]. Besides an unfavorable appearance, patients with

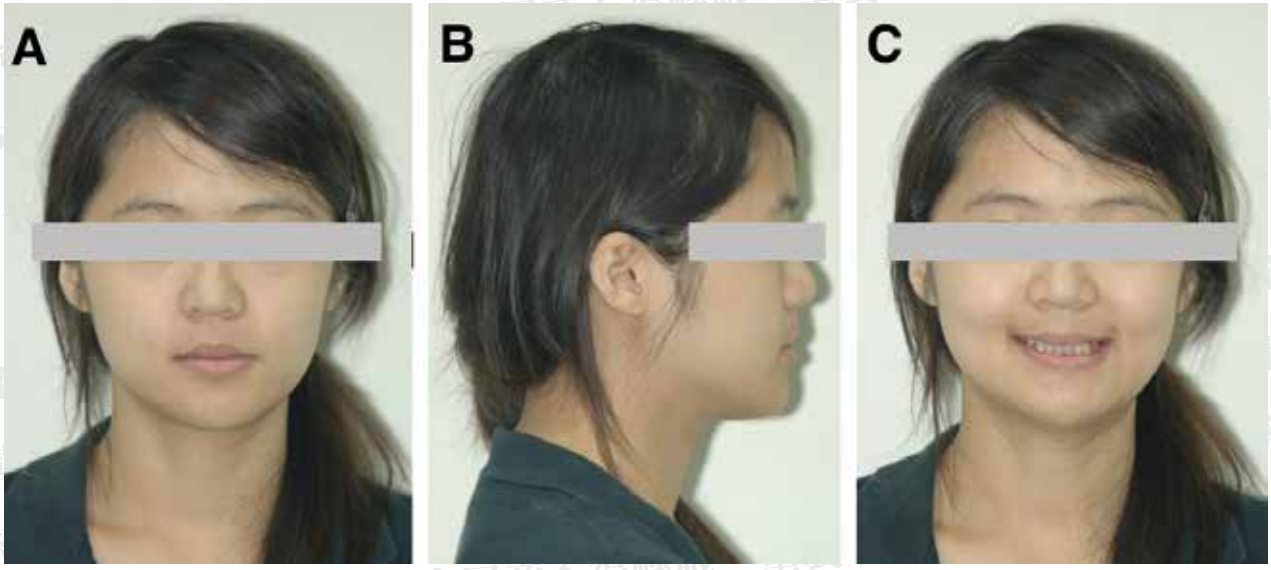

Fig. 1 Extra-oral view before treatment: (A) frontal view, (B) lateral view, (C) low smile line without showing upper teeth

severe hypodontia may suffer from malocclusion, periodontal damage, insufficient alveolar bone quantity, reduced chewing ability, and other problems[1].

The functional and psychosocial impacts of severe hypodontia are profound, and the restorative management of severe hypodontia is more complex than such management for non-hypodontia patients[4]. Generally speaking, the treatment of severe hypodontia is usually complicated, expensive, and interdisciplinary. To achieve an optimal outcome for a patient, counseling from clinicians specializing in several professional fields, such as orthodontics, prosthodontics, oral and maxillofacial surgery, and implantology, is indispensable during treatment planning[5,6].

Currently there is no standard treatment for hypodontia, but multiple modalities, including conventional fixed crowns or bridges, dental implants, and space re-distribution with orthodontic therapy, can be applied. Several factors, such as the positions of missing teeth, the bone quality of the edentulous ridge, the space available for restorations, the age of the patient, and the economic budget may influence the final decision regarding treatment. Filius et al. reviewed the survival rates of implants in hypodontia patients, reporting that they ranged from 35.7% to 98.7% (mean 93.7%) [5]. Creton et al.[7] and Finnema et al.[8] had different perspectives about the implant survival rate with the former stating that it may be affected by bone augmentation in the unfavourable anatomic ridge conditions and the latter reporting that implant loss was equally distributed between bone graft-augmented sites and ungrafted sites. Undoubtedly, ample bone volume is essential for the successful osseointegration of dental implants.

In this case report, we present a case of full mouth rehabilitation of severe hypodontia accomplished through the cooperative efforts of orthodontic, implantology, and prosthodontic specialists. Furthermore, in order to place implants over the edentulous ridge, we used orthodontic tooth movement to increase the patient's bone volume.

Case report

A 24-year-old female came to the Department of Prosthodontics at Taipei Medical University Hospital with the chief complaints of an unpleasant appearance to her smile and impaired chewing function.

An extra-oral examination revealed an ovoid and symmetry frontal profile, along with a flat lateral profile. The nasolabial angle was within normal limits, and the lower lip was full. The patient had a low smile line and flat incisal curve (Fig.1).

The patient had an ill-fitted and dislodged 10-unit long-span bridge for the upper arch and a lower removable partial denture with fair oral hygiene and no caries (Fig.2). A radiographic examination revealed that 16 permanent teeth were congenitally missing (specifically, teeth 22, 31, 41, 36-38, 46, 47, 14, 15, 17, 18, 24, and 26-28) and the presence of a retained primary tooth (tooth 62) and an impacted tooth (tooth 48) (Fig.3). The width-length ratio and the proportions of the upper anterior teeth were

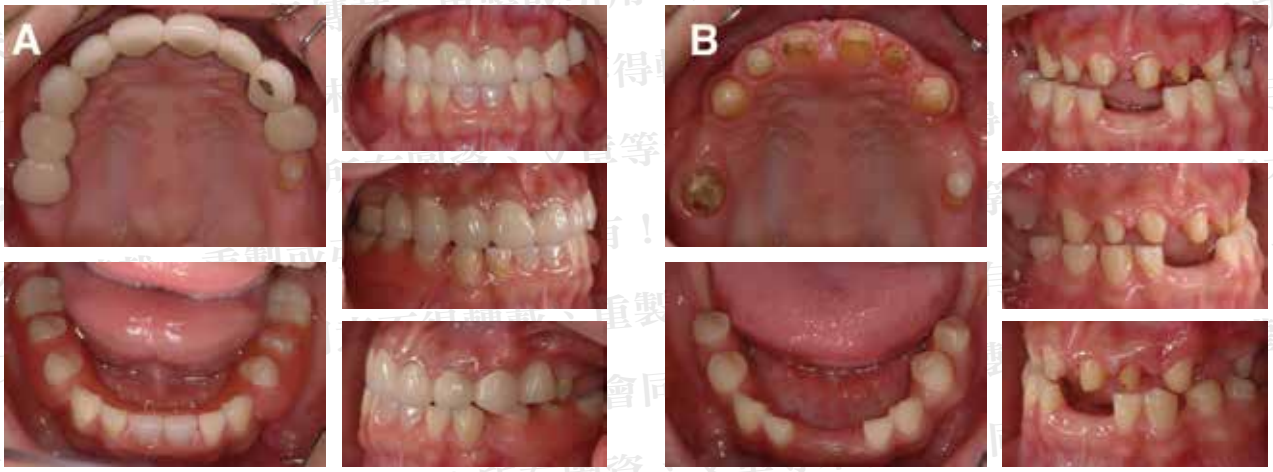

Fig. 2 Intra-oral views: (A) with and (B) without previous prosthesis

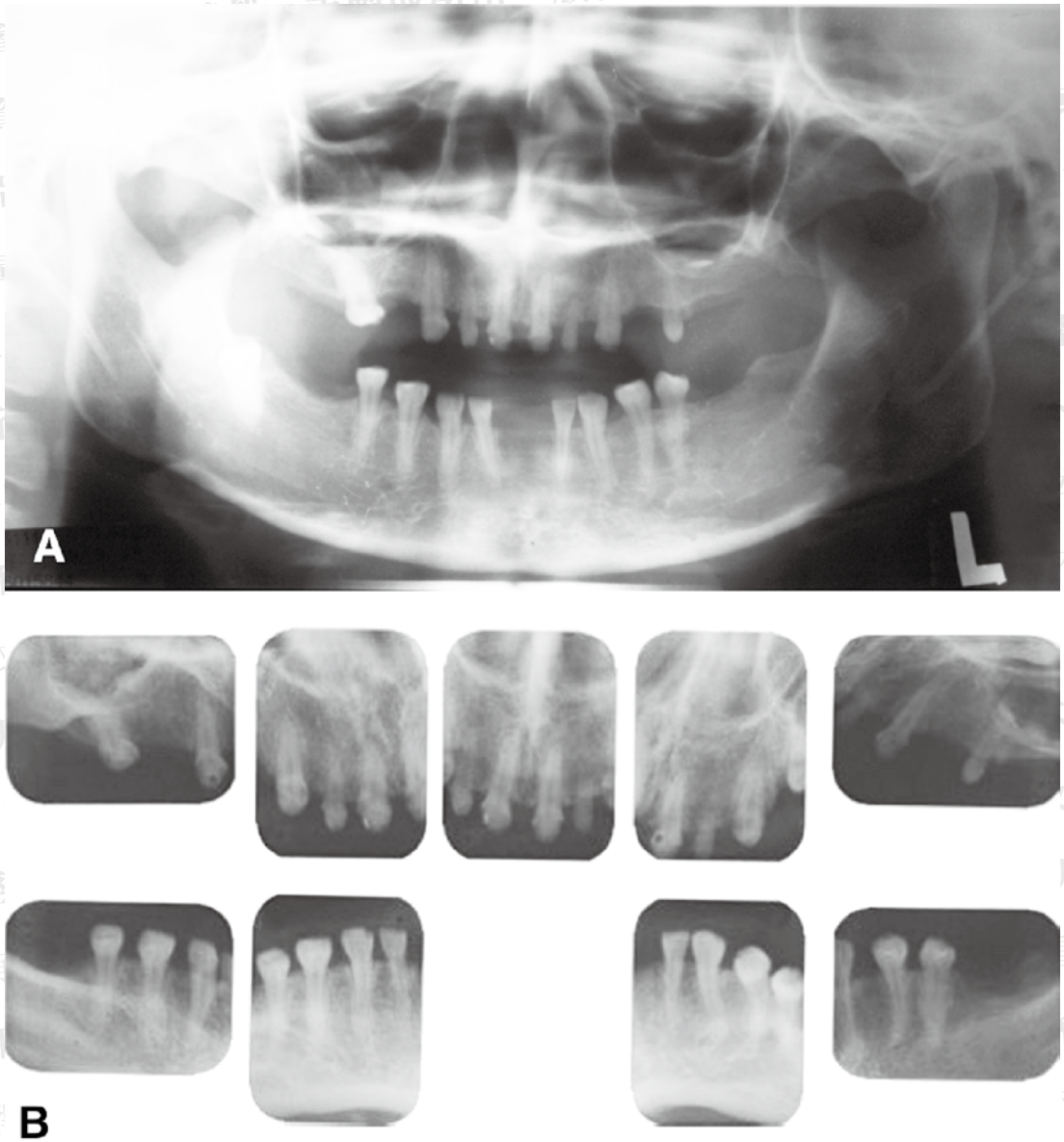

Fig. 3 The radiographic images before treatment: (A) panoramic film, (B) peri-apical films

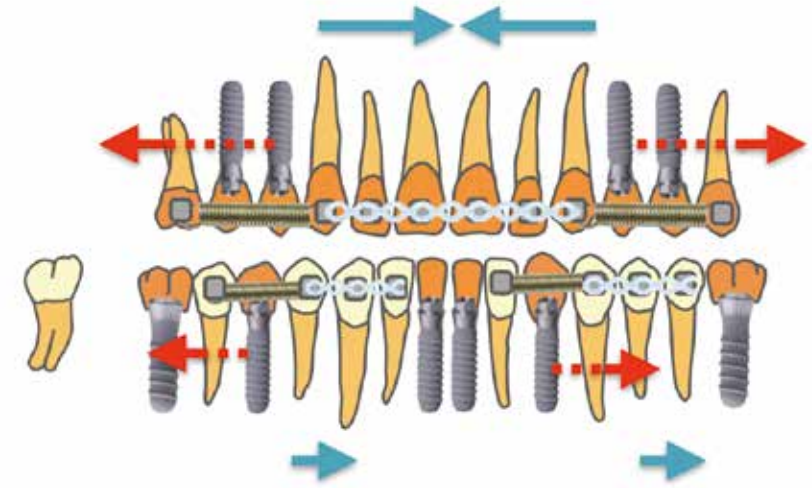

Fig. 4 Final treatment plan with redistribution of interdental spaces

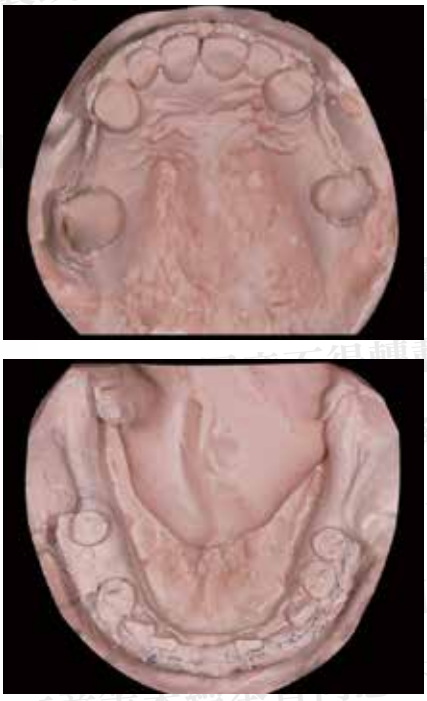

Fig. 5 Maxillary and mandibular stone casts showing the redistributed teeth after orthodontic management

not ideal and posterior occlusal support was poor with insufficient chewing function. Due to the patient's severe hypodontia, the edentulous alveolar ridge was severely resorbed both in height and width (Fig.2).

Based on the patient's expectations, the treatment goals were (1) to achieve an acceptable occlusion and establish posterior support, (2) to control and use the available spaces for the prosthesis, (3) to increase ridge dimension and height with bone augmentation for implant placement, and (4) to achieve an attractive smile and maintain a proper facial profile. Therefore, interdisciplinary treatment was conducted by a prosthodontist, an orthodontist, and oral surgeons, and the treatment plan included the following aspects: (1) orthodontic treatment to redistribution space; (2) ridge augmentation and implant placement over 14, 15, 24, 25, 33, 31, 37, 45 and 47 area. Full mouth space re-distribution, closure or open, planned by orthodontists; and (3) fixed prostheses for all teeth and implants except lower lateral incisors, canines, and premolars (Fig.4).

Pre-prosthetic orthodontic therapy

Before the orthodontic treatment, we remade all maxillary provisional crowns and delivered lower new interim removable denture. On October 22, 2010, orthodontic appliances were bonded on maxillary provisional crowns to level the patient's tooth alignment and distalize the two second premolars. After five months, the mandibular teeth were also subjected to orthodontic treatment to distalize teeth 33 and 45 and close the diastema while maintaining anterior space. After one year and two months, the orthodontist created the space needed for the placement of implants in the 47, 45, 33, 37, 14, 15, 24, and 25 positions (Fig.5).

Ridge augmentation and implant placement

Before the placement of the implants, the surgeon scheduled a guided bone regeneration and sinus lifting surgery on the maxillary posterior area to increase the bone width and height on August 11, 2012. In the following month, one Ø3.3 mm implant with a 10 mm long narrow neck (Standard plus implant, SLA, Straumann®) was inserted into the site of the 45 position. Eight months after the ridge augmentation of the maxilla, three Ø 3.3 mm implants with 12 mm long narrow necks (Standard plus implant, SLA, Straumann®) were placed in the 14, 24, and 25 positions.

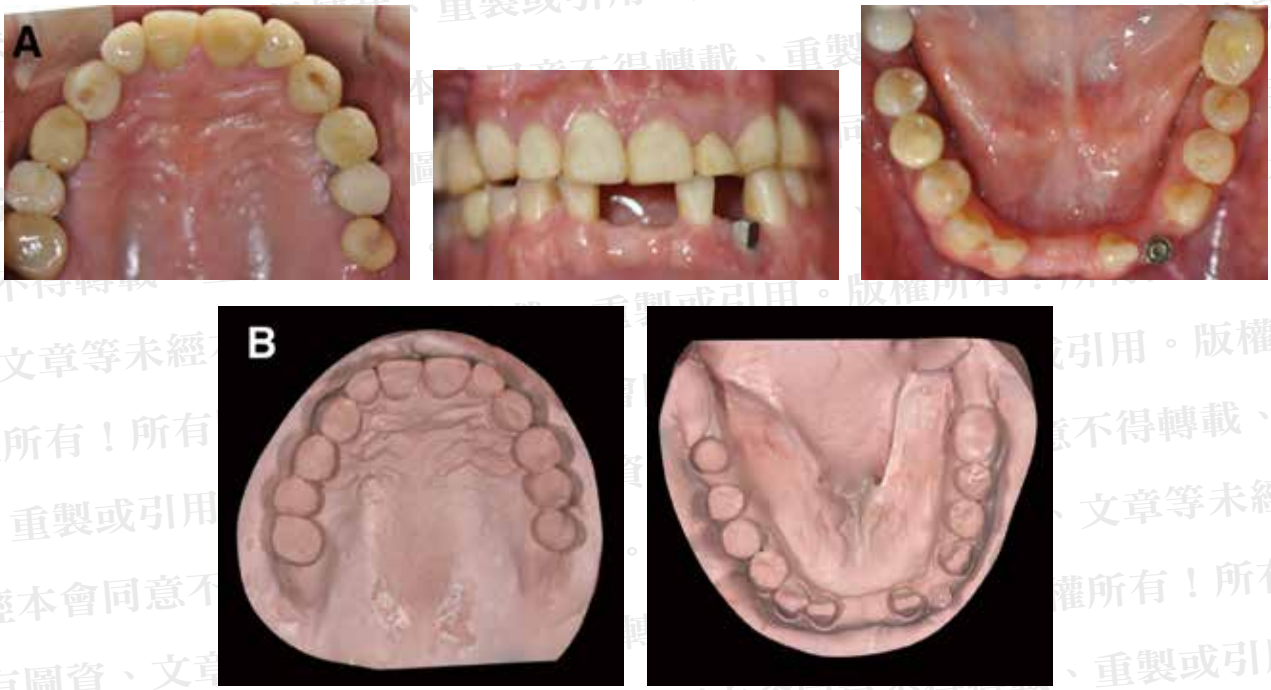

Fig. 6 Healing abutments were replaced with provisional restorations except tooth 33 implant. (A) intra-oral photos, (B) study casts

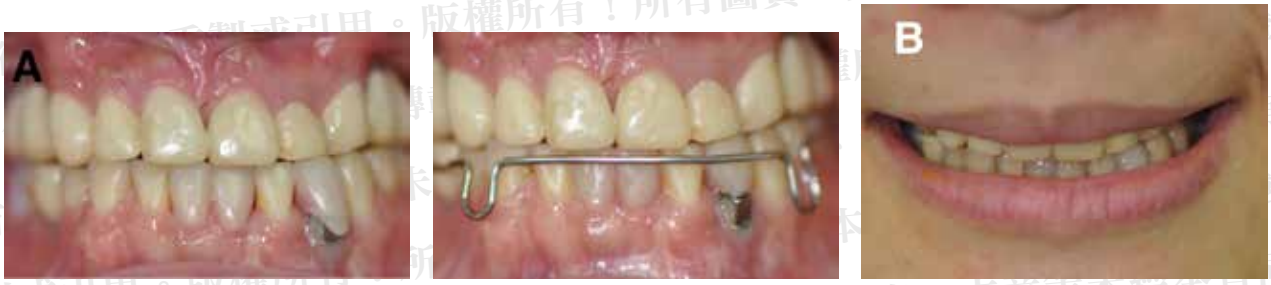

Fig.7 Final provisional stage. (A) With and without the transitional orthodontic retainer, (B) lips and teeth alignment during smiling

Due to the insufficient mesial-distal space of the upper right area, the orthodontist kept to distalize tooth 16 some more. Then, two weeks later, the surgeon placed one Ø3.3 mm implant with 10 mm long regular neck and one 3.3 mm implant with 8 mm long regular neck (Standard plus implant, SLA, Straumann®) in positions 36 and 47. During the same appointment, the guided bone regeneration of the tooth 33 area was also performed. The last two Ø3.3 mm implants with 10 mm long narrow necks (Standard plus implant, SLA, Straumann®) were finally inserted at positions 33 and 15 after six months of ridge augmentation. The ridge augmentation and placement of implants in positions 31 and 41 were postponed because patient got a job overseas, and the edentulous area would restored by the interim removable denture.

Prosthetic therapy

During the period of osseointegration, we kept adjusting the lower denture and the provisional crowns, and progressively replaced the implant healing abutments with provisional restoration (Fig.6). When all the implants were stable and all the provisions were exhibiting good function and appearance, we de-bonded the orthodontic appliance and delivered the transitional retainers on April 8, 2015 (Fig.7). The final impressions were made for both arches for crown restoration of all the implant abutments and maxillary teeth. All the permanent crowns were fabricated using CAD-CAM zirconia except the four distal abutment restorations for positions 47, 36, 16, and 26, which were porcelain-fused-to-metal crowns with metal occlusion and underwent permanent cementation on June 12, 2015, after try-in and

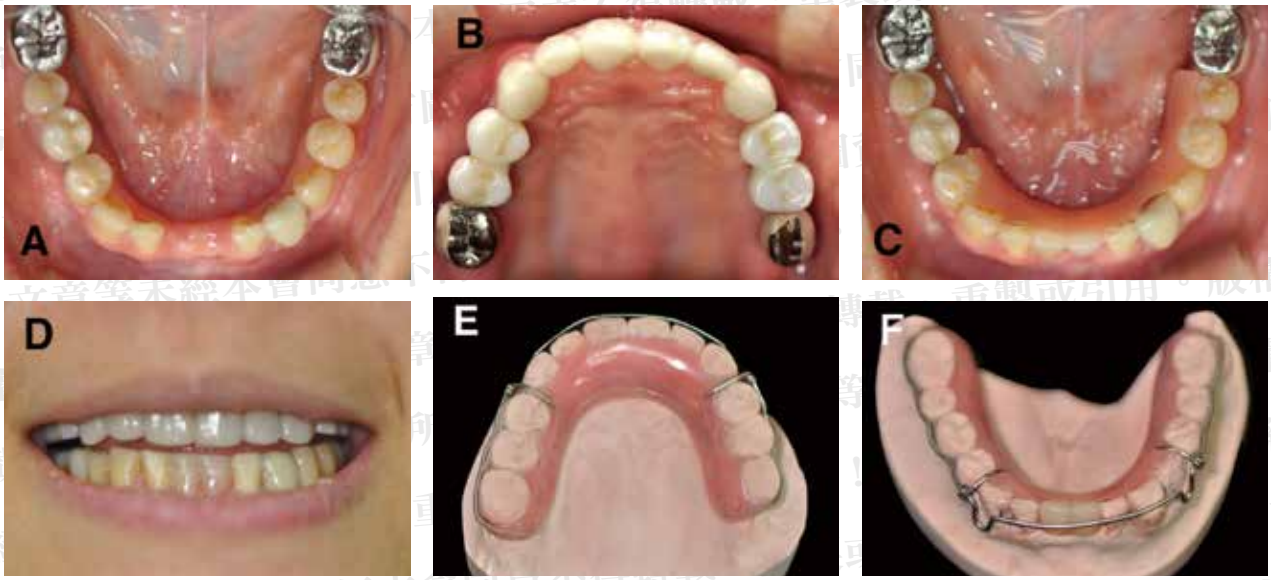

Fig. 8 The final prosthesis stage (A) maxillary occlusal view, (B) mandibular occlusal view, (C) occlusal view of mandible with removable partial denture, (D) smile view with permanent prosthesis, (E,F) final tooth alignment with orthodontic retainers

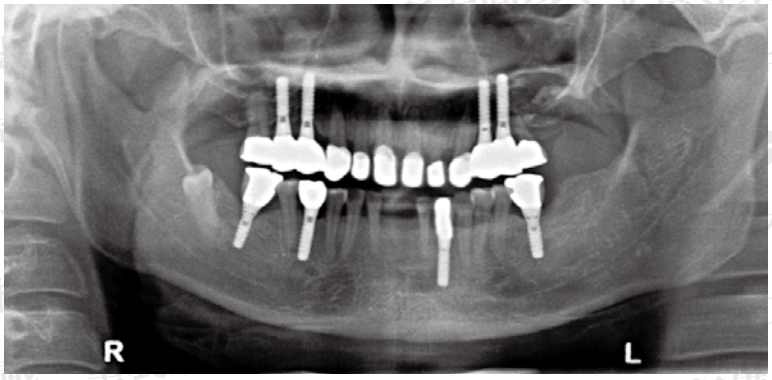

Fig. 9 The post-treatment panoramic film

occlusal adjustment. The orthodontic retainers and the interim removable partial denture of lower anterior teeth were then delivered (Fig.8). Finally, the patient was scheduled for a 6-month follow-up appointment (Fig.9).

Discussion

Severe hypodontia (≥6 missing teeth) is usually associated with esthetic and functional problems, and the treatment may also be expensive and interdisciplinary in nature[5]. When the treatment plan includes orthodontic treatment to create or redistribute the space required for later rehabilitation, which means that the treatment process will take a relatively long amount of time. Due to the congenital absence of teeth in the case presented herein, the amount of available bone in the edentulous area was extremely insufficient and posed a great challenge in terms of implant placement. We spent approximately two years achieving an adequate bone volume and the osseointergration of the implants.

Even though the technique of guided bone regeneration for ridge augmentation has been well studied and thoroughly reported, it may nonetheless require two or more surgeries to create adequate ridge dimensions. Some experimental studies and case series have revealed that the indications for orthodontic treatment were space closure or opening due to lack of adequate space for prosthetic reconstructions, in addition to finding that an increase of the width of the alveolar ridge followed tooth movement into an area of reduced ridge dimensions, even though some reduction in

the width was seen in the area from which the tooth was moved [9-12]. These findings suggest the possibility of combining both treatments, orthodontic tooth movement and guided bone regeneration, to make our case more predictable instead of doing the ridge augmentation surgery only. However, there were some noteworthy complications, such as lateral root resorptions, which were found on the pressure side of all the orthodontically moved teeth. But in most of the past case reports, no signs of further resorptions were observed after termination of the active tooth movement[12]. In our case, the most pronounced lateral resorption was found at the upper left distal abutment, which moved the greatest distance and was subjected to the longest treatment duration.

Notwithstanding the generally high survival and success rate of implants, the failure rate in severe hypodontia is higher than in non-compromised subjects, an issues which seems to be mainly associated with the location, the bone volume, and the need for augmentation. Peri-implant bone loss, peri-implant mucositis, and peri-implantitis have not been well assessed in severe hypodontia patients, and long-term (>10 years) results are also lacking[5]. However, we still can not deny the fact that treatment with dental implants is promising and advantageous to patients. We placed a total of eight implants, four in the maxilla and four in the mandible, to establish a proper and sufficient occlusion.

Despite the reliability of metal being better than that of ceramic, we used zirconia as the restorative material for the fixed prosthesis, except the four distal abutments of all four quadrants, which consisted of porcelain-fused-to-metal with metal occlusion, due to esthetic concerns. The planned treatment of the lower anterior area also consisted of the placement of implants, but we had to postpone that part of the treatment because the patient was going abroad for work and thus had insufficient time for the surgery. As such, a removable partial denture was applied to this patient as an interim treatment.

Summary

Although it is not yet possible to make decisions regarding the treatment of patients with severe hypodontia based on clear evidence, this case report successfully illustrates an interdisciplinary treatment combining the disciplines of orthodontics, implant surgery, and prosthodontics for a severe hypodontia patient. The strategy used in this case— i.e., orthodontic tooth movement combined with bone augmentation surgery— can make a treatment involving the placement of implants more predictable and valid, especially in a patient whose alveolar bone quality is poor and insufficient.

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Case Report

The Tripodal Mandibular Subperiosteal Implant: A Case Report

Yen-Jung Lai DDS, MS
Attending Doctor,
Hualien Tzu-Chi Hospital, Hualien, Taiwan

Ming-Jay Hwang DDS, MS
Attending Doctor,
Hualien Tzu-Chi Hospital, Hualien, Taiwan

Corresponding author:
Ming-Jay Hwang DDS, MS
Hualien Tzu-Chi Hospital,
Department of Dentistry
707, Chong-Yang Rd., Secfion 3,
Hualien City
Tel: +886-3-856-1825 ext. 2433
E-mail: mingjays@gmail.com

Abstract

The subperiosteal implant is a modality that has been used for several decades, although its popularity has declined due to the increasing use of endosseous dental implants. Nonetheless, it remains a treatment option in some situations, especially for cases of atrophic mandible. This article reports the case of a patient rehabilitated using a simplified surgical protocol involving CAD/CAM technology and a screw-retained denture supported by a tripodal subperiosteal implant.

Keywords: Subperiosteal implant, CAD/CAM, stereolithography, screw-retained denture

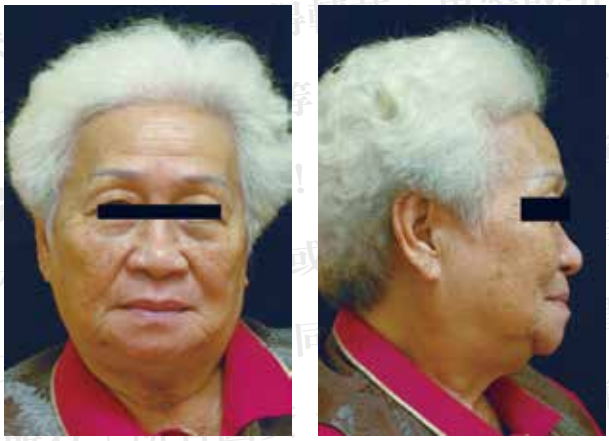
Introduction

For patients with a severely resorbed mandible, wearing a denture may be uncomfortable. In such patients, the bony structure and musculature, such as the mentalis muscle, that would otherwise support the denture may be lost, and without a broad base of bone and the musculature necessary to maintain the denture in place, the denture may move constantly when utilized for various functions[1].

A subperiosteal implant consists of a custom-fabricated titanium framework that is designed to rest on top of the mandibular bone, under the periosteum, and be stabilized by a combination of fibrous tissue and bone support. Permucosal extensions provide for support and attachment of the prosthesis[2]. Dahl placed the first subperiosteal implants in 1940. However, criticism of his implant technique by the Swedish government caused him to abandon his efforts[3]. In 1947, the first American subperiosteal implants were developed, and in 1948, Gershkoff and Goldberg placed the first subperiosteal complete denture implant manufactured from Vitallium[4].

Previous subperiosteal frameworks were designed to rest directly on the alveolar crest[3,5]. In 1982, however, a new design called the tripodal mandibular subperiosteal implant was devised by Linkow[5] and his laboratory technician. This type of implant rests on the thick cortical bone present at the external oblique ridge and the symphysis of the mandible at the genial tubercles[6].

The use of subperiosteal implants has declined in recent



1(a) 1(b)

Fig. 1 Extra-oral views with complete dentures, (a) frontal view, (b) lateral view

years due to the increasing use of endosseous dental implants. However, in some extreme cases, the use of endosseous implants may not be suitable because of increased cost, the time required for treatment, postoperative pain, and the need for multiple invasive procedures (e.g., iliac grafting). Such hardships may seem likely to cause too much suffering in some patients to make a simple gain in the stability and masticatory function of a lower denture worthwhile.

In the old days, the surgical protocol for a tripodal mandibular subperiosteal implant was comprised of a two-stage surgery, the first for taking a direct bone impression and the second for placing the custom-made implant. More recently, however, techniques have been developed for making subperiosteal titanium frameworks based on models of jaws made via computerized tomography (CT) scans and CAD/CAM technology[7].

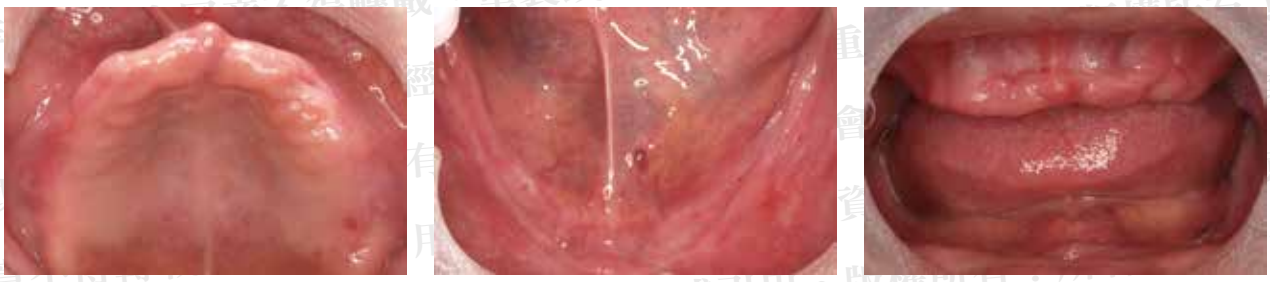
This article describes the case of a patient with a severely resorbed mandible treated with a tripodal mandibular subperiosteal implant designed with the assistance of CAD/CAM technology.

Case report

A 74-year-old woman came to Tzu-Chi Hospital in September 2011, complaining about the poor chewing function of her dentures. She had been wearing the dentures, which were ill-fitted and loosened easily during function, for more than 10 years. She received a new set of complete dentures after the extraction of a retained root from the maxilla. She was satisfied with the maxillary denture, but she still complained about the instability of the mandibular denture when chewing and also had recurrent ulcerations on the mandibular ridges. She also disliked her dentofacial appearance (Fig. 1). Therefore, she asked for an evaluation regarding implantation and fixed prostheses.

The patient's medical condition included osteoporosis controlled by a dose of 60 mg of Prolia every half year. She also had other systemic diseases and health issues including rotator cuff syndrome, lumbosacral spondylosis, kyphosis, and a closed fracture of the dorsal thigh, all of which were under regular follow-up by her physician at Tzu-Chi hospital. Otherwise, the patient was generally healthy and did not have any drug or food allergies. In discussing the subject with her physician, she stated that dental surgery under general anesthesia was acceptable to her.

Clinical examination showed that even with the new set of complete dentures, she still had a reduced facial height in the lower part of her face and a drooping appearance at the corners of her mouth, which was due to the severely resorbed mandible. Intra-orally, the ridge of the maxilla was flat and rounded with an undeveloped tuberosity. Even though the ridge was severely resorbed, especially in the posterior area, the retention of the maxillary denture was well achieved by border seal. However, the mandibular denture was not stable on the flat ridge of the mandible, which made her uncomfortable when chewing and



2(a) 2(b) 2(c)

Fig. 2 Intra-oral views. (a) Maxillary occlusal view, (b) mandibular occlusal view, (c) frontal view

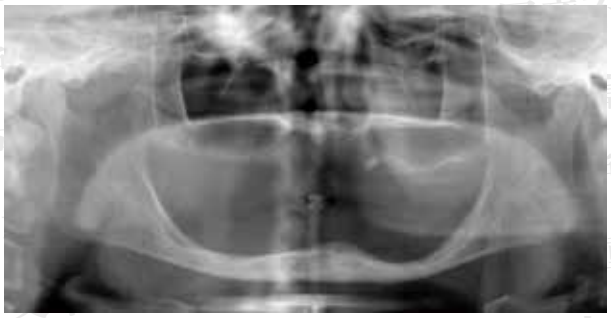


Fig. 3 Panorex film

caused ulceration easily (Fig. 2). No temporal mandibular disorder (TMD) problems were noticed. The muscles of mastication were not tender to palpation, and no soreness was noted by the patient upon opening or closing her mouth.

Panorex film (Fig. 3) indicated that the alveolar ridges were severely resorbed, especially in the mandible, and almost only basal bone remained. She had approximately 12 mm of bone height in the anterior symposis and 10 mm of bone height at the mental foramen. Using the newly made complete dentures as a reference, a CT scan (Lightspeed VCT 64-Slice CT Scanner, General Electric, USA) was performed.

According to the radiographic examination, there was insufficient bone height for root form implants unless the patient plans to receive extensive bone grafting from the iliac or tibia. The other treatment option was a tripodal subperiosteal implant made of cast titanium and fabricated with the assistance of CAD/CAM technology, with a overlay prosthesis screw-retained on the implant framework.

After being informed about all the treatment options, the patient and her family chose a mandibular denture supported by a subperiosteal implant and an opposing maxillary denture.

The CT scan files were sent to a milling center (TDS Biotech, Taiwan) to create a 3D computer model using medical imaging software (Designer, TDS Biotech, Taiwan). Rapid prototyping by 3D printer was then used to fabricate precise anatomical resin models of the patient's jaw. Since the patient was still not satisfied with her extra-oral profile with the newly made dentures, and since the space was not sufficient for overdenture either, the vertical dimension had to be increased. With the

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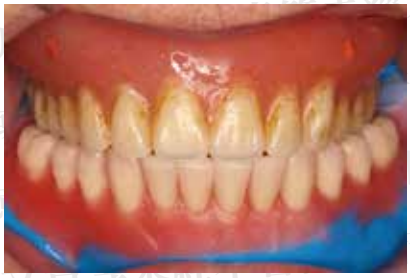

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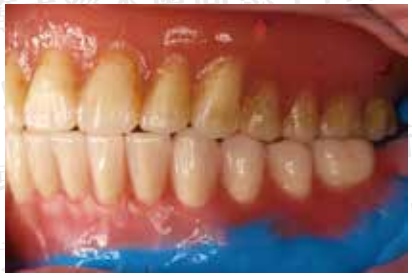

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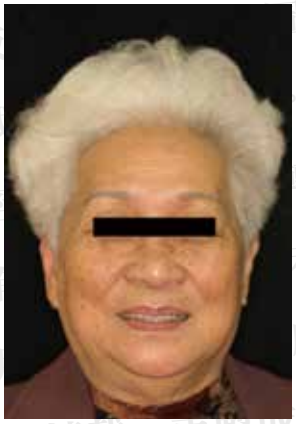

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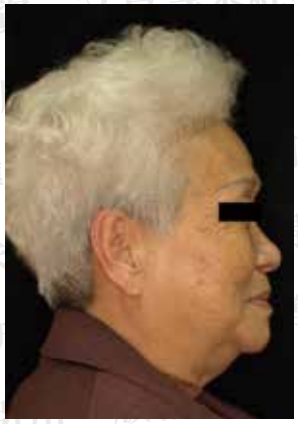
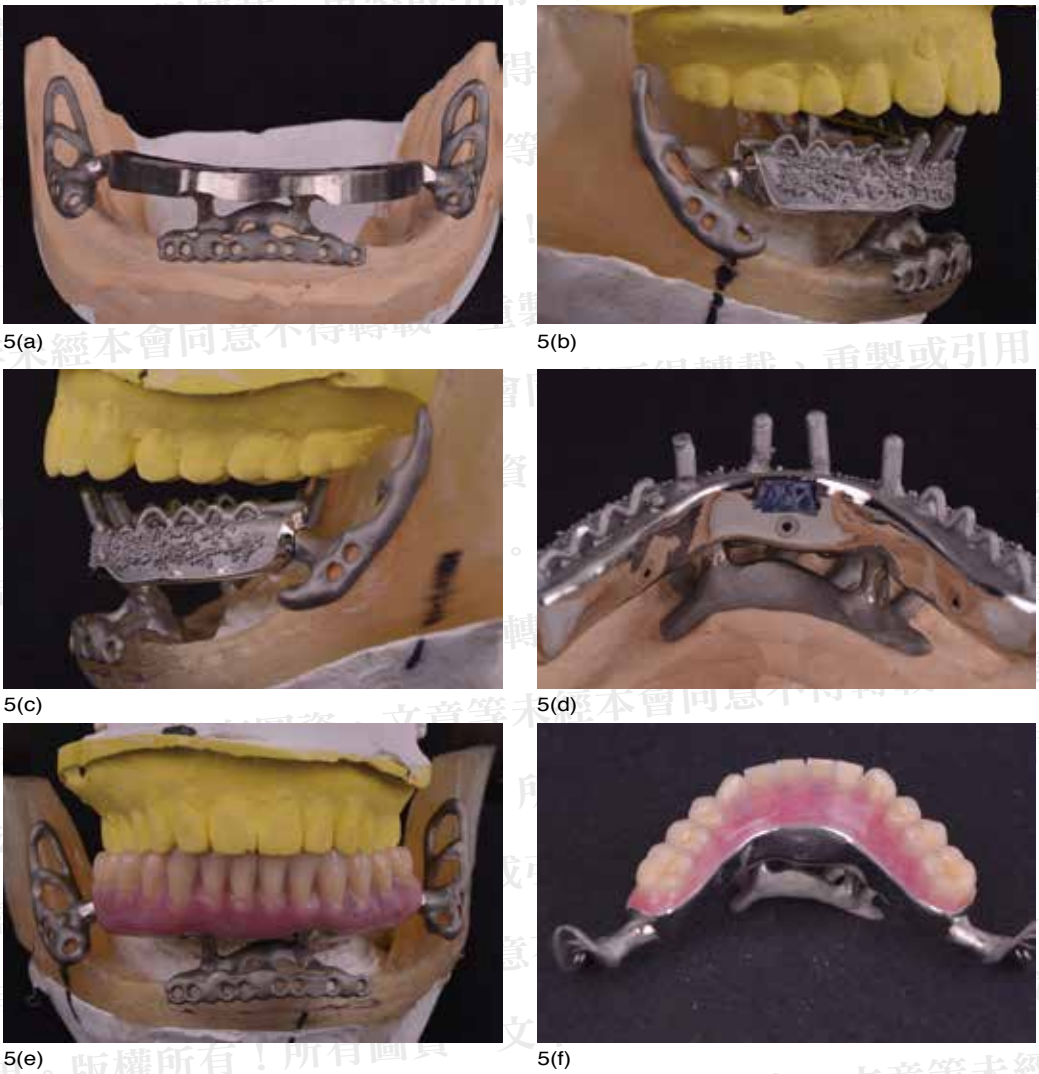


4(f)

Fig. 4 Clinical procedures: (a) Mandibular model, (b) wax dentures try-in — frontal view, (c) wax dentures try-in — right buccal view, (d) wax dentures try-in — left buccal view, (e) verify vertical dimension — frontal view, (f) verify vertical dimension — lateral view



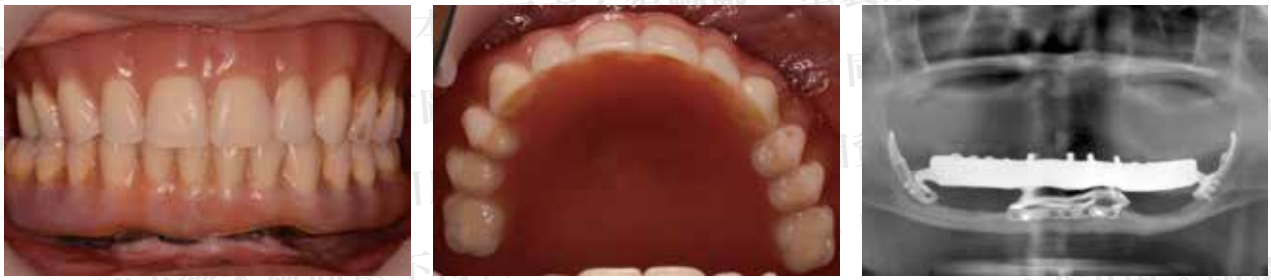
5(a) 5(b) 5(c) 5(d) 5(e) 5(f)

Fig. 5 Lab procedures. (a) TSI titanium framework, (b) overdenture framework — right view, (c) overdenture framework — left view, (d) overdenture framework — lingual view, (e) overdenture — frontal, (f) overdenture — lingual view

mandibular model, a record base was made to verify the vertical dimension and the jaw relationship for further teeth arrangement (Fig. 4). The CAD/CAM-made model eliminated the need to conduct a preliminary surgery simply to make a model of the patient's mandible. The framework of the tripodal subperiosteal implant was easily designed from the resin model, and the relevant communication between the clinician and the technician was also easier.

Once the design of the subperiosteal implant was completed, it was delivered to a dental laboratory (Gija Dental Lab, Taipei, Taiwan) for fabrication of the titanium framework (Biotan Titan Grad 1, Schutz, Germany) of the implant and of the mandibular denture. The denture was screw-retained to the implant framework with titanium screws (Bredent, Germany) inserted through screw holes on the lingual side. The mandibular denture was packed at the same time. The casting framework of the implant was polished, sandblasted, passivated, and sterilized before being delivered (Fig. 5).

At the surgical appointment, the patient was sedated via general anesthesia and intubated by nasal approach, and the oral cavity was swabbed with chlorhexidine gluconate 12% for 30 seconds. An oral pack was then placed, after which flap reflection from the retromolar pad at about 5 cm along the bilateral sides was accomplished. Another flap incision about 6 cm long was made at the anterior of the mandible. A 1.5 cm vertical releasing incision was made in the center of the symphysis, and the soft tissues were reflected by elevators. The tripodal



6(a) 6(b) 6(c)

Fig. 6 Surgical procedures. (a) TSI insertion — frontal, (b) TSI insertion — maxillary, (c) Panorex after TSI insertion

subperiosteal implant (TSI) was then seated on the patient's jaw and a titanium screw was used to establish a firm initial fixation. The soft tissues were approximated, and primary closure was achieved with 5.0 vicryl. The mandibular denture was also delivered during the surgery (Fig.6). To decrease postoperative swelling, the patient was administered 8 mg of dexamethasone. The patient withstood the whole procedure well and was discharged the day after the surgery.

Soft and liquid diets were suggested after the surgery. The wound healing was even, and the sutures were removed two weeks later. The maxillary denture was made following with final impression, jaw relationship verification, and wax denture try-in. The tripodal subperiosteal implant was loaded 8 weeks after the surgery. The patient was satisfied with the profile and the function of the new dentures (Fig.7). Regular follow-ups were arranged for every 2 months after delivery, and no complications were noticed during a 2-year follow-up period (Fig.8).

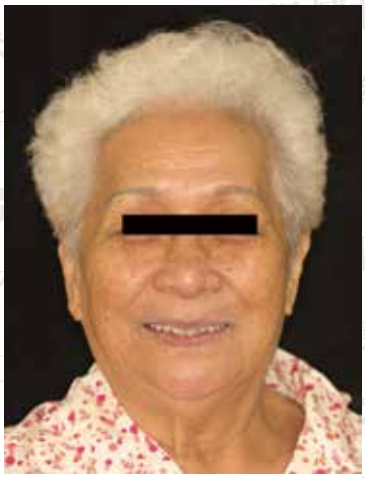
Discussion

Implant treatment can be simple and highly predictable nowadays. Owing to implants, the increase in comfort in recent years for patients who wear dentures has been striking, especially for those who suffer from a lack of stability and retention. At the same time, advanced surgical techniques, such as alveolar augmentations or sinus grafting, or even grafting from the iliac, are required for some conditions. Relatedly, treatment with some types of implants may occasionally be compromised due to limited bone height. Therefore, subperiosteal implants, although declining in use overall, have been shown to be a successful treatment option for patients who are not suitable for extensive graft surgery.

The reasons that subperiosteal implants sometimes fail have previously been discussed. Some subperiosteal implants have shown poor biocompatibility, resulting in inflammatory responses and rejection when alloys such as chrome-cobalt were used. However, the utilization of titanium has greatly improved biocompatibility and reduced the rate of rejection issues common with chrome-cobalt alloys[8,9]. Corrosion resulting from the instability of this oxide-metal interface has previously been reported to cause foreign body reactions leading to chronic inflammation and eventual implant rejection and failure[10]. In the case described herein, the framework of the subperiosteal implant was made of commercially pure titanium. After the casting process was completed, the titanium surface was sandblasted to remove the oxidation layer. Except for those parts of the framework with rough surfaces, such as the meshes and parts of the posts, that were intended to stay beneath the soft tissues, the other parts of the framework were highly polished.

The second reason for the failure of subperiosteal implants is a lack of osseointegration due to the nature of the surgical techniques and loading protocol traditionally used for such implants. Traditionally, chrome-cobalt subperiosteal implants would be placed on top of the bone and loaded with prostheses either immediately or soon after placement. However, a lack of direct bone contact and an immediate loading protocol often lead to fibrous integration11. In the case described herein, the tripodal subperiosteal implant was seated directly on the bone and had a firm initial fixation provided by titanium screws. Furthermore, the mandibular denture was not loaded until 8 weeks after the surgery to allow time for bone remodeling.

The tripod design of the implant used in this case is different from the design of the original subperiosteal implants from the early 1940s. It uses the mandibular symphysis and the angle of the mandible as locations for



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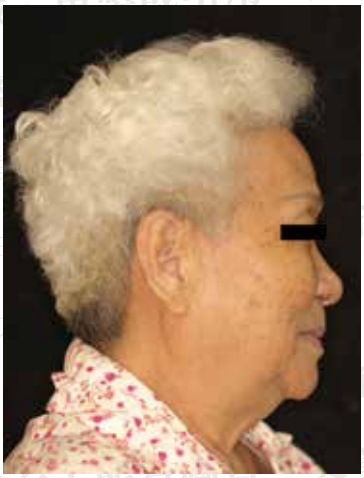

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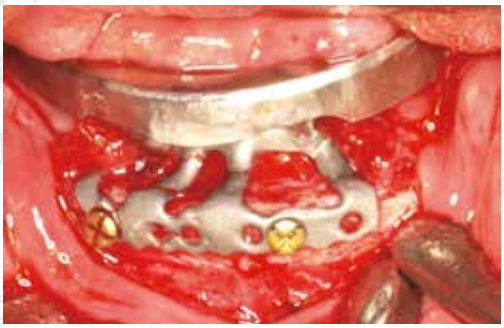

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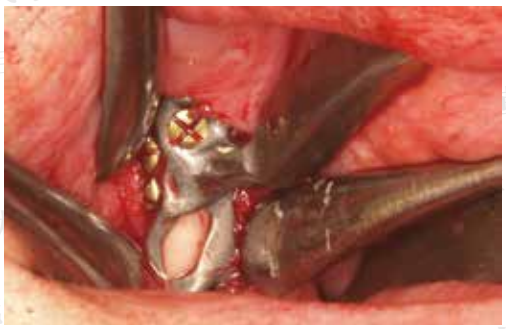

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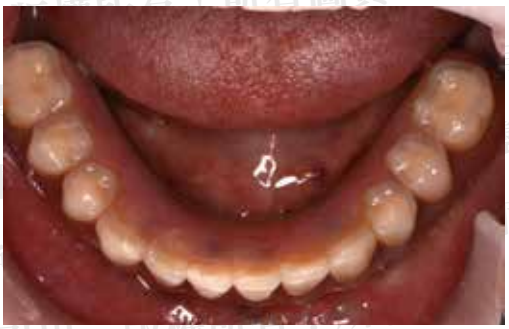
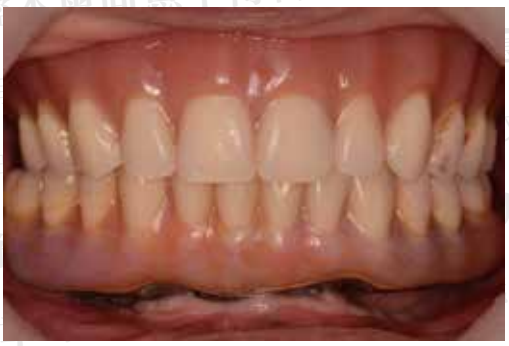
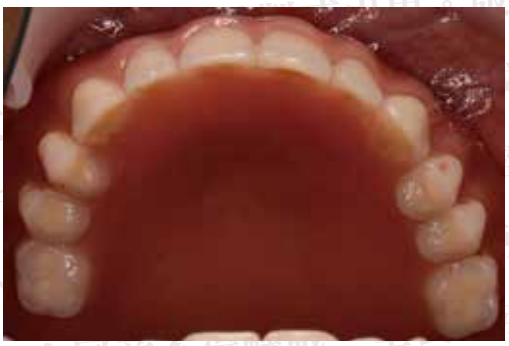


7(e)



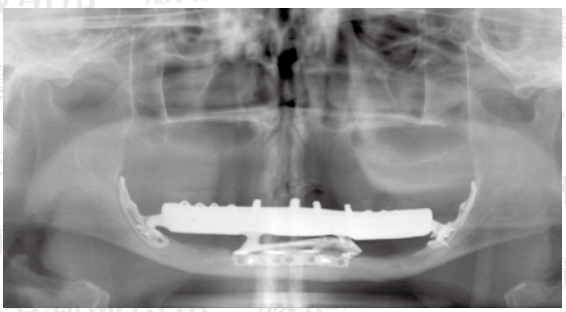
7(f)



7(g)

Fig. 7 Overdenture delivered. (a) Extra-oral frontal view, (b) extra-oral lateral view, (c) intra-oral frontal view, (d) intra-oral maxillary occlusal view, (e) intra-oral mandibular occlusal view, (f) intra-oral right buccal view, (g) intra-oral left buccal view

8(a)



8(b)

Fig. 8 Follow-up. (a) Hygiene care instruction, (b) Panorex after 2 years

the framework to rest upon. The area of the mandibular symphysis, where the genioglossus muscle and the geniohyoid muscle attach, forming the genial tubercle, is resistant to resorption over time. The angle of the mandible, meanwhile, is the attachment for the internal pterygoid muscle and the masseter muscle. Due to the functional attachments for these muscles, the angle also resists resorption over time. These two locations, the symphysis and the angle of the mandible, are thus better areas for the location of the feet or mesh of a subperiosteal implant[5,12]. The current design effectively transfers force to the substructure through the permucosal posts, which are anterior to the mental nerve, in the retromolar pad area, and connected to a continuous mesobar[2,7].

In the old days, patients had to undergo two surgical phases of treatment involved in fabricating and inserting a TSI. Nowadays, it is possible to print out models of jaws via computerized tomography (CT) scans and CAD/CAM technology. With this approach, there is no need for another surgery simply to obtain a model of a patient's jaw[2,7,12]. This is of substantial benefit to patients, especially elderly patients. Nonetheless, the subperiosteal titanium framework still has to be made by casting since the curvatures and the minor structures of mesobars cannot be milled by the CAD/CAM machine.

In the case described herein, after completing the surgical phase of the implant insertion, the mandible overlay prosthesis was seated on the mesostructure. The maxillary denture was fabricated 8 weeks later, after which the occlusion was checked and balanced to eliminate unilateral and protrusive interferences. The buccal cusps of the mandibular posterior teeth occluded with the flat occlusal surfaces of the maxillary teeth, and the mandibular lingual cusp contacts were relieved. For the most part, the implant denture for a TSI is implant-borne and retained on the framework by O-rings[1,2,5,13] or ERA attachments[8]. In this case, the implant prosthesis was fixed to the TSI by three screws on the lingual side in order to prevent lifting forces when the prosthesis is removed or transfered to the framework repeatedly, thus eliminating mandibular tissue irritation. Hygiene care can be accomplished, meanwhile, by using interdental brushes.

Conclusion

The previously unpredictable tripodal subperiosteal implants have in recent years become more predictable and less invasive, while also requiring fewer surgical procedures and being less technique-sensitive than in the past. CAD/CAM technology has effectively simplified the lab procedures involved in the fabrication of these implants, although this technology still has some limitations. Moreover, screw-retained dentures may effectively lower the repeated lifting forces associated with TSIs. At the same time, a periodic recall, just as with all other implant programs, is an important part of successful tripodal subperiosteal implant treatment.

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