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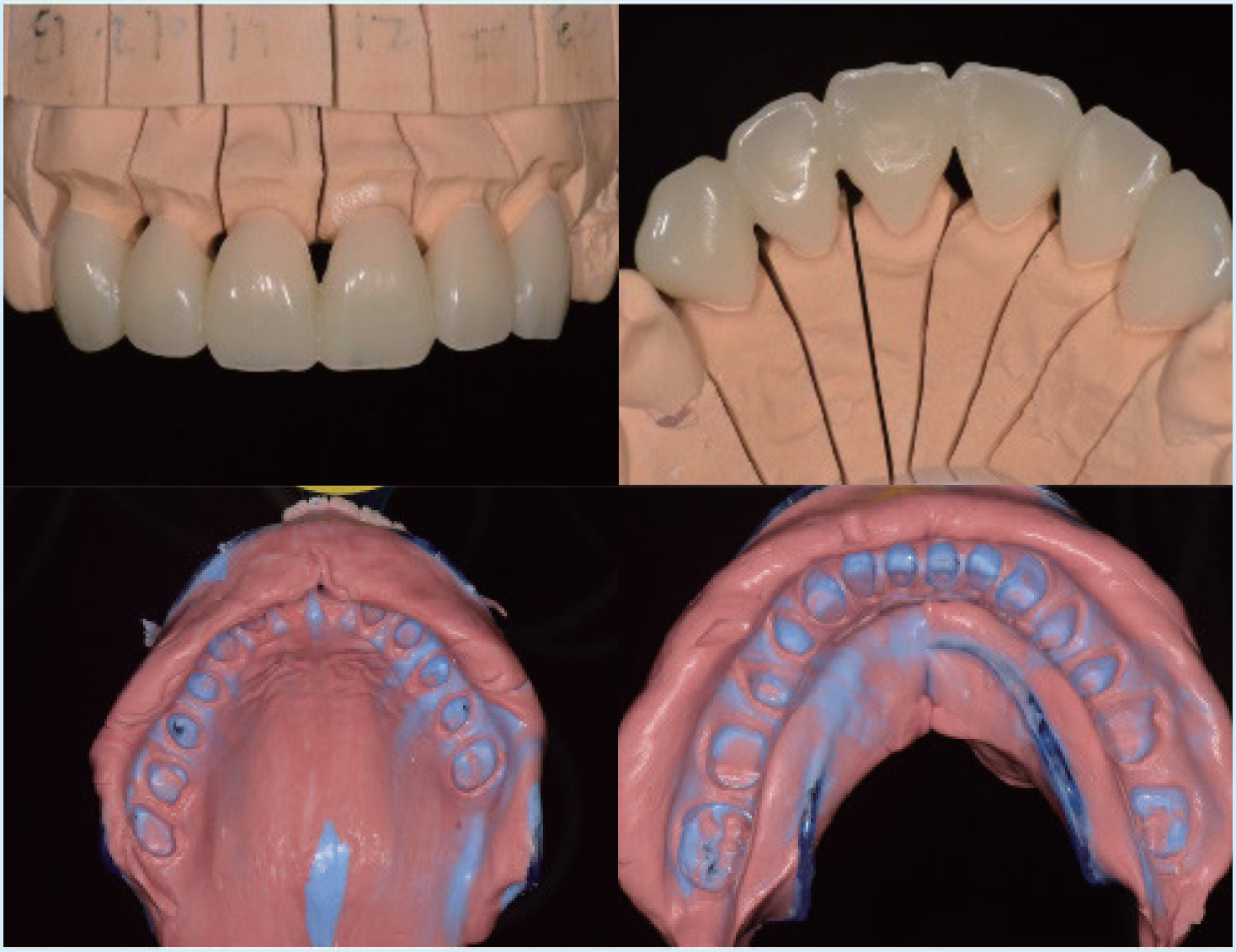
JCDD

Journal of Clinical & Digital Dentistry



Cover Images from Wongun Chang. (J Clin Digit Dent 2025;7(2):6-19)

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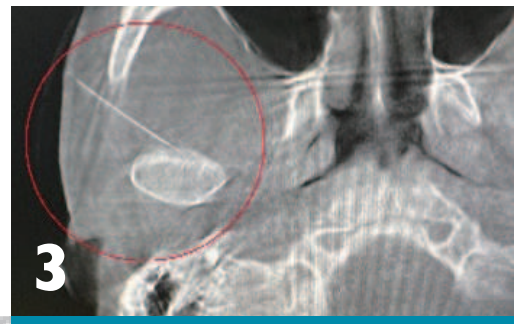

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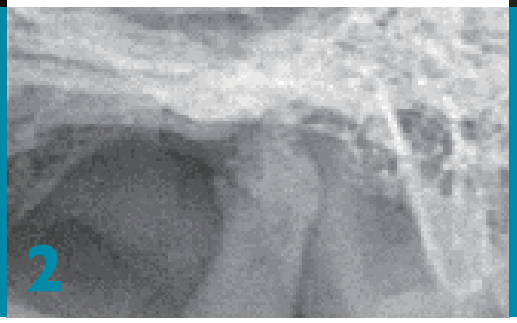

JCDD
Journal of Clinical & Digital Dentistry

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About the Journal

The Journal of Clinical and Digital Dentistry are published four times (March, June, September, and December) annually since May 2019. The abbreviated title is "J Clin Digit Dent". In the journal, articles concerning any kind of clinical dentistry such as prosthodontics, orthodontics, periodontics, implant dentistry and digital dentistry are discussed and presented.

Aims and scope

This journal aims to convey scientific and clinical progress in the field of any kind of clinical and digital dentistry.

This journal publishes

- Original research data and high scientific merit in the field of clinical and digital dentistry.
- Review articles.
- Case reports in implant dentistry including GBR, digital dentistry, 3D printing, and prosthodontics.
- Short communications if they provide or document new technique and clinical tips.

About the Journal

Editorial Board

Editorial

Hot summer, Hotter passion for dentistry

Last May, I attended the 6th Congress of the European Aligner Society (EAS) held in Rhodes, Greece. The journey from Seoul, including flight transfers, took nearly 24 hours. Contrary to my expectation that a congress held on a small Greek island would attract few attendees, I was surprised to see over 600 dentists from around the world participate. I was even more impressed by their dedication, as they filled the lecture halls from morning until the end, focusing intently on the presentations rather than enjoying the island's leisure. Their passion was truly inspiring.

As a congress focused on Clear Aligner orthodontics, I anticipated discussions solely on treating various malocclusions with clear aligners. However, I was struck by the number of lectures addressing temporomandibular joint disorders and occlusal issues—challenges even in traditional bracket orthodontics—through clear aligner therapy. This showed that clear aligners are no longer just an emerging treatment but have become an established method, surpassing traditional bracket orthodontics in some respects.

The dental field continues to evolve rapidly with advancements in materials and technology. The development and application of digital treatment methods are expanding, with guided systems for arch expansion and miniscrew placement now incorporating digital technology and metal printing. This left me wondering which dental field will be transformed by digital innovation next.

What was even more remarkable was that both the speakers and many attendees were elder dentists. There relentless efforts to adapt to the evolving landscape of dentistry, regardless of age, were truly admirable. This congress was a valuable learning experience for me and a source of inspiration to push myself further.

In this issue of JCDD, a paper on the clinical application of PDRN in dentistry is published. As the use of PDRN is increasing across various dental fields, it remains an area of curiosity and interest for many dentists due to its relative novelty. This paper provides an opportunity to gain a clear understanding of the fundamentals and applications of PDRN.

May our passion for dentistry burn even hotter than the summer heat this season.

Wongun Chang, DDS MS PhD

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Full mouth rehabilitation in a patient with a severely worn dentition: A case report ②

Wongun Chang, DDS, MS, PhD

Case report

Actual course of treatment procedures for the real patient

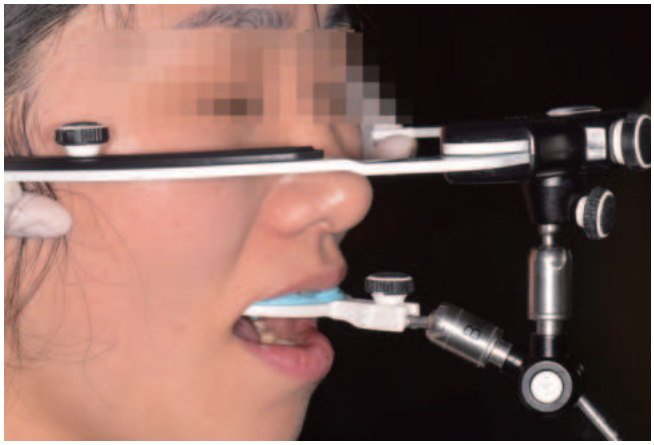
1. Fabricating and using a splint to evaluate the changed vertical dimension of occlusion under an increased vertical dimension of occlusion after mounting on a semi-adjustable articulator : A facebow transfer was performed to mount the upper and lower jaw models on the A7 plus semi-adjustable articulator with maximum intercuspation **(Fig. 1-2)**. After mounting, patient's occlusal scheme is evaluated **(Fig. 3-7)**. The vertical dimension of occlusion is subjectively determined with the patient by having them bite onto a curtain roll placed on the anterior teeth, considering the aesthetic proportions of the face. The bite is recorded in this position and then remounted onto the articulator using the acquired bite. In this state, a splint is fabricated to achieve a mutually protective occlusion, and the patient is monitored for functional adaptation to the altered vertical dimension of occlusion.

The evaluation typically lasts 2-4 weeks. After approximately 4 weeks of use, any discomfort can be noted, and, if necessary, the vertical dimension of occlusion can be re-evaluated by slightly decreasing or increasing it.

After fabricating the mandibular splint **(Figure 8)**, the patient was instructed to wear it as long as possible to assess for any discomfort **(Figure 9)**. The patient returned after approximately 2 weeks of use and reported no discomfort (such as difficulty swallowing or muscle fatigue around the jaw). She also mentioned that she was pleased with the appearance of her mouth after wearing the splint.

Wongun Chang

Dr. Wongun Chang graduated from Seoul National University College of Dentistry, and then earned MS degree from New York University College of Dentistry(NYUCD), PhD degree from Dept. of Dental materials sciences, Seoul National University College of Dentistry. He completed Advanced Specialty Program in Orthodontics for International grauduates(1997) and Advanced Education Program in Prosthodontics(2009), NYUCD. He gives lectures in various topic, especially occlusion, complete denture, orthodontics, and interdisciplinary dental treatment nationally and internationally. His books "The answer is COVAN, Harmonized stomatognathic system", and "Functional occlusal harmony in orthodontics"are best seller in Korea from 2019. He is an immediate president of Korean Academy of Esthetic Dentistry, a vice president of Asian Academy of Aesthetic Dentistry. and a President-elect of International Federation of Esthetic Dentistry. He is an editor-in-chief of JCDD and a head coach of Team CTS. He maintains a private practice in Milestones Dental Institute, Seoul, Korea.



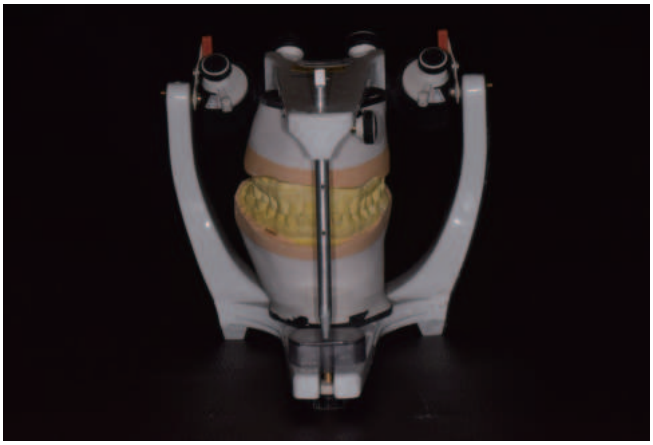
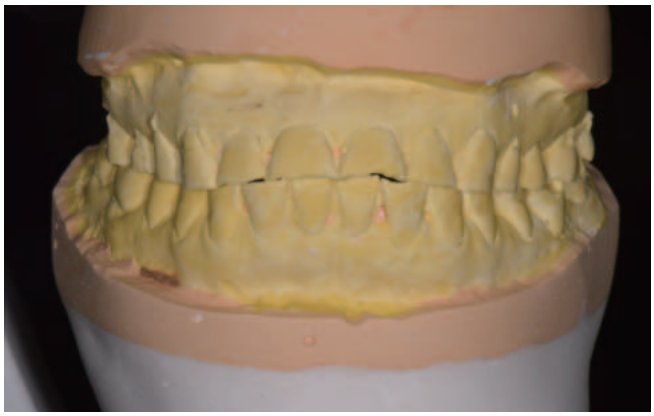
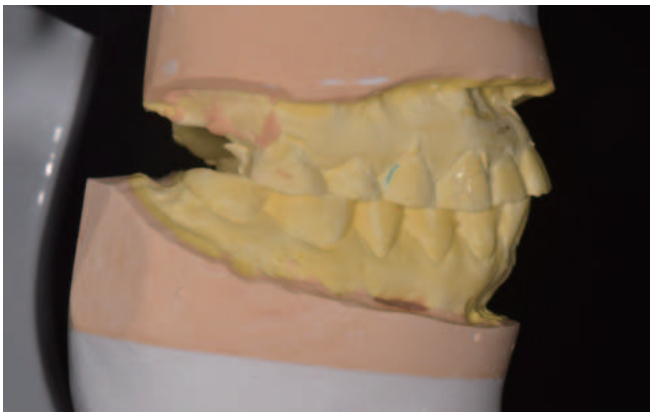
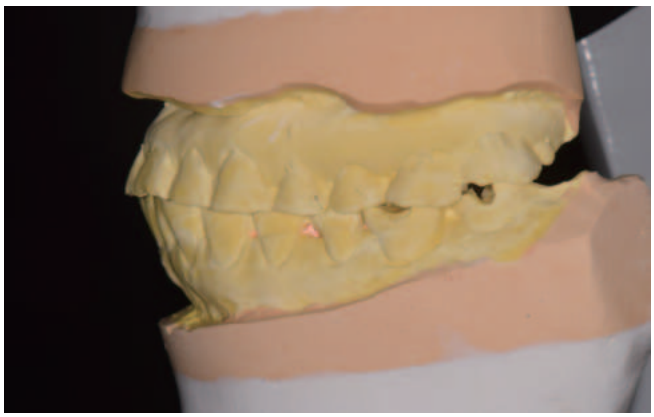


Fig. 1-2. Upper and lower models mounted on the semi-adjustable articulator at maximum intercuspation following facebow transfer







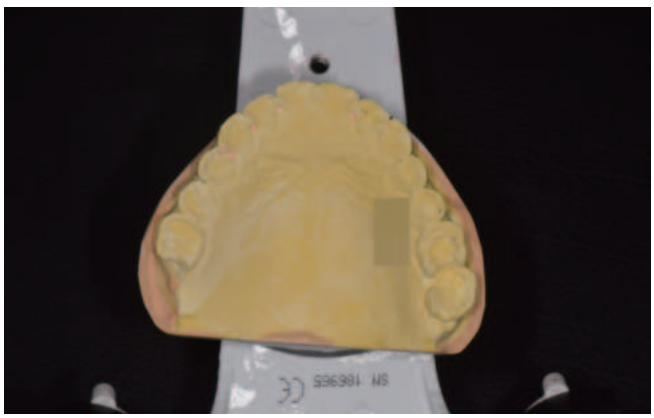


Fig. 3-7.
Model mounted on the articulator with the increased vertical dimension of occlusion

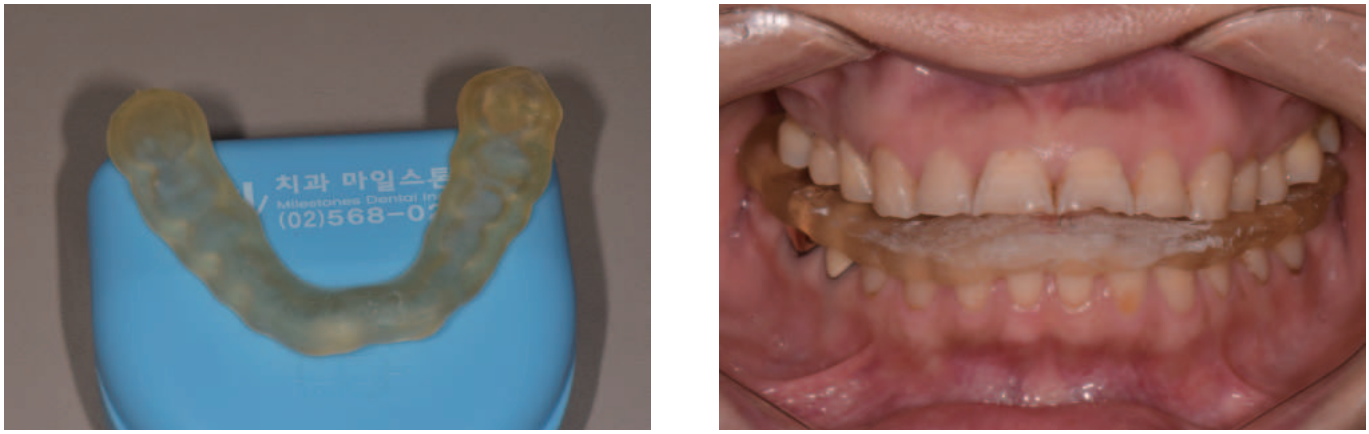


Fig. 8-9. Photographs of the fabricated mandibular splint and the mouth with the splint in place

2. Diagnostic wax-up and provisional restoration fabrication with the determined vertical dimension of occlusion : Initially, the diagnostic and splint-making stone casts are mounted on the articulator, with the diagnostic wax-up cast mounted separately. Two stone casts are prepared and mounted to preserve the pre-treatment condition. After determining the vertical dimension of occlusion with the splint, a diagnostic wax-up is performed with an elevated incisal pin **(Fig. 10-14)**. The occlusal scheme is established with canine guidance. The diagnostic wax-up model is duplicated to create a provisional restoration. The provisional restorations are fabricated three pieces, anterior teeth, right and left posterior teeth, and are fabricated in a shell-type provisional splinted crowns for relining after teeth.

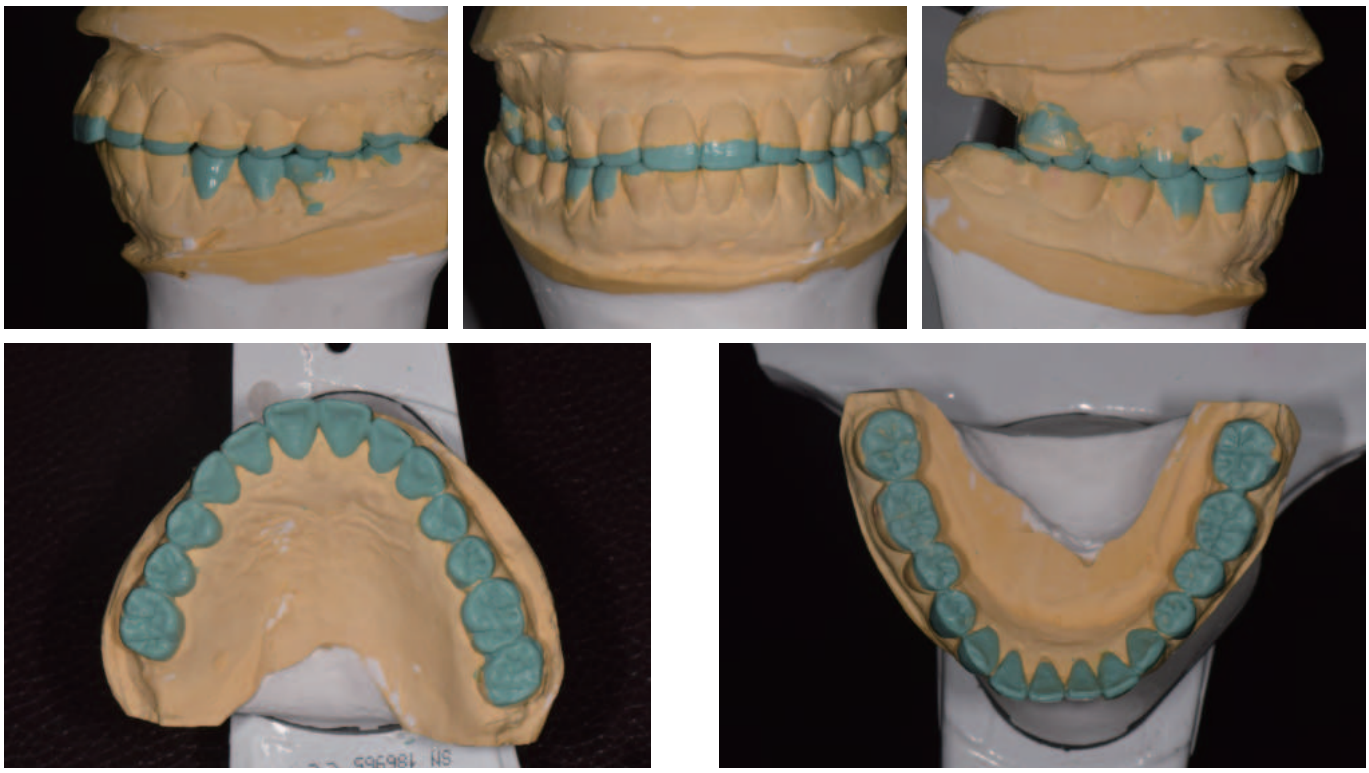


Fig. 10-14. Diagnostic wax-up with the determined vertical dimension of occlusion, achieving mutually protective occlusion with canine guidance

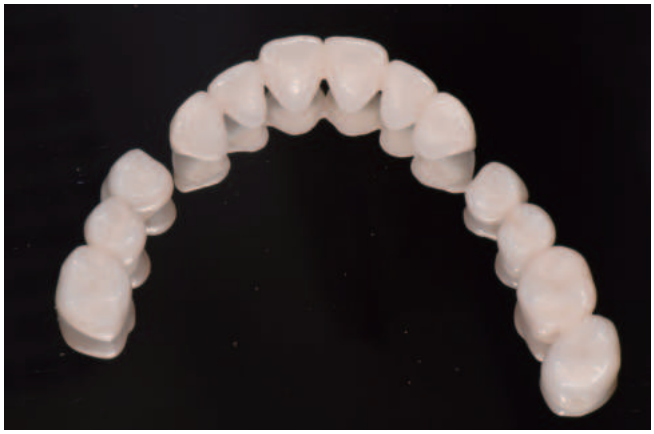


Fig. 15. Provisional restorations fabricated as wax-ups (shell-type provisional splinted crowns)

3. Tooth preparations and setting of provisional restorations : All teeth preparations and relining provsional restorations in a single visit poses significant challenges for both the patient and the dentist. Consequently, the initial phase of treatment involved preparing the maxillary teeth and relining provisional restorations, specifically temporary crowns. The mandibular teeth were scheduled for the next appointment. The maxillary dentition has been prepared **(Fig. 16-19)**. Some bleeding from the gums is evident in this photograph, which was taken after the retraction cord was placed and impressions were made to create new provisional crowns following the preparation. After taking impressions, the shell-type provisional teeth were relined and set using Temp-Bond Clear **(Fig. 20-23)**. The relining process is not performed with great rigor, as it typically requires only a few days to fabricate a new provisional tooth. For provisional teeth intended for use beyond two weeks, meticulous relining is essential. However, excessive time spent on relining is not necessary, as these teeth are designed for short-term use.

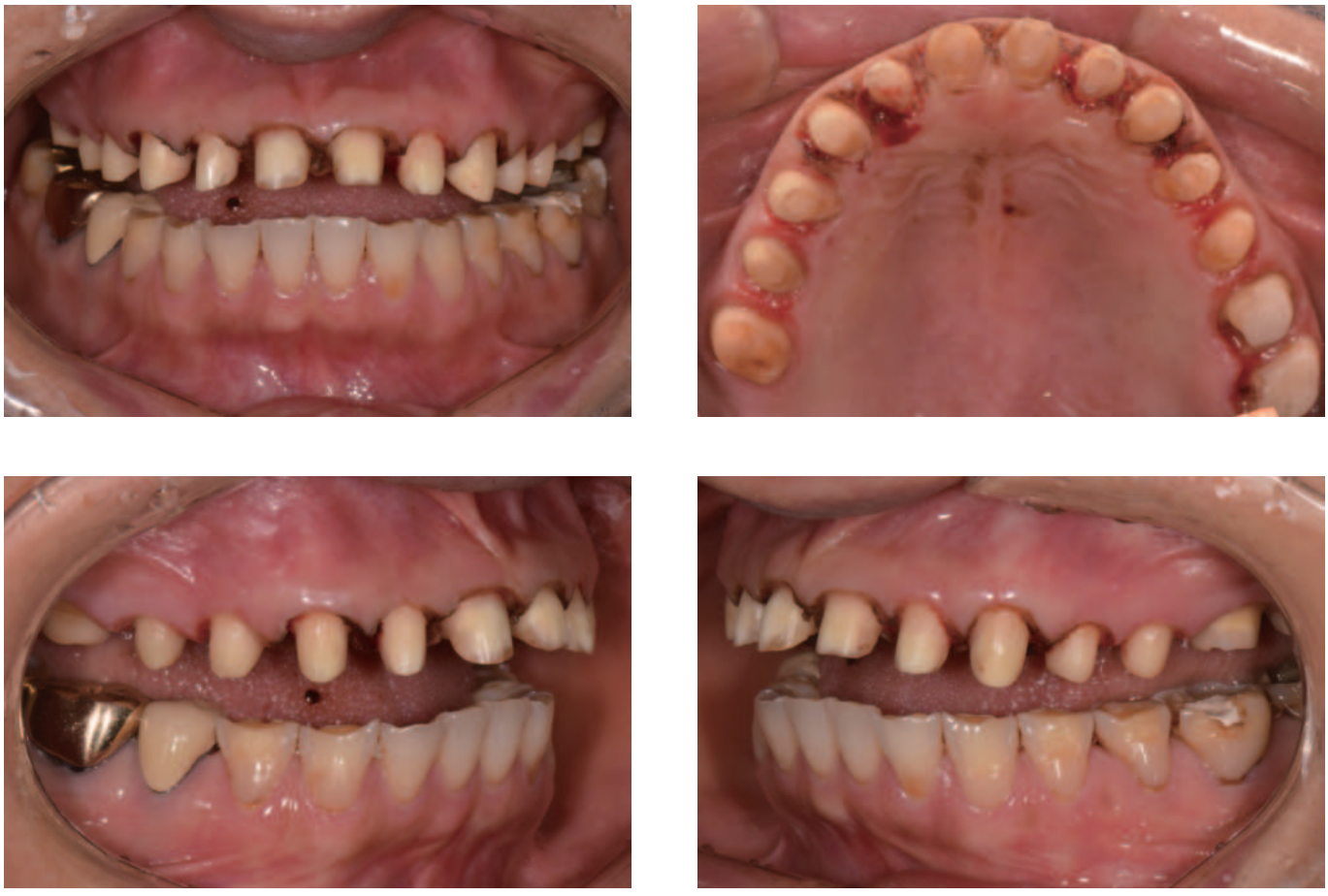


Fig. 16-19. Maxillary interproximal reduction for the placement of a provisional restoration

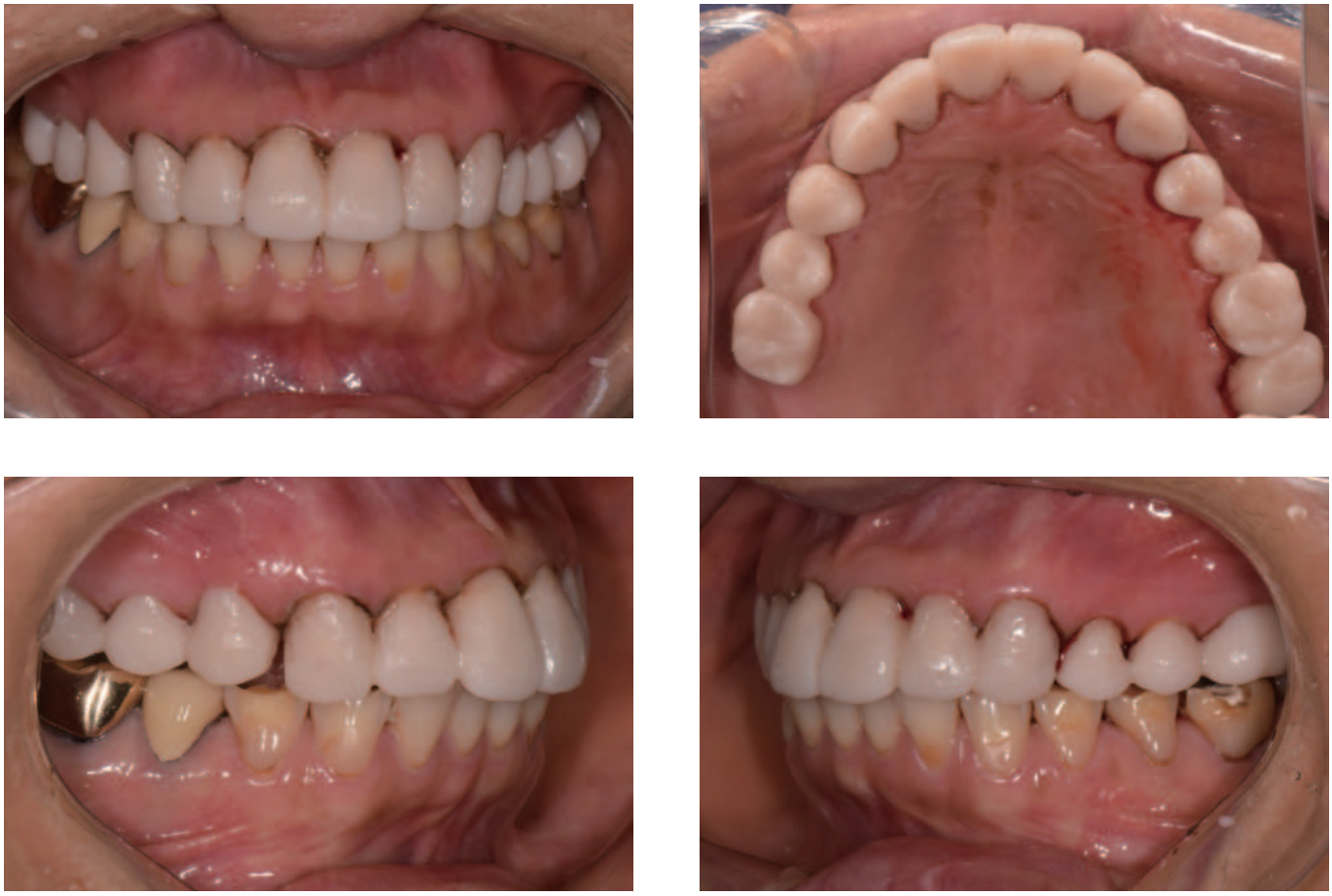
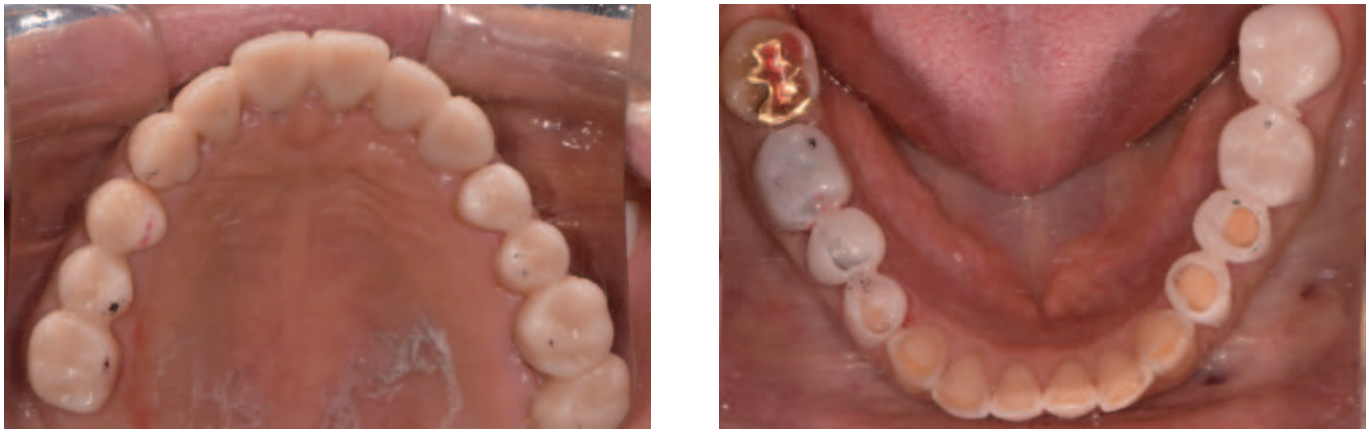


Fig. 20-23. Maxillary teeth with provisional restorations placed after chairside relining of shell-type provisional crowns

4. Mandibular teeth preparations and relining provisional crowns : After placing the maxillary provisional restoration, the patient returned to remove the existing posterior mandibular crown and cement the mandibular provisional restoration after interproximal reduction **(Fig. 24-28)**. The crown was extracted, and a shell-type provisional restoration was cemented. However, due to inadequate cementation, the inner surface of the restoration was adjusted and relined prior to the application of the relining material. The provisional restorations used are essentially temporary crowns. Although they were fabricated after the wax-up, the occlusal surface required modification during the process of setting the provisional restoration. Therefore, another impression was required to fabricate new provisional crowns and evaluate their fit and function.



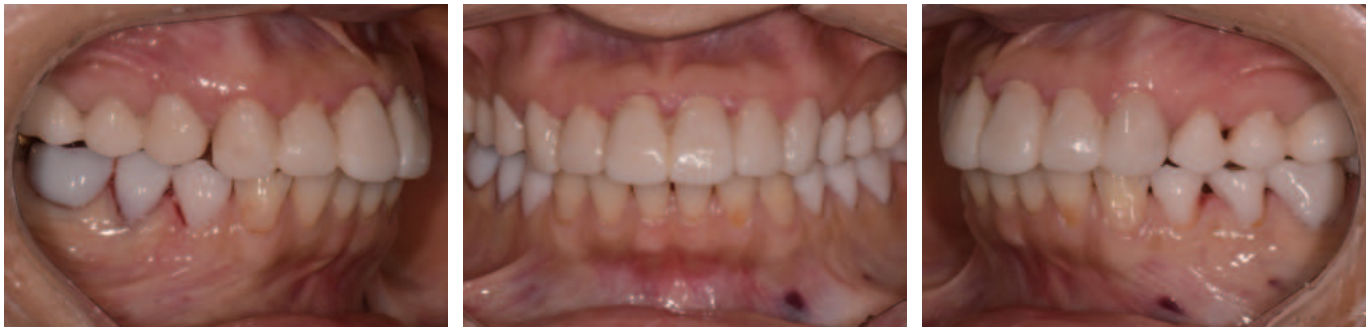


Fig. 24-28. Provisional restorations placed after removing the existing crown in the mandibular posterior teeth

Evaluation with provisional crowns is one of the most important steps in prosthodontic treatment, as it evaluates the occlusion, occlusal scheme, tooth shape, length, and the relationship with soft tissues before the definitive restoration. As the current intraoral provisional restorations are temporary crowns, it is not necessary to spend excessive chair time on them. Instead, the time spent on relining the temporary crowns should be directed more toward the impression-taking process for the provisional crowns.

The impression for provisional crowns should be taken in the same manner as for definitive crowns, using a gingival retraction cord. Furthermore, the VPS impression should be taken in a manner that ensures full visibility of all margins. Provisional teeth are not described to the patient as temporary teeth. In my office, a provisional restoration is explained to the patient as a crown identical to the definitive crown, except that the material of the crown is made of plastic, allowing evaluation of how well the patient adapts to it.

In order to remove the provisional restorations in the maxilla and fabricate provisional crowns, bites were taken to maintain the current vertical dimension of occlusion, and impressions were taken **(Fig. 29)**.

For full mouth rehabilitation, bite taking while preserving the current vertical dimension of occlusion intact can be carried out in the following order.

(1) The anterior teeth bite is taken with the posterior provisional crowns in place.

(2) The posterior teeth bite is taken with the anterior teeth bite in place after removing the posterior provisional teeth.

(3) All bites are connected while taking an anterior teeth bite with the anterior provisional teeth removed and the posterior teeth bite in place.

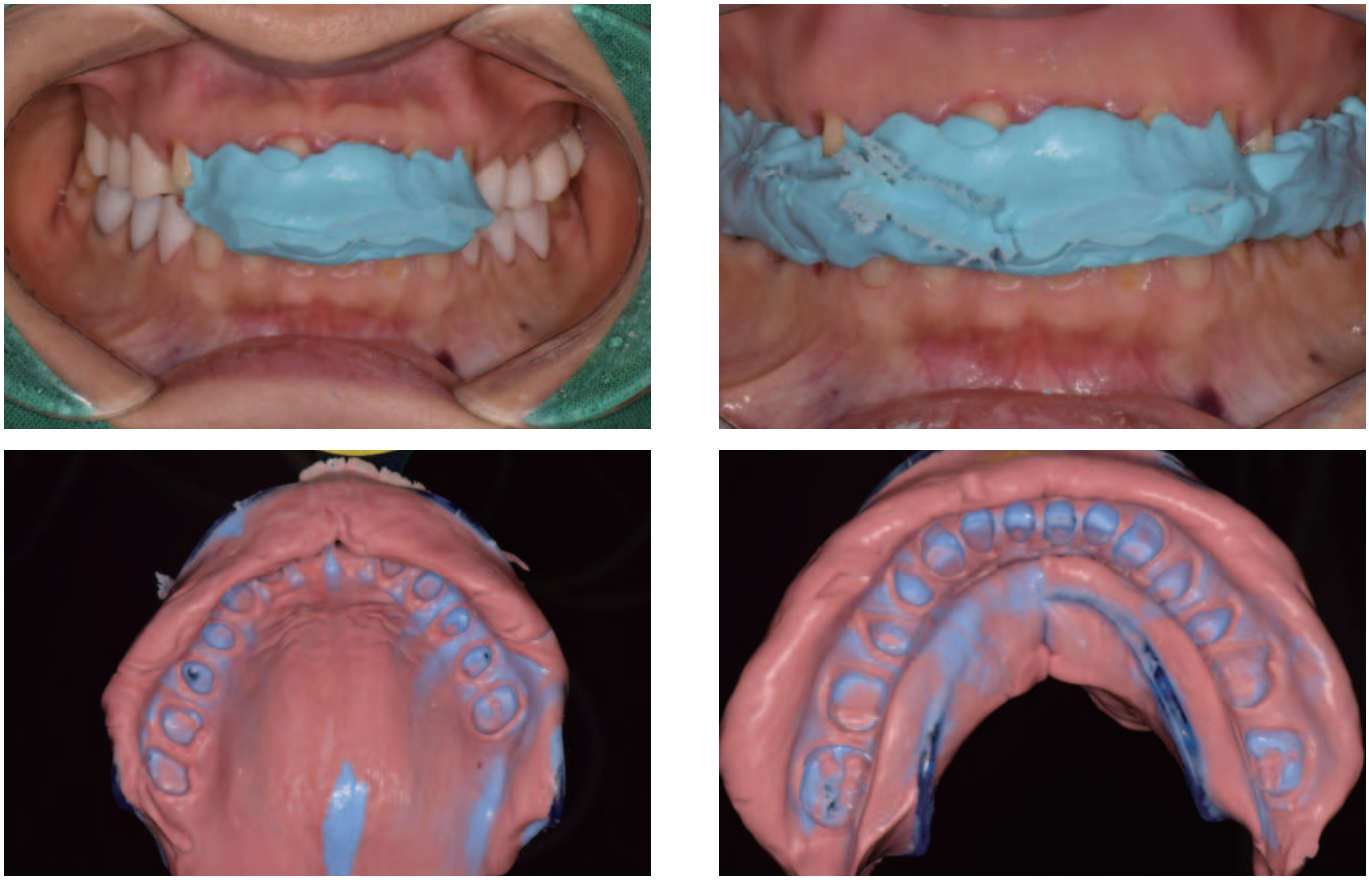


Fig. 29. Bite registration and VPS impression taking to fabricate provisional crowns

5. Fabrication of provisional restorations : When fabricating provisional crowns, a request is made to the laboratory to create them identically to the definitive crowns. They are manufactured using the same die and ditching processes as the final crown. Once created and archived, these provisional crowns can be used to create the definitive crown in the future without the need for additional impressions. In the context of full mouth rehabilitation, the provisional teeth are not fabricated as individual teeth but are separated into anterior teeth (canine to canine) and posterior teeth (premolars and molars). Although they are provisional crowns, they are temporarily bonded in this manner to maintain the occlusion and function during the treatment process. As a result, fabricating the provisional teeth as single crowns carries a high risk of them falling out. Fabrication of the anterior and posterior teeth separately is also necessary as treatment progresses by separating the posterior and anterior teeth. Although the entire tooth can be fabricated at once for the definitive crown, separating the teeth during the provisional phase is more practical.

The provisional restorations made in the laboratory **(Fig. 30)** indicate that margin trimming was carried out in conjunction with the die work. For this reason, impressions should always be taken the same way as for the final crown. In a full mouth rehabilitation, such as this one, multiple provisional restorations may need to be fabricated and evaluated, making relining at each visit unnecessary and time consuming. The provisional restorations created can be placed immediately without the need for relining and require only minimal occlusal adjustments.

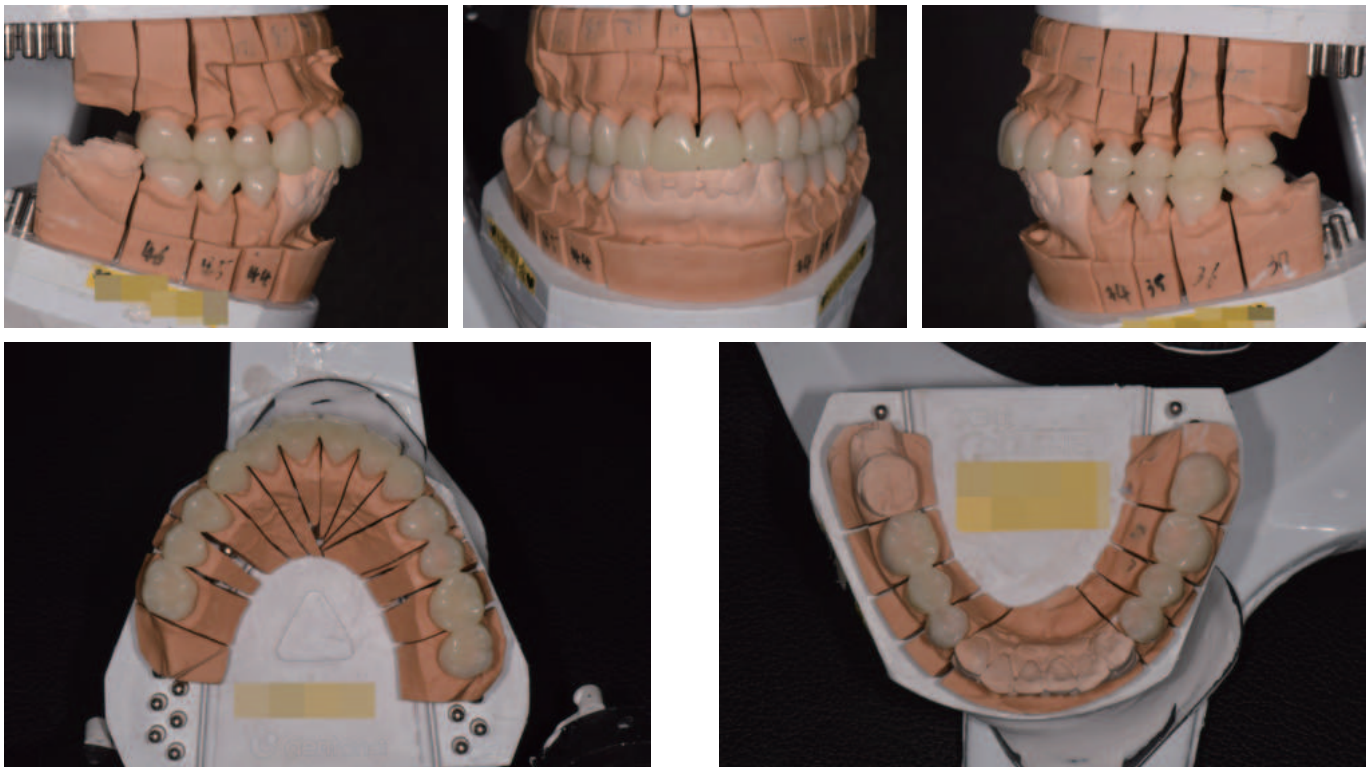


Fig. 30. Provisional restorations fabricated for the anterior and posterior teeth. They employ the same occlusal scheme with the definitive restorations.

6. Provisional restoration setting : Following the removal of existing provisional teeth and the subsequent insertion of provisional crowns, an evaluation is conducted. (1) First, at maximum intercuspation, it is assessed to ensure that the left and right posterior teeth are evenly occlued. If the left and right molars are engaged and premature contact occurs in the anterior teeth, necessary occlusal adjustments are made. (2) Once the occlusion of the left and right posterior teeth has been equalized, the articulation paper slips should be assessed for any slight slip from the anterior teeth. Ideally, the occlusal contact points of the anterior teeth should not be imprinted. Since provisional restorations are subject to wear, occlusal interference in the anterior teeth may result over time.

(3) During eccentric movements, the congruence of the occlusal scheme with the wax-up model is examined. Complete absence of contact on the non-functional side, particularly during lateral movements, must be ensured.

The provisional restoration was set using Temp Bond Clear (Fig. 31). The molars were examined for the left and right occlusion and mutually protective occlusion during eccentric movements. As the patient had spent a long period with worn anterior teeth, longer normal-sized teeth could be felt.

Therefore, at least 4 weeks is recommended to allow for proper adaptation and evaluation of the length and shape of the anterior teeth. Considering that the patient was to receive treatment exclusively with prosthetics, without undergoing orthodontic treatment, the shape was designed to minimize the proclination of the maxillary anterior teeth. The maxillary anterior teeth appear straight when viewed from the side.

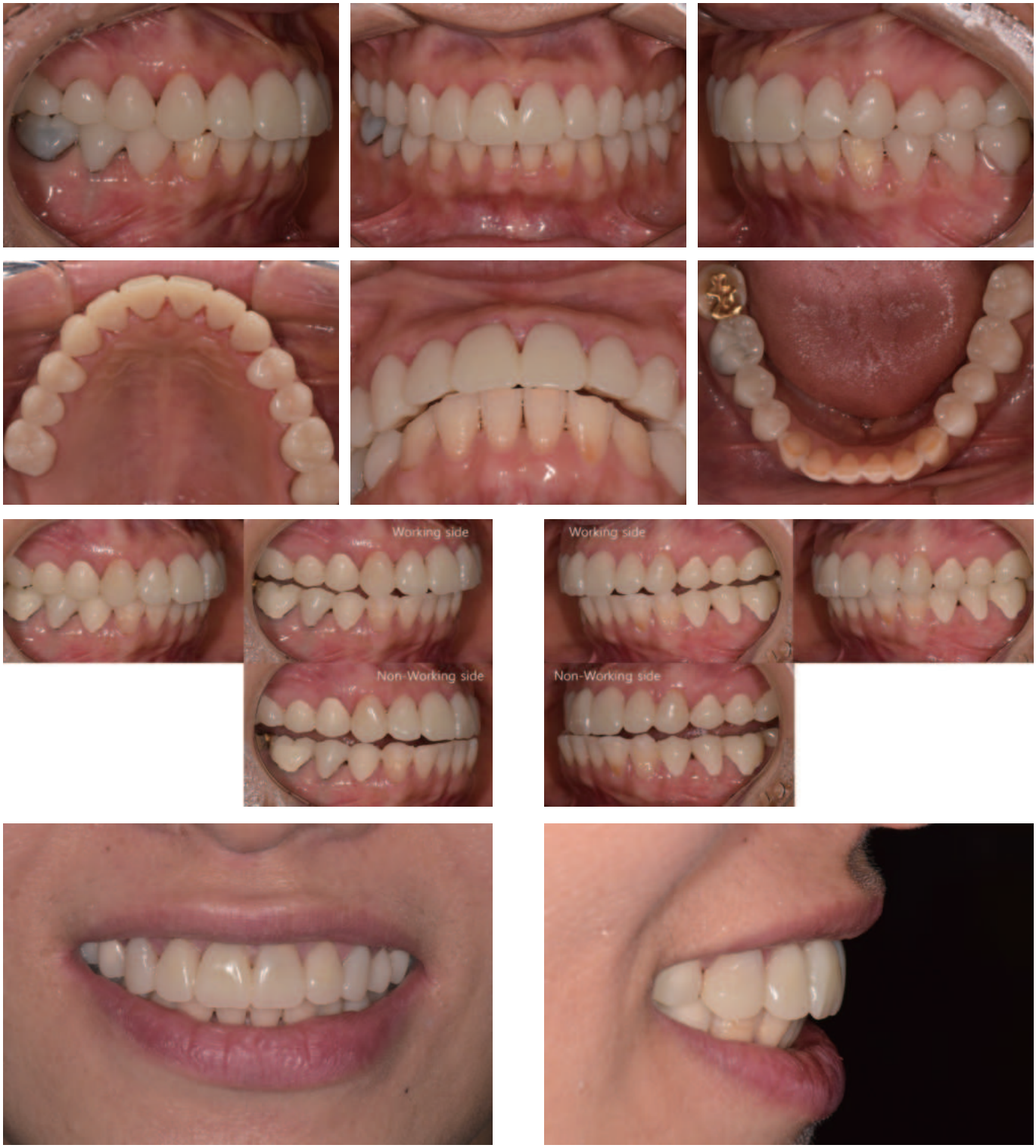


Fig. 30. Photographs of the intra-oral and smile with the provisional restorations in place

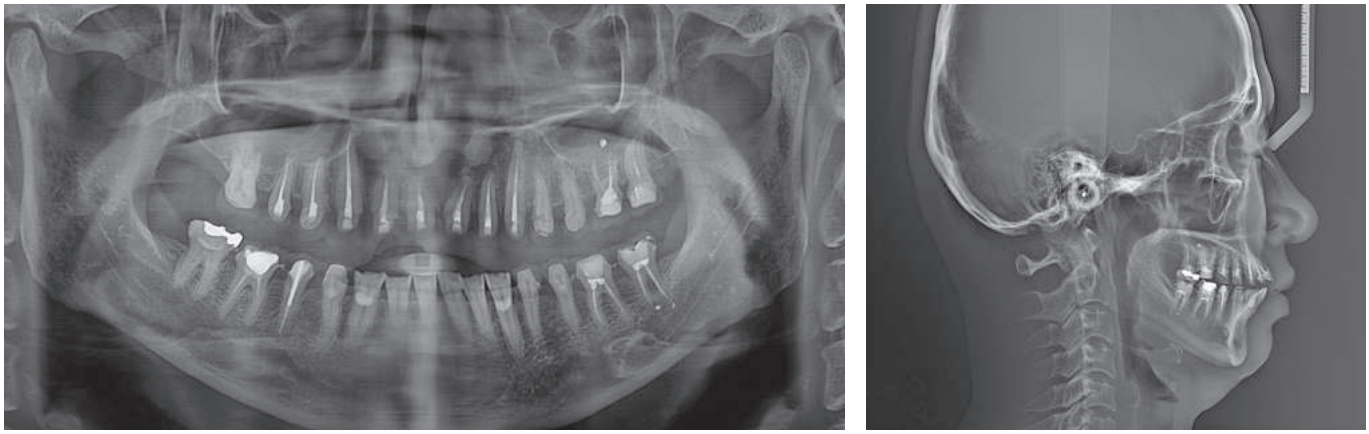
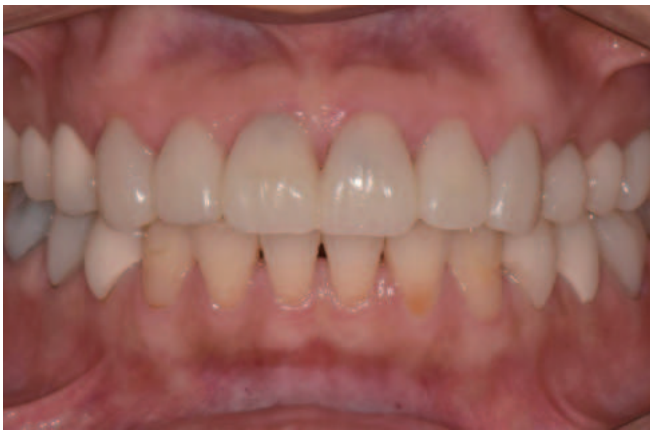
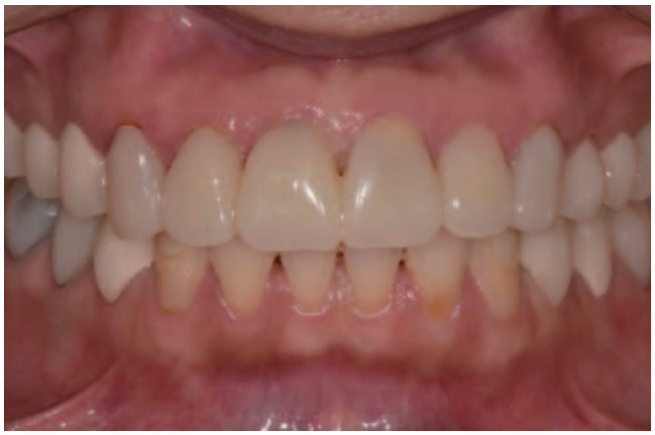


Fig. 31. Panoramic radiographs and cephalometric radiographs with provisional restorations in place

7. Evaluation of provisional restorations : After using the provisional restorations for 2 months, an evaluation was conducted. The patient did not report any significant issues with mastication; however, she experienced discomfort when her canines made contact during speech or movement. Additionally, she expressed a desire for shorter upper incisors, citing their perceived length as excessive, resulting in misalignment. The discomfort associated with the canines was attributed to the guidance they provided to the mandible, which had not been fulfilling its intended function. As canine guidance was considered an integral component of the functional occlusal scheme, the patient was expected to gradually adapt. Regarding the length of the maxillary anterior teeth, the patient felt that the anterior teeth were too long and had difficulty adjusting to the new bite, an issue that had likely been present for some time. However, the patient requested a slight shortening of the anterior teeth without compromising the functional aspects, as she had been accustomed to shorter anterior teeth for an extended period.

8. Second provisonal restorastion for upper anterior teeth : At the patient's request, the provisional restoration on the maxillary anterior teeth was modified by reducing their length and enhancing their aesthetic appearance **(Fig. 33)**. The patient expressed satisfaction with the slight adjustment. It was decided to proceed with the fabrication of the definitive restorations, provided no further issues arose during the continued use of the provisional restorations.





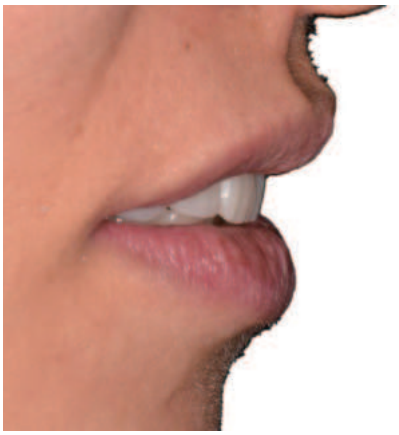


Fig. 32. Oral condition 2 months after using provisional restorations

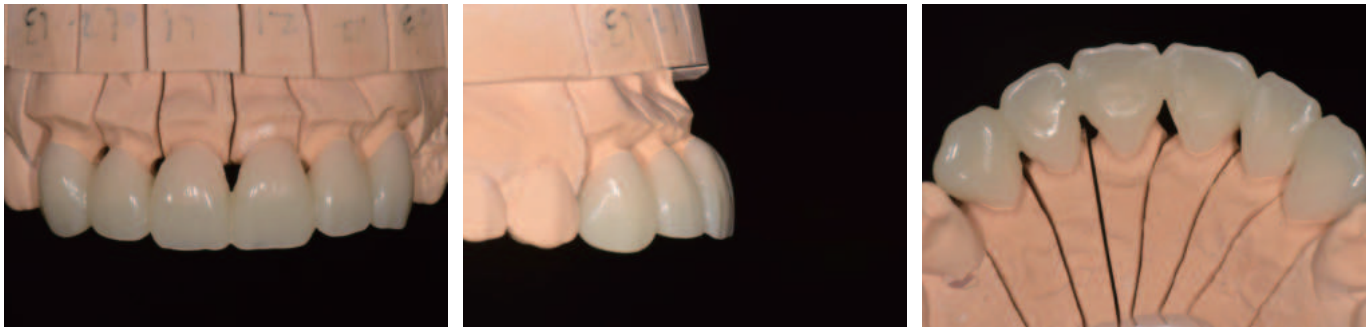


Fig. 33. New provisional restorations with a controlled cut of the maxillary anterior teeth without disrupting the anterior guidance

9. Fabrication of the definitive crowns for posterior teeth : The final impression was taken for posterior teeth **(Fig. 34)**. Zirconia crowns were created as a single crown for each tooth. In full mouth rehabilitation, the principle is to prioritize treatment of the posterior teeth, especially if the patient may want to modify the shape of the anterior teeth or if they prefer to proceed sequentially. From a therapeutic standpoint, it is beneficial to fabricate the final crowns of the anterior teeth while maintaining a stable posterior bite, ensuring that the anterior teeth's function is properly incorporated.

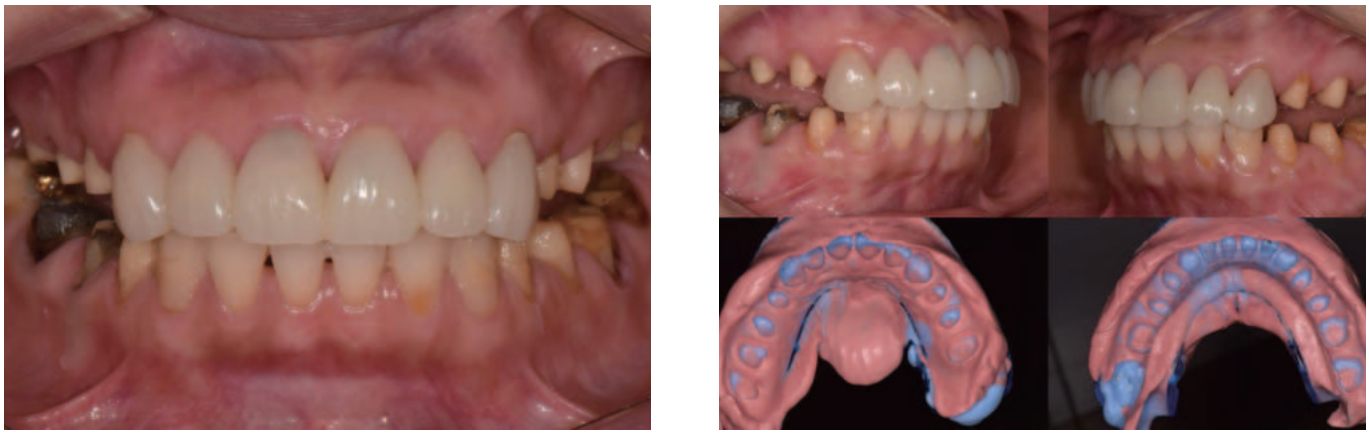


Fig. 34. Taking impressions for the fabrication of final crowns for the posterior teeth

A zirconia crown was fabricated in the laboratory based on the shape of the provisional restoration mounted on the existing articulator **(Fig. 35)**.

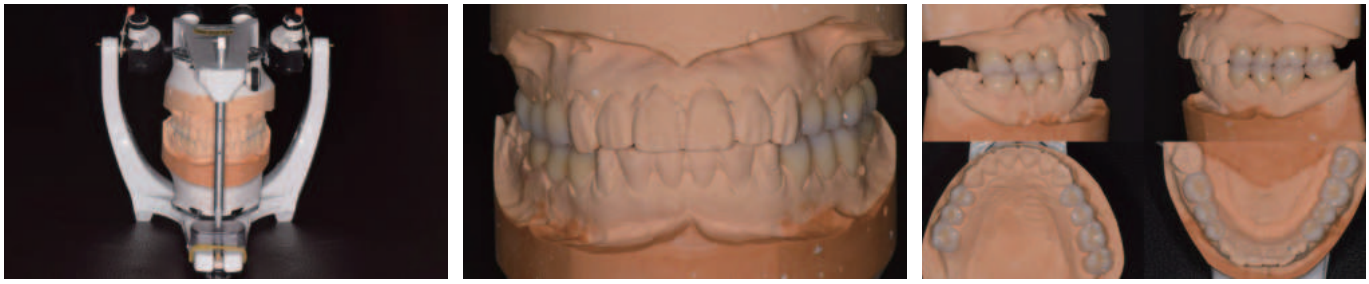


Fig. 35. The final zirconia crowns, each made as a single crown

10. Posterior crown setting : The molar crown was set, and the occlusal relationship and scheme were confirmed **(Fig. 36)**. Although fabricated in the same form as traditional provisional restorations, the properties of the provisional restoration and the final crown differ significantly, necessitating an occlusal check after placement. Following the initial occlusal evaluation, which includes the left and right posterior teeth, a re-evaluation of the mutual protective occlusion during lateral movements was conducted. A total of 14 crowns were set, but the actual chair time did not significantly differ from that of a single crown. They were placed in two stages: upper and lower right and upper and lower left.

When the patient returned 3 months after the molar crown placement, she reported significant improvement in her canine discomfort, although some awkwardness remained. Therefore, a canine-guided splint was then fabricated to protect the molar crown, enhance the patient's chewing pattern, and prevent involuntarily excessive force on the canine teeth during sleep.

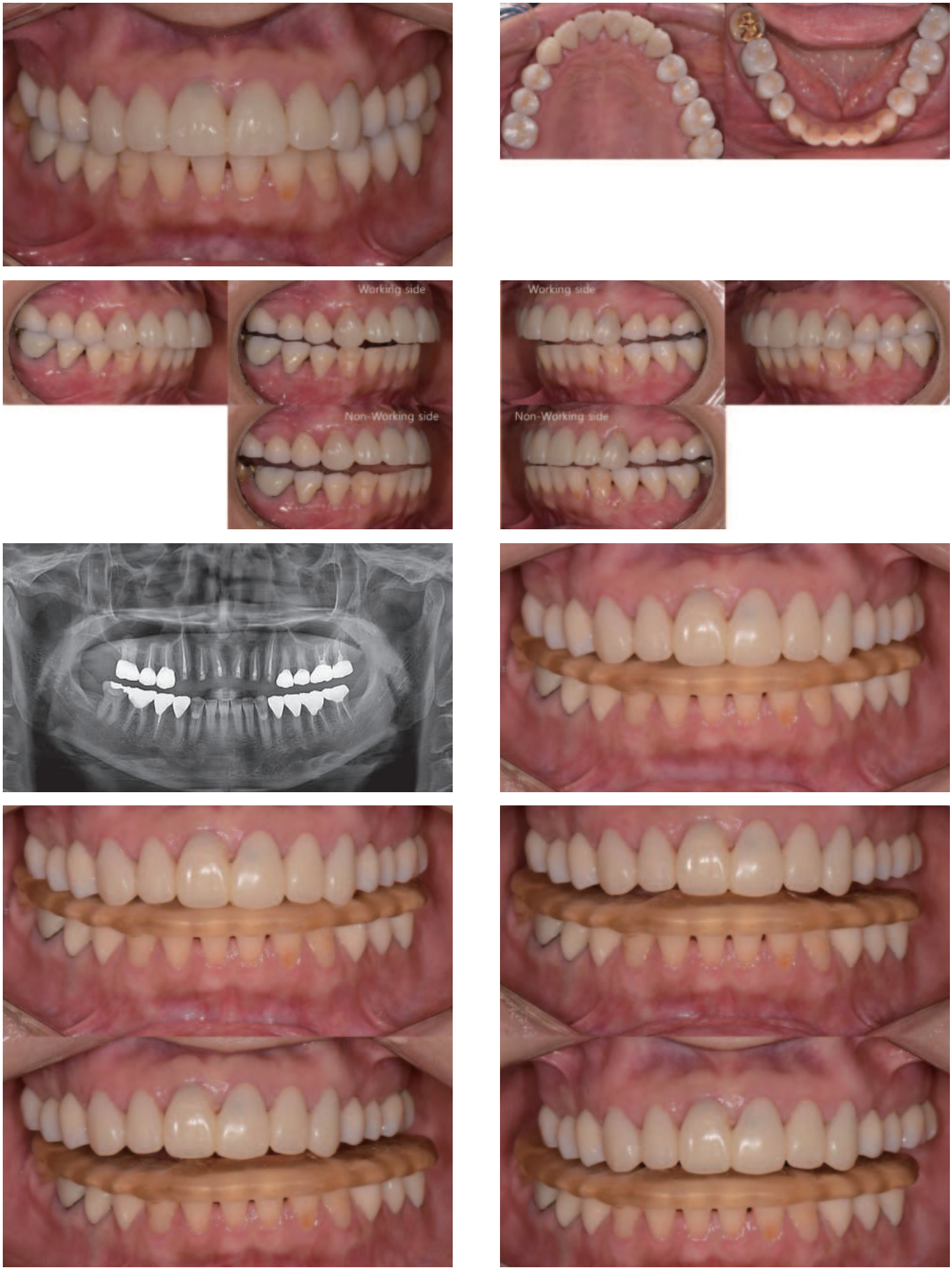


Fig. 36. Canine-guided splint designed to refine the occlusal scheme, improve the chewing pattern, and protect the restoration while the posterior zirconia crowns are in place

11. Fabrication of final crowns for the maxillary anterior teeth : The patient subsequently opted to have the #37 crown extracted due to tooth fracture and had an implant placed. Prior to treatment, the possibility of future extractions for teeth with minimal residual teeth was discussed. The patient reported no other complications with the root canal treatments on the remaining teeth, aside from intermittent discomfort. Therefore, a final crown was fabricated for the maxillary anterior teeth. After determining the desired shade, the impression was taken using VPS impression material **(Fig. 37)**.

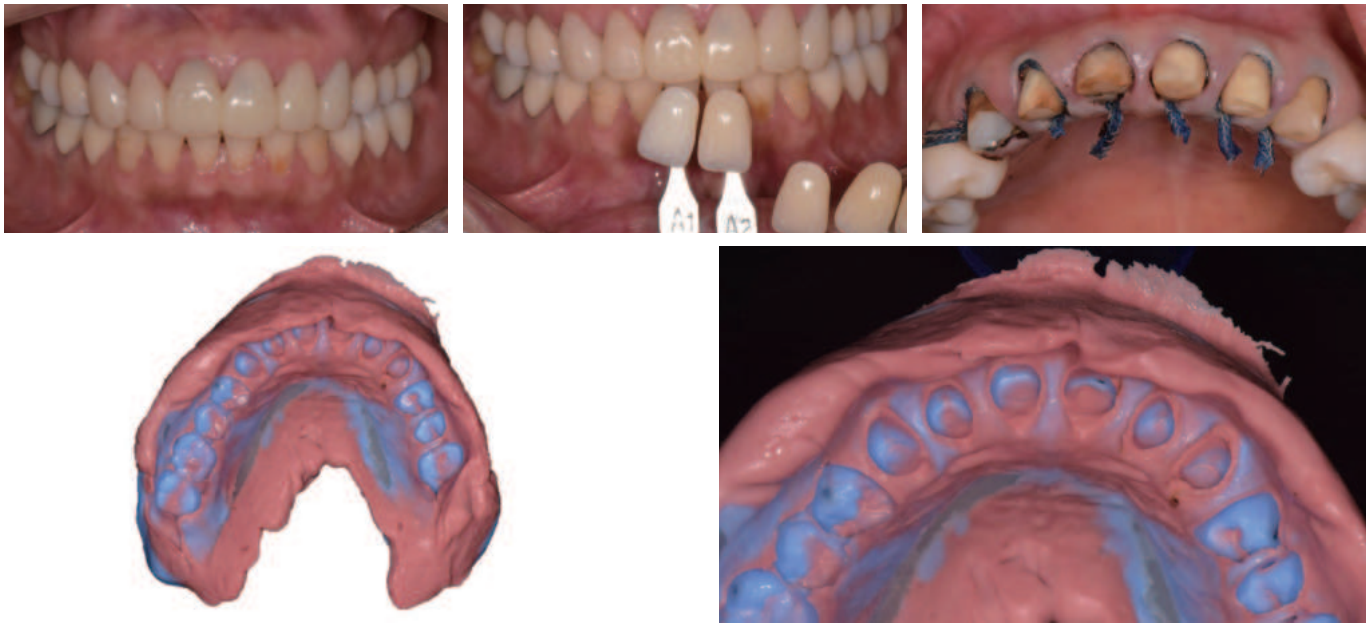
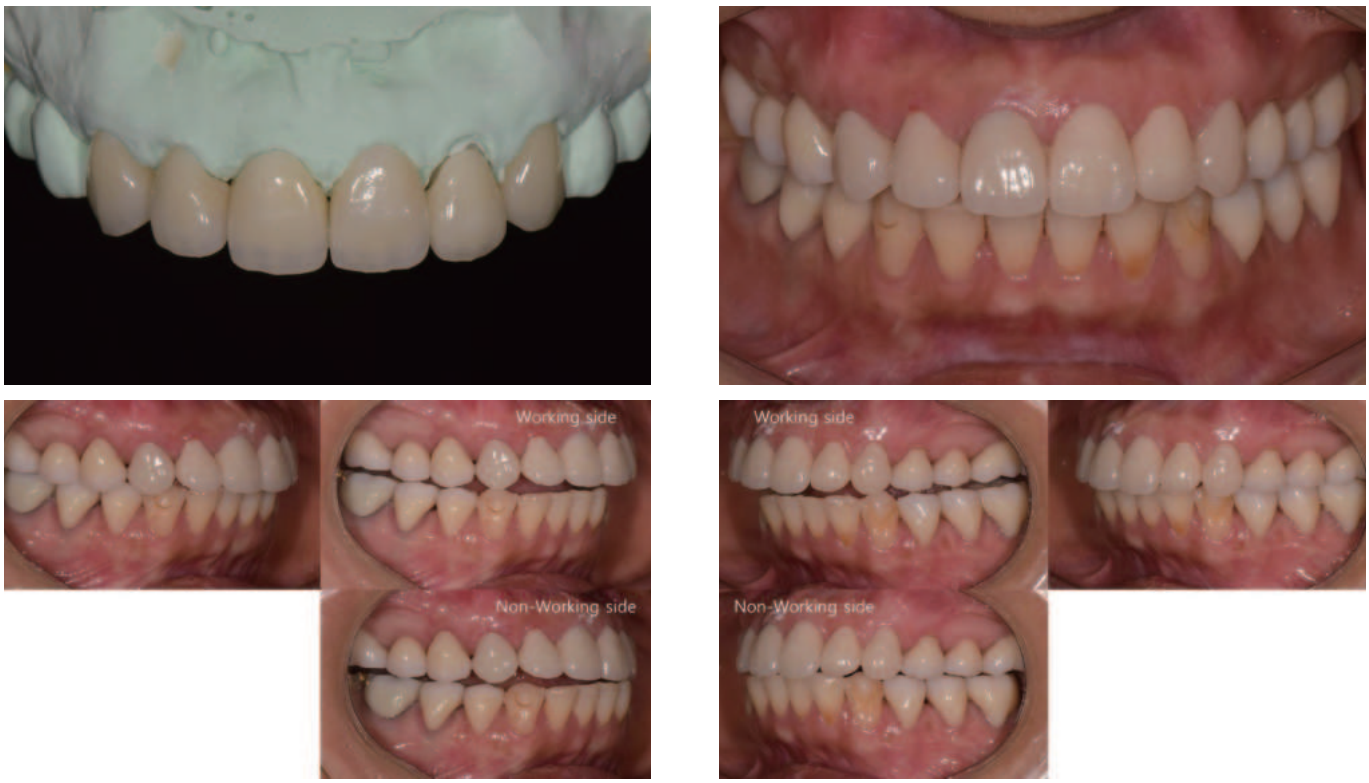


Fig. 37. Impressions taken for the fabrication of final zirconia crowns for the maxillary anterior teeth

12. Definitive crown fabrication and setting : Each single crown was fabricated using PFZ and set in place **(Fig. 38)**. The patient did not report any discomfort or aesthetic concerns regarding the definitive restorations. These restorations were designed based on the shape of the existing provisional restorations to maintain a mutually protective occlusion guided by the canines.



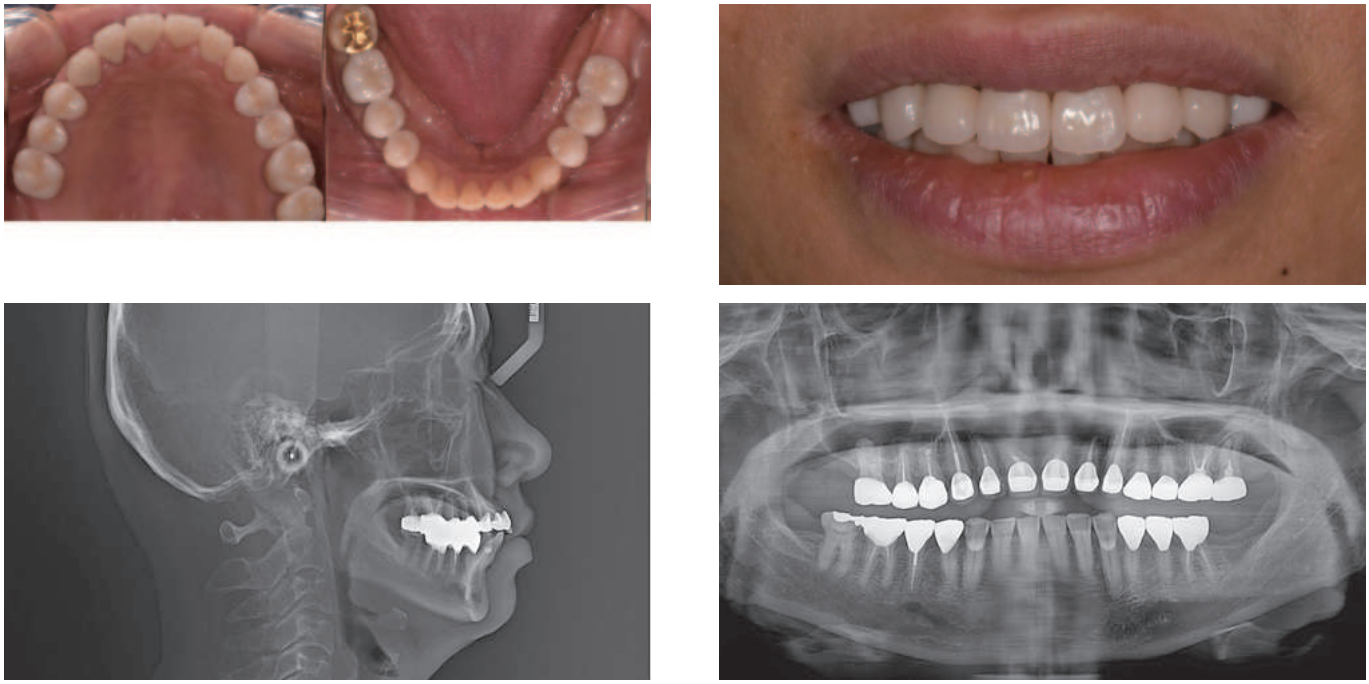


Fig. 38. Photographs of the oral cavity and radiographs after setting the final crowns for the maxillary anterior teeth

13. Routine follow-up :The #37 implant restoration treatment was completed, and the patient expressed satisfaction during the routine checkup 1 year after treatment. Due to the potential for teething and grinding habits, the splint was worn at night. At this stage, the patient was advised to maintain regular checkups and consistent oral care. If dental issues arise, necessitating implant or crown restoration, the patient's overall occlusal stability would ensure that the treatment can be effectively managed by any dentist.

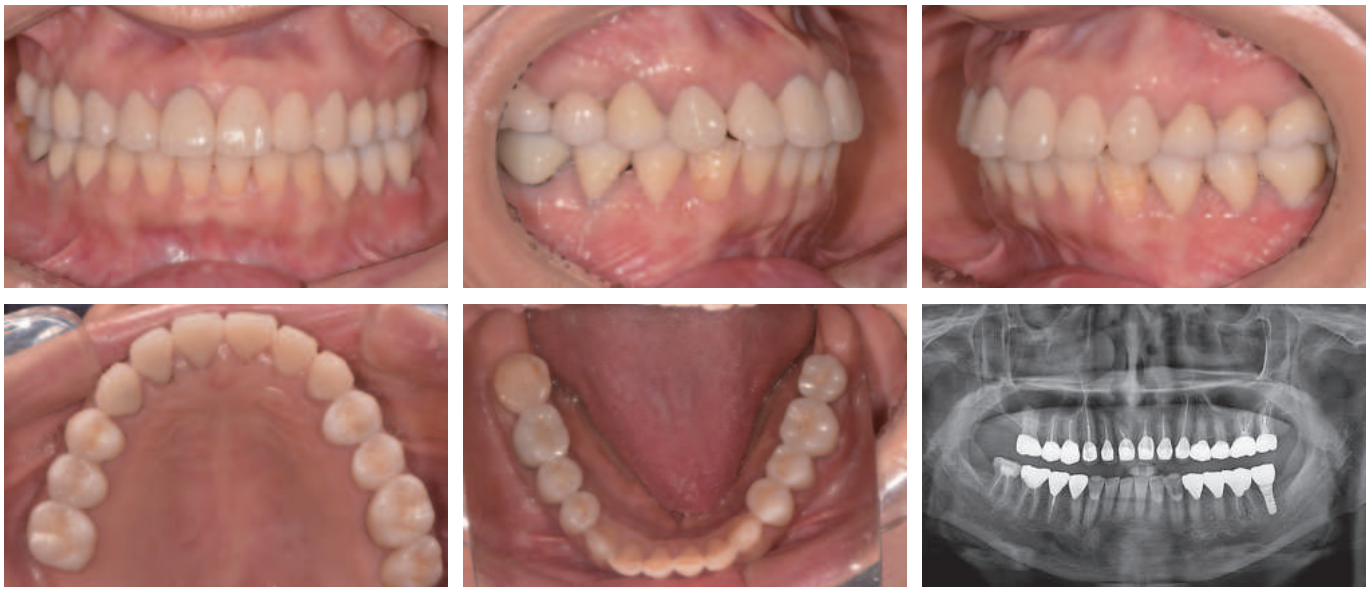


Fig. 39. Photographs of the oral cavity and panoramic radiograph 1 year after treatment

Conclusion

In full mouth rehabilitation, each treatment modality contributes to the long-term outcome. However, the determination of the vertical dimension of occlusion, the enhancement of the occlusal plane, and the determination and adaptation of the occlusal scheme through provisional restorations constitute the pivotal components of the comprehensive treatment process, as determined by the dentist. The initial step in this process is the determination of the appropriate vertical dimension of occlusion.

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1. Hobo S. Twin-tables technique for occlusal rehabilitation: part II - clinical procedures. J Prosthet Dent 1991;66(4):471-477. doi: 10.1016/0022-3913(91)90507-s.

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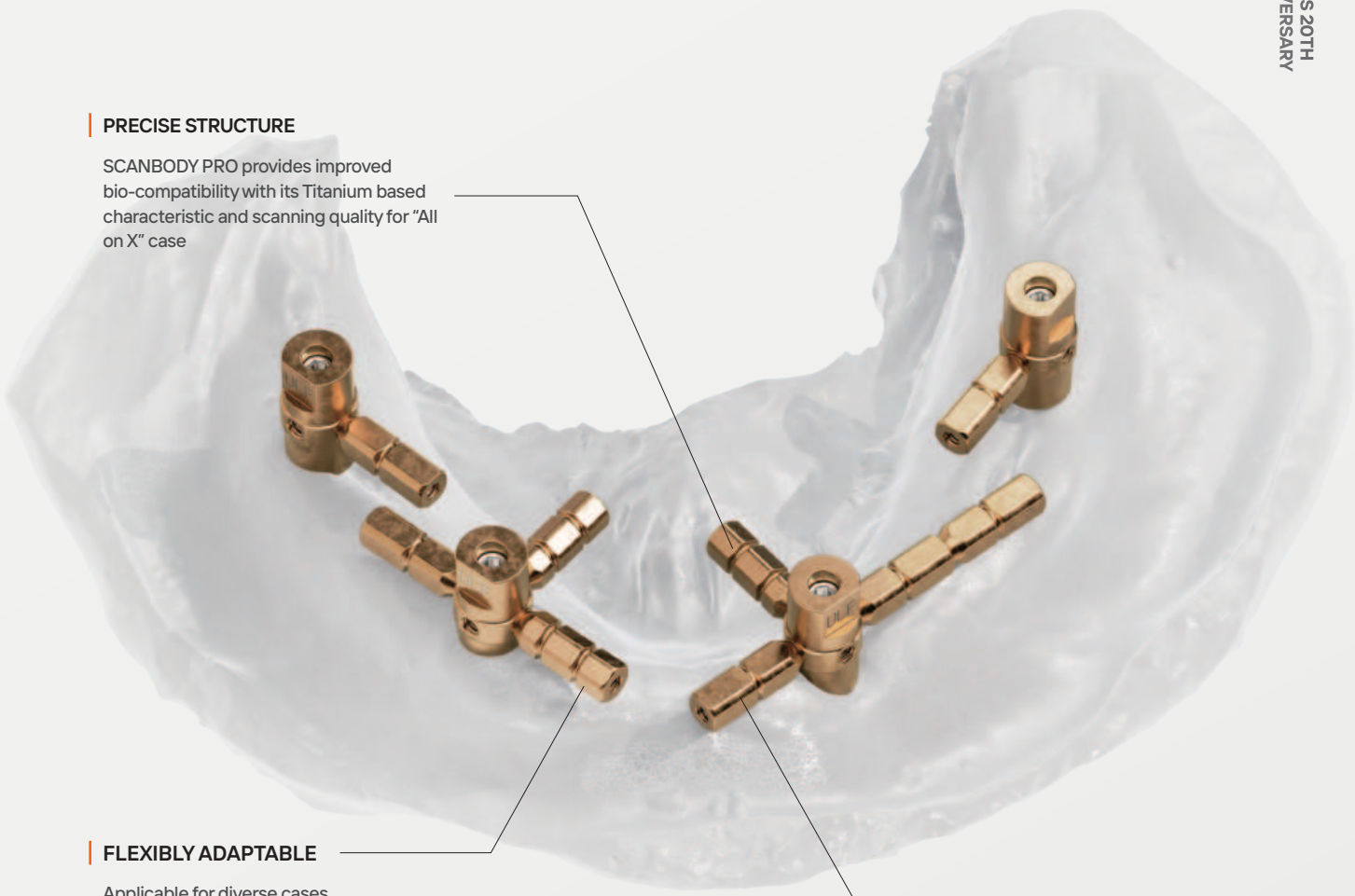

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Ultrasonography-Guided TMJ Injection : Case Report of Ultrasonography-guided TMJ Intra-articular Injection on Refractory pain in Osteoarthritis Patient

Sanghoon Cho, PhD

Introduction

Temporomandibular joint disorders (TMD), which are characterized by pain and functional impairments in the masticatory system, differ from diseases of the teeth, surrounding tissues, or oral mucosa in that clinicians cannot directly observe pathological changes in the tissues with the naked eye. This limitation increases the reliance on diagnostic imaging to observe and track such changes. Consequently, during the diagnosis and treatment of TMD, traditional radiographic modalities such as panoramic radiography, cone-beam computed tomography (CBCT), and, in some cases, magnetic resonance imaging (MRI) are utilized.

In addition to these well-established imaging modalities, advancements in technology have introduced newer imaging tools for the diagnosis and treatment of musculoskeletal conditions like TMD. One notable example of these newer tools is diagnostic ultrasonography.

Diagnostic ultrasonography is an important imaging modality that provides anatomical and pathological information about soft tissues and internal organs by utilizing sound waves, without exposing patients to ionizing radiation. Although initially used primarily in internal medicine, from around the year 2000 onward, its application has been actively expanded into rheumatology and other fields dealing with musculoskeletal disorders. More recently, there has been a growing interest in the field of dentistry regarding the use of diagnostic ultrasonography.

The expansion of ultrasonography's application, from its traditional use in internal medicine and obstetrics/gynecology to specialized fields dealing with musculoskeletal diseases, is largely attributable to technical advances in ultrasonography equipment. With the development and distribution of ultrasound machines offering much higher resolution than in the past, its clinical utility is expected to expand further.

SangHoon Cho

Dr. Cho is an adjunct professor of Dental College in Pusan National University . He is a specialist in Oral Medicine certified by the Korean Academy of Orofacial Pain and Oral Medicine. Dr. Cho is the director of Good-Jaw Dental Clinic in Ulsan. He authored several authoritative books, including "Clinical Pharmacology for Dental Practitioners", "Understanding TMDs for Dental Practitioners", "Understanding Iatrogenic Nerve Injury for Dental Practitioners", and "Clinical Laboratory for Diagnosing TMDs with Video Materials".

Ultrasonography produces diagnostic images by projecting sound waves generated by an ultrasound device into tissue, receiving the reflected waves after interaction with internal structures, and reconstructing them into images using specialized algorithms. It provides excellent information about soft tissues and, in the case of bone where sound waves are totally reflected and cannot pass through, it can still offer limited information about the outermost boundary of the skeletal structures **(Fig. 1)**.

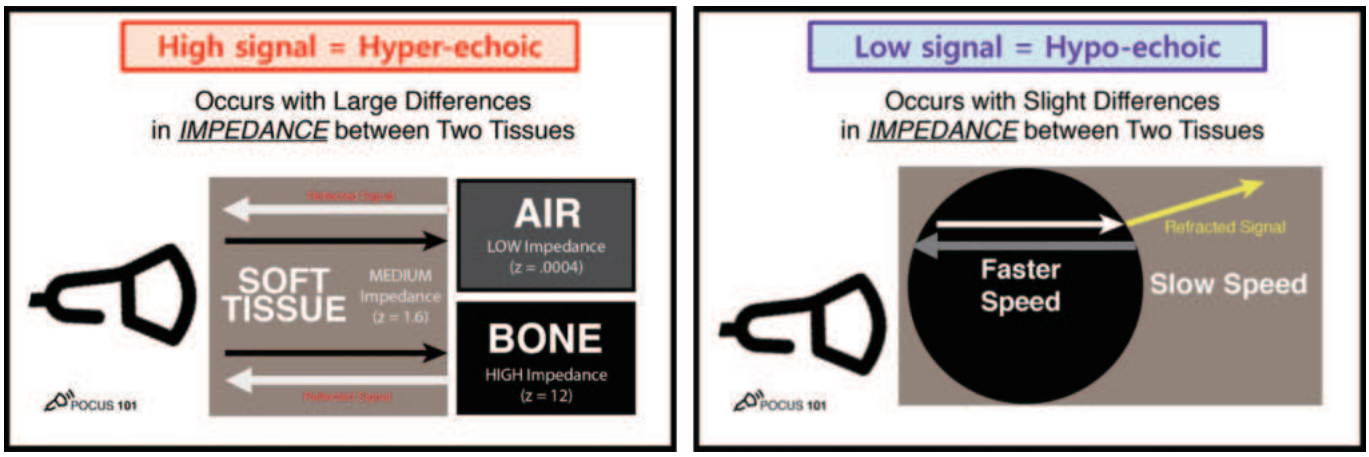


Fig. 1. Diagram of the Principle of Diagnostic Ultrasound Image Formation

Due to space limitations, we will not go into further detail about the principles of diagnostic ultrasonography here. Those interested are encouraged to consult specialized literature for more in-depth information.

In the field of dentistry, ultrasonography has previously been explored, particularly in periodontology, for the measurement of gingival thickness and periodontal pocket depth. Diagnostic devices employing ultrasound have been developed and used for these purposes. More recently, manufacturers of ultrasound equipment have developed intraoral probes to enhance accessibility within the oral cavity. However, the routine use of diagnostic ultrasonography in dentistry faces clear limitations. The oral cavity lacks large, well-defined soft tissue organs, and structures such as the alveolar and palatal bones are covered by relatively thin mucosal tissue. As a result, there are only a few conditions that can be effectively diagnosed or evaluated using ultrasonography in the oral environment.

In contrast, in cases of temporomandibular joint disorders (TMD), diagnostic ultrasonography proves to be a valuable imaging modality. It provides important information about the musculoskeletal components of the masticatory system—information that is not easily obtained with conventional imaging techniques. Beyond its diagnostic value, ultrasonography also offers real-time imaging capabilities that can guide interventional procedures, such as ultrasound-guided intra-articular injections. This real-time functionality significantly enhances its clinical utility in managing TMD**(Fig. 2)**.

Fig. 2. Diagnostic Ultrasonography equipment in my clinic

When diagnostic ultrasonography is applied to the diagnosis of temporomandibular joint disorders (TMD), it is clinically useful for assessing early signs of osteoarthritis, such as capsular distension caused by intra-articular effusion, inflammatory changes and hypertrophy of the synovial membrane, cortical erosion, and the formation of osteophytes. These diagnostic benefits have been widely recognized by rheumatology societies. In addition, when applied to muscles, ultrasonography allows for accurate measurement of muscle thickness and the evaluation of intramuscular injuries such as tears or hematomas. In recent years, ultrasound resolution for muscle imaging has even been reported to surpass that of MRI.

Given the wide range of diagnostic benefits, a single clinical column is insufficient to fully convey the usefulness of ultrasonography for TMD, and a more detailed discussion is warranted in a future installment.

One of the greatest advantages of diagnostic ultrasonography is that it exposes the patient to no radiation, making it highly accessible for outpatient use. Furthermore, its ability to provide dynamic, real-time imaging of the target tissues enables its use in non-invasive interventional procedures.

A representative example of such non-invasive interventions is the ultrasound-guided intra-articular injection. This method has long been used in the treatment of inflammatory joint diseases. Although numerous studies have reported positive clinical outcomes from intra-articular injections for these conditions, there are also studies that raise questions about their efficacy. However, most of the previous research employed traditional blind techniques, such as anatomic landmark-guided injections, which do not allow verification of whether the injection was accurately placed within the joint space. Therefore, clinical evaluations of the injected medication or of the injection procedure itself, when the intra-articular delivery is not confirmed, are fundamentally flawed.

In a 2019 cadaveric study by Cha et al. (Int J Oral Maxillofac Surg, 2019;48:540–545), the accuracy of traditional versus ultrasound-guided intra-articular injections into the temporomandibular joint was assessed. The success rates for the traditional landmark-guided injections were 80% for the superior joint space and 30% for the inferior joint space. In contrast, the success rates for ultrasound-guided injections were 100% and 90%, respectively. This clearly demonstrates the limitations of the traditional technique, especially for accessing the lower joint compartment, where the accuracy was clinically unreliable. Conversely, ultrasound-guided intra-articular injections demonstrated a high success rate, even in the lower joint compartment.

Although the study was conducted on cadavers, where postmortem tissue rigidity may differ from living tissues, in clinical practice the needle is inserted only after confirming in real time that it has entered the joint space. Therefore, once the intra-articular placement is confirmed under ultrasound, the injection can be regarded as almost certainly successful.

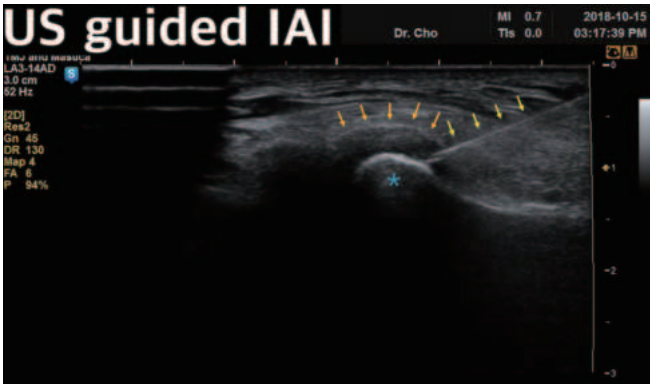


Fig. 3. Intra-articular injection: Yellow arrow (needle), orange arrow (joint capsule), asterisk (mandibular condyle)

Due to the significantly higher success rate of intra-articular injections, ultrasound-guided intra-articular injection has become the standard method in specialized fields such as rheumatology and rehabilitation medicine for the treatment of musculoskeletal disorders.

Despite the active and widespread clinical application of diagnostic ultrasonography in these medical specialties, its use in dentistry—particularly in the treatment of temporomandibular joint disorders (TMD)—remains limited. Although several domestic universities in Korea have recently begun adopting diagnostic ultrasonography for the evaluation of TMD, the application of ultrasound in interventional procedures, such as ultrasound-guided intra-articular injections, is still extremely rare. This scarcity is not limited to Korea but is also observed globally, as evidenced by the lack of related articles in dental literature and journals.

While there are indeed pioneering studies within dentistry that explore the diagnostic value of ultrasonography for TMD, they are few in number compared to other dental fields. Therefore, it is naturally difficult to expect widespread clinical reports on the use of non-invasive interventional procedures guided by ultrasonography in dentistry.

The following is a summary of clinical research identified through a PubMed search using the keyword "Ultrasonography guided TMJ Injection" **(Fig. 4)**.

Fig. 4. Result of Pubmed search using Ultrasonography guided TMJ Injection

The number of clinical studies identified through PubMed on this topic is extremely limited. Among those that do exist, the vast majority focus on temporomandibular joint (TMJ) involvement in patients with juvenile idiopathic arthritis (JIA) and are primarily conducted by medical professionals in rheumatology and pediatrics, rather than by dental researchers or clinicians. There is a near-total absence of such studies authored by individuals from the dental field.

Even when using alternative search engines or different keywords, the results are unlikely to vary significantly.

However, interest and research into the use of diagnostic ultrasonography for TMD within dentistry are steadily increasing. Furthermore, there are emerging developments within South Korea indicating that this trend is gaining momentum domestically as well. As such, it is anticipated that reports on both the diagnostic use of ultrasonography for TMD and its application in non-invasive interventional procedures will grow substantially in the near future.

The author of this article operates a facial pain clinic in Ulsan, which primarily serves patients with TMJ disorders. Since 2016, the clinic has employed diagnostic ultrasonography equipment (Model No.: Samsung Medison H60) and a linear probe (Model No.: LA3-14AD) (see Fig. 2) for the active diagnosis and treatment of TMD. The author now aims to introduce clinical cases in which ultrasound-guided intra-articular injections were used to successfully treat refractory TMD patients.

Case Report

[Case 1]

In 2016, a 40-year-old female patient visited our clinic with chief complaints of left-sided jaw pain, limited mouth opening, and changes in occlusion. She reported experiencing pain in the temporomandibular joint area for approximately 4 to 5 years. Two years prior, she had been diagnosed with rheumatoid arthritis due to shoulder joint pain and was taking medications related to this condition at the time of her visit **(Fig. 5)**.

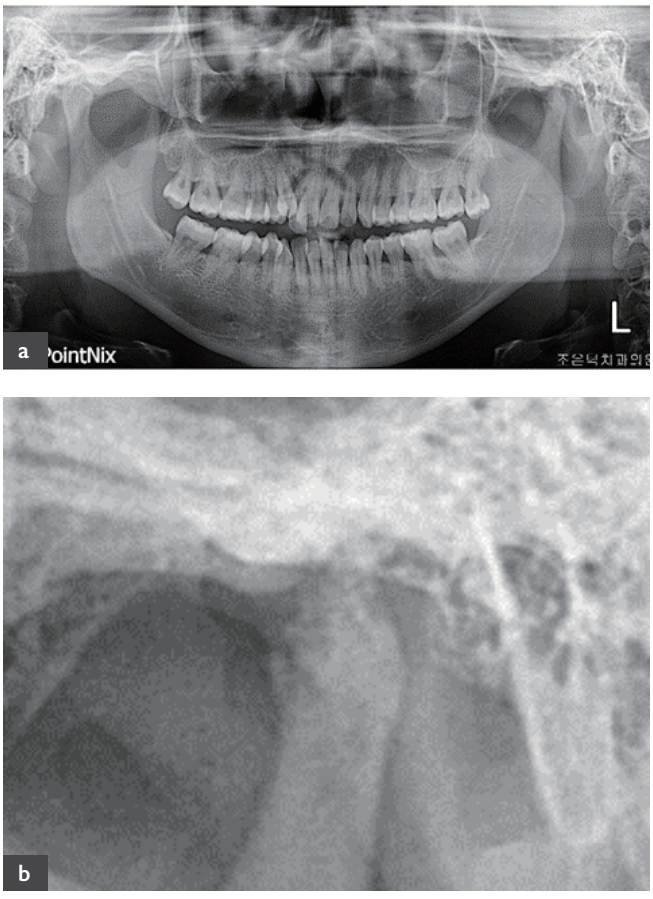


Fig. 5a-b. Initial panoramic radiograph and magnified view of the left mandibular condyle revealed resorptive bony changes in the left condylar head.

To alleviate the patient's symptoms, a custom intraoral appliance was fabricated. On the day the appliance was delivered, an ultrasound-guided intra-articular injection was administered to the right temporomandibular joint. When the patient returned one month after the injection, she reported that the jaw pain had almost completely subsided.

She did not return until March 20, 2019, at which point she presented with recurrent pain in the left TMJ. During the intervening period, she had undergone anterior maxillary orthodontic treatment, which rendered the previously fabricated appliance incompatible, and thus, she had been unable to wear it.

One week after the second visit, the patient returned to have a new appliance fabricated, reporting that post-injection pain had decreased by approximately 80%, allowing her to eat normally with only minimal residual discomfort.

Following appliance delivery, she did not return until October 28, 2020, this time complaining of right-sided jaw pain. She stated that she had not been wearing the appliance regularly. On that visit, another ultrasound-guided intra-articular injection was administered to the right TMJ.

Two weeks after the injection, she returned for follow-up and reported that her pain had decreased by about 70%. Since then, she has not returned to the clinic.

The following images show coronal CBCT views of the left TMJ taken during follow-up after the initial visit **(Fig. 6)**.

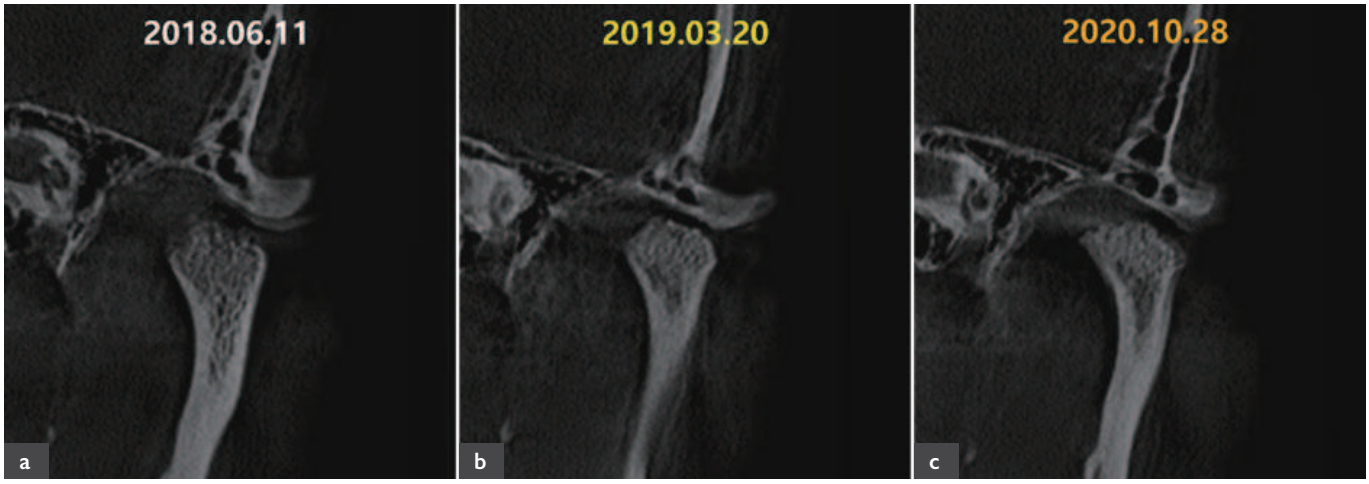


Fig. 6a-c. Follow-up CBCT Series of Left Condyle

[Case 2]

On June 19, 2020, a 71-year-old female patient presented with complaints of pain in the right jaw and limited mouth opening. Her symptoms had persisted for approximately four years, and for the past two years, she had been receiving treatment at the oral and maxillofacial surgery department of a university hospital. Despite undergoing three arthrocentesis procedures for pain control, her symptoms remained unresolved. When she was recommended for TMJ surgery, she sought alternative treatment options and visited our clinic.

Clinical examination revealed an active maximum mouth opening of 23 mm and a passive maximum opening of 30 mm. CBCT imaging showed cortical erosion and resorptive bony changes in the lateral and medial thirds of the right mandibular condyle **(Fig. 7)**.

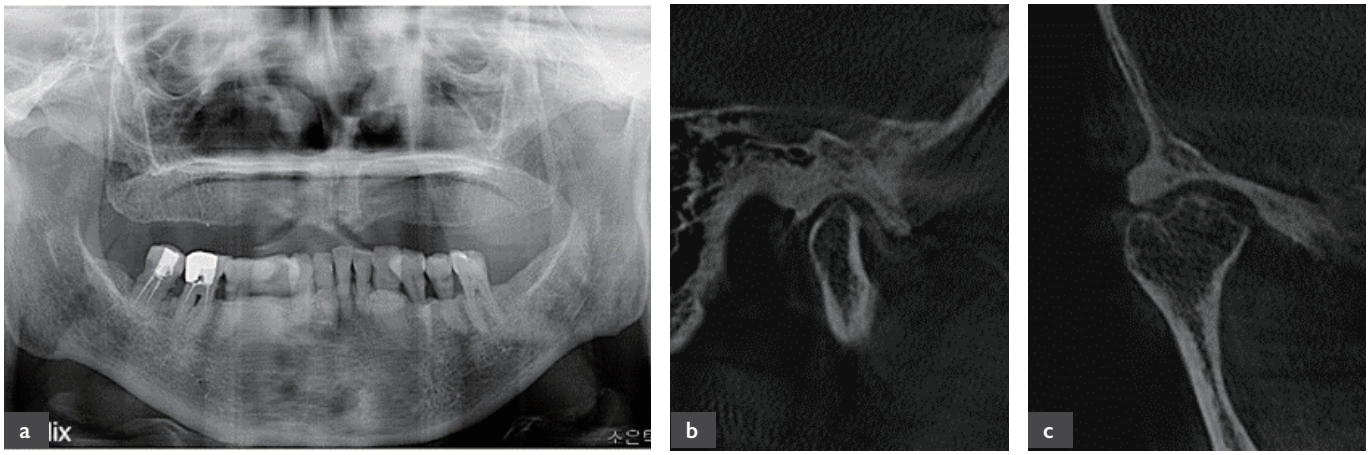


Fig. 7a-c. Panorama, CBCT images of Right Condyle at first visit

To manage the patient's pain, an intraoral appliance was fabricated and delivered, and pharmacological treatment was initiated. However, despite taking nonsteroidal anti-inflammatory drugs (NSAIDs) for 31 days, there was no significant improvement in her symptoms. Therefore, on July 29, 2020, an ultrasound-guided intra-articular injection was administered to the right TMJ.

By the second week after the injection, the patient reported a dramatic improvement in pain—over 90% relief. She remained symptom-free until September 11, 2020, when pain recurred on the right side. Although NSAIDs were prescribed again, they provided little benefit, so a second intra-articular injection was performed on September 21, 2020.

Compared to the first injection, pain relief from the second injection was slower, but by the fourth week, the patient experienced an 80% reduction in pain, with gradual and definite improvement noted over time.

She remained pain-free until May 12, 2021, when right TMJ pain recurred. A third injection was performed on May 20, 2021. After this injection, the patient's pain gradually improved, and by the third week, she reported over 90% pain relief. Since then, no further episodes of TMJ pain have occurred **(Fig. 8)**.

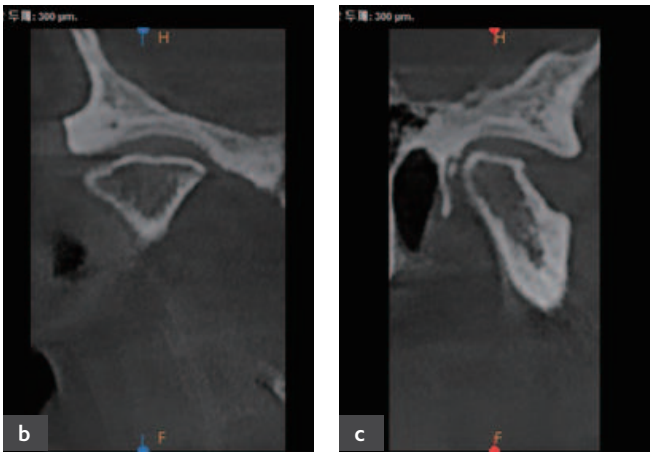
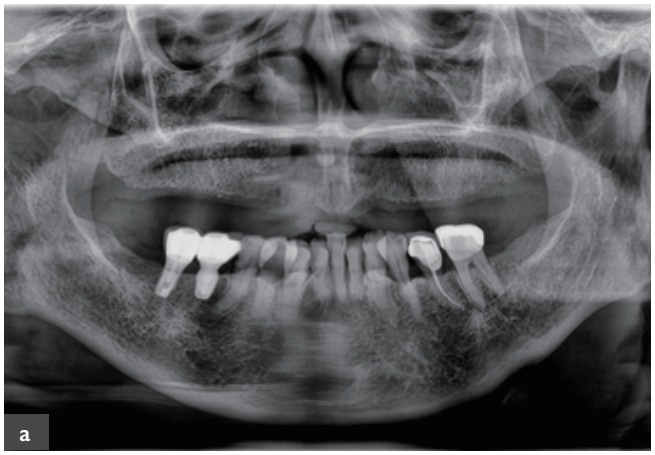


Fig. 8a-c. 2023.06.15 Follow-up Images



Discussion

Intra-articular injections have long been used to manage symptoms of musculoskeletal disorders associated with inflammatory changes within joints, such as osteoarthritis and rheumatoid arthritis. Commonly used medications for intra-articular injection include corticosteroids and hyaluronic acid, while other agents such as platelet-rich plasma (PRP) and mesenchymal stem cells (MSCs) cultured from adipose tissue or other sources are being explored on an experimental basis.

In the author's clinical experience, since the introduction of diagnostic ultrasonography in 2016, intra-articular injections have been actively employed to treat refractory cases of osteoarthritis and rheumatoid arthritis involving the TMJ that are unresponsive to conventional conservative treatments (e.g., pharmacotherapy, physical therapy, and intraoral appliances). Initially, both corticosteroids and hyaluronic acid were used for these injections. However, based on observed clinical outcomes, corticosteroids demonstrated superior efficacy in controlling refractory joint pain. As a result, the author now uses only corticosteroids for intra-articular TMJ injections, based on this clinical judgment.

There are several considerations related to TMJ intra-articular injections, including the questions: "Which compartment should be injected, with what medication, and using what technique?"

First, regarding the medication: Corticosteroid preparations for intra-articular injection may be soluble or insoluble. Most corticosteroids used in these settings are esters, which are highly insoluble in water and thus form microcrystalline suspensions. In contrast, dexamethasone preparations are non-ester and freely soluble in water, appearing as a clear (nonparticulate) solution.

The potential advantage of corticosteroid esters lies in their pharmacokinetics: they require hydrolysis by cellular esterases to release the active drug, allowing the agent to remain longer in the joint compared to soluble, non-ester preparations.

The author currently uses the corticosteroid ester triamcinolone acetonide for TMJ intra-articular injections **(Fig. 9)**.

Fig. 9. Injectable Triamcinolone acetonide

A study by Jean-Pierre Raynauld et al. (2003) titled "Safety and Efficacy of Long-Term Intraarticular Steroid Injections in Osteoarthritis of the Knee: A Randomized, Double-Blind, Placebo-Controlled Trial" (Arthritis & Rheumatism, Vol. 48, No. 2, February 2003, pp. 370–377), demonstrated that administering corticosteroid intra-articular injections at intervals of at least three months resulted in no significant adverse events.

Based on such findings, corticosteroid injections—when administered at appropriate intervals—can be considered a very safe treatment modality. In fact, their biological safety profile is so well established that corticosteroids are now used confidently even in the treatment of juvenile idiopathic arthritis (JIA) in children and adolescents.

When it comes to injection techniques for intra-articular therapy, there are two primary approaches: In-plane technique vs. Out-of-plane technique **(Fig. 10)**.

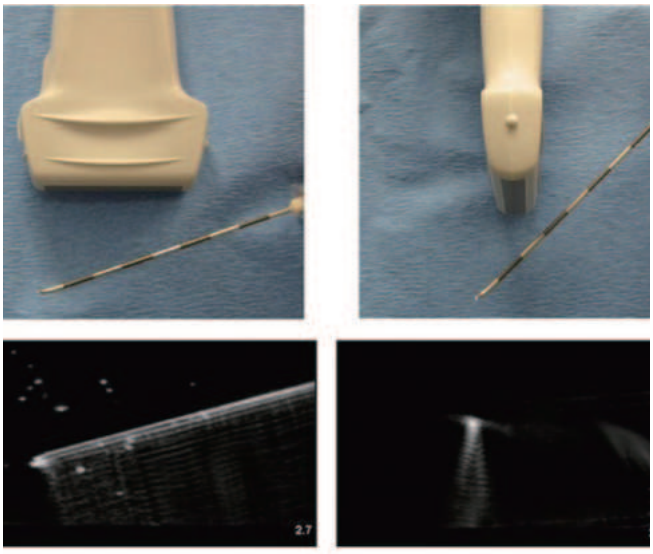


Fig. 10. In-plane technique(Left) vs. Out-of plane technique(Right)

In addition to their clinical efficacy, the potential side effects of corticosteroid intra-articular injections have long been a subject of interest. Numerous adverse effects associated with corticosteroids used in joint injections are well documented. However, with proper use and careful dosing, these side effects can be effectively minimized.

The "out-of-plane technique" involves inserting the injection needle perpendicularly to the direction of the ultrasound waves emitted by the probe (as shown in the figure). In this approach, the needle appears on the ultrasound image as a round cross-sectional view, making it relatively easy to identify the presence of the needle. However, because only a portion of the needle is visible on the screen, it is not possible to accurately determine the location of the needle tip.

In contrast, the "in-plane technique" involves advancing the needle parallel to the ultrasound beam. On the ultrasound image, the needle appears as its entire longitudinal shaft, allowing for precise visualization of the needle tip's position. This accuracy is crucial for confirming successful intra-articular injection. Therefore, the in-plane technique is fundamentally preferred for TMJ injections. However, because the needle must be kept precisely aligned within a narrow ultrasound beam (usually less than 1 mm in thickness), achieving consistent and accurate needle placement requires training and practitioner proficiency.

In the author's practice, the in-plane technique is used to inject corticosteroids into the lower joint space of the TMJ, where the mandibular condyle is located. The needle is advanced from an inferior to superior direction, and its correct placement below the lateral pole of the mandibular condyle is confirmed in real-time using ultrasound before injection is performed.

Another essential consideration is which joint compartment to inject. The TMJ is unique among synovial joints in that its internal space is divided into superior and inferior compartments by the articular disc. This raises the question of whether the superior or inferior joint space should be targeted.

A well-known procedure for intra-articular injection in TMD patients is TMJ arthrocentesis, which typically targets the superior joint space using anatomic landmarks. However, the mandibular condyle resides in the inferior joint space. Recognizing this, the author adopted ultrasound guidance to ensure that medication is delivered accurately to the inferior compartment, especially in cases involving direct condylar pathology.

While issues like a "stuck disc" may originate in the superior joint space, effective intervention for condylar involvement necessitates delivering medication to the inferior space. Therefore, ultrasound-guided TMJ injection into the lower compartment may offer greater therapeutic effectiveness than superior joint-targeted arthrocentesis.

Although it may be anecdotal, the author cautiously speculates that the dramatic response observed in Case 2, where the patient failed to improve after three sessions of TMJ arthrocentesis but responded positively to ultrasound-guided lower joint injection, supports this notion.

Since adopting diagnostic ultrasound in 2016, the author has performed more than 300 ultrasound-guided intra-articular TMJ injections using the in-plane technique. A clinical manuscript is currently being prepared based on this raw data. Although the study has limitations—such as the absence of formal statistical analysis and a control group—preliminary data show a pain control success rate of approximately 95% in patients with refractory osteoarthritis or rheumatoid arthritis who did not respond to conventional conservative treatments.

While the results are early and should be interpreted with caution, this approach has significantly reduced the stress of managing difficult TMJ cases in clinical practice.

Given the growing understanding of the biological mechanisms underlying osteoarthritis and other joint diseases, and the ongoing development of various injectable agents for intra-articular therapy, the ability to perform ultrasound-guided TMJ injections represents a highly promising therapeutic option with a bright clinical future.

Reference

1. Cha et al. "Ultrasound-guided versus blind temporomandibular joint injections: a pilot cadaveric evaluation" Int J Oral Maxiloofac Surg, 2019;48:540-545

2. Jean-Pierre Raynauld et al." Safety and Efficacy of Long-Term Intraarticular Steroid Injections in Osteoarthritis of the Knee, A Randomized, Double-Blind, Placebo-Controlled Trial"(ARTHRITIS & RHEUMATISM Vol. 48, No. 2, February 2003, pp 370–377)

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Efficacy of Ultrasound-Guided Prolotherapy with PDRN in Patients with Chronic Temporomandibular Joint Pain

Hyunok Yoon, DDS
Yongil Cho, DDS

Introduction

In the treatment of temporomandibular joint (TMJ) disorders, injections are among the most established modalities. These injections may include substances that enhance joint lubrication, such as hyaluronic acid, and anti-inflammatory properties, such as corticosteroids. Furthermore, biostimulant injections into damaged joints have demonstrated regenerative effects in the affected area. High-concentration dextrose (10% to 20%) has historically been the most commonly used agent for this type of prolotherapy.

More recently, injectable agents such as platelet-rich plasma (PRP), whole blood, placenta extract, and polydeoxyribonucleotide (PDRN) have also been employed. This study aims to introduce prolotherapy using PDRN, which has recently gained significant attention in Korea.

Hyunok Yoon

Dr. Yoon graduated from Chosun University College of Dentistry in 2002. He is a board-certified specialist in integrative dentistry and serves as a clinical adjunct professor at Chosun University. He is currently the president of the Prolotherapy TMJ Research Society and the director of Woori Dental Clinic in Ulsan, Korea. He is the co-author of the book Clinical TMJ Prolotherapy, published in March 2024.

Yongil Cho

Dr. Cho graduated from Chosun University College of Dentistry in 2007. He is a board-certified specialist in integrative dentistry. He currently serves as a clinical adjunct professor at Chosun University and was a visiting fellow in the Department of Periodontics and Prosthodontics at Texas A&M University (2017–2019). He is the secretary general of the Prolotherapy TMJ Research Society and the director of Welcome Dental Clinic in Ulsan, Korea. He is also the co-author of Clinical TMJ Prolotherapy, published in March 2024.

What is PDRN?

PDRN stands for polydeoxyribonucleotide. It is a DNA fragment extracted from the genital organs of salmon or trout and purified into specific molecular units to facilitate absorption by the human body.

PDRN was developed approximately 50 years ago by Mastelli, an Italian pharmaceutical company, under the drug name Placentex. It was initially used to promote wound healing in trauma patients. Over time, its application expanded in dermatology, where it is now commonly used for wrinkle reduction, burn recovery, pigmentation control, skin whitening, and improvement of acne scars owing to its skin-healing properties. PDRN is also known to support tissue regeneration when injected into damaged areas such as ligaments, tendons, and cartilage.

It is widely used in orthopedics and rehabilitation to alleviate pain and restore function within the musculoskeletal system.

Although PDRN is relatively unfamiliar in dentistry, its regenerative properties have recently led to its introduction in the management of TMJ disorders and periodontal diseases.

The in vivo activity of PDRN is well documented in the scientific literature. When injected, PDRN binds to adenosine A2a receptors on human cells, initiating various physiological cellular responses **(Fig. 1).**

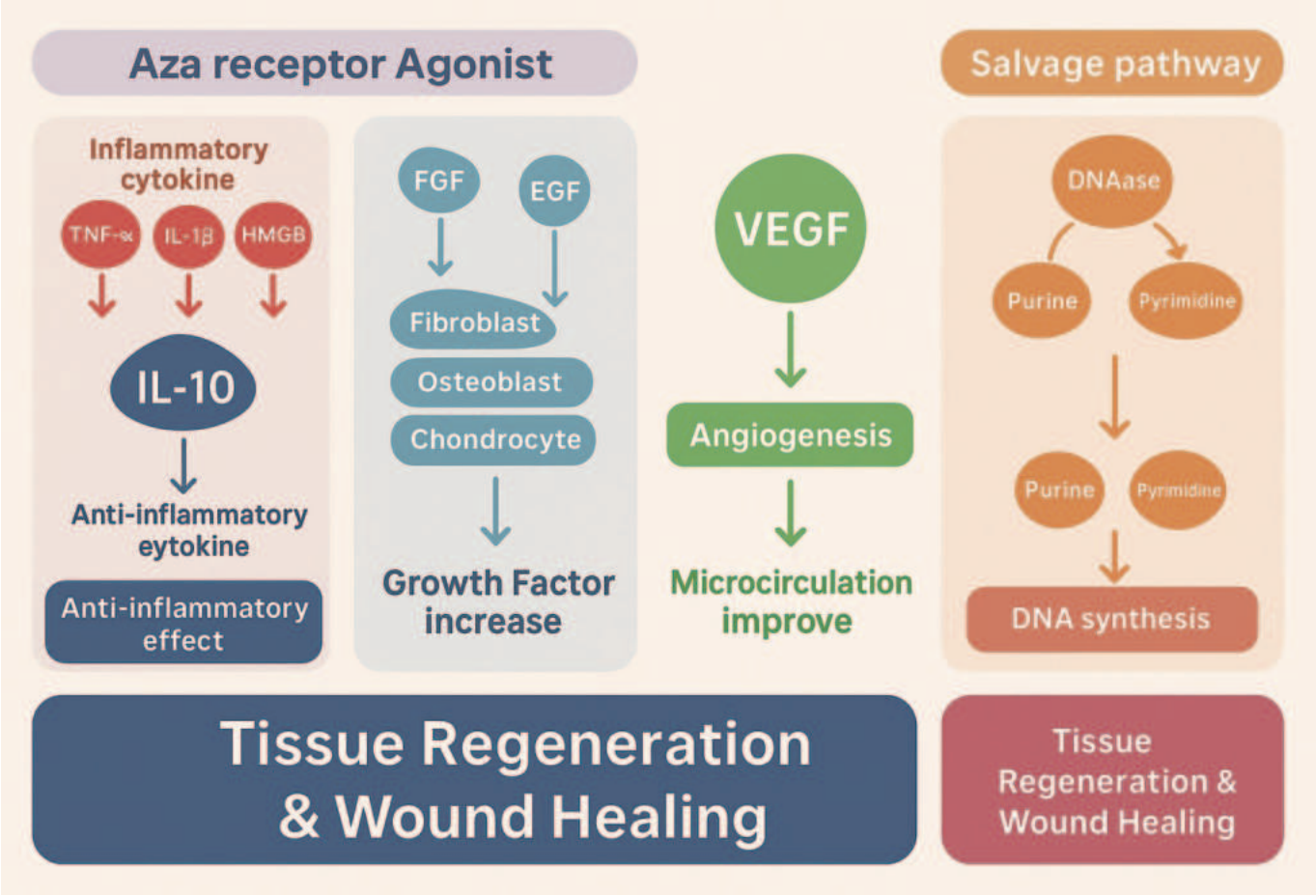


Fig. 1. PDRN exhibits several pharmacological actions by acting on the A2a receptor in humans and promotes DNA synthesis required for tissue regeneration through the salvage pathway.

1. PDRN suppresses inflammation by inhibiting the production of pro-inflammatory cytokines (tumor necrosis factor alpha [TNFα], high mobility group box [HMGB1], interleukin 6 [IL-6]) and promoting the secretion of anti-inflammatory cytokines such as interleukin-10.

2. It stimulates the release of various growth factors that promote the aggregation of regenerative cells, including fibroblasts, osteoblasts, chondrocytes, and myofibroblasts.

3. It enhances angiogenesis by inducing the release of vascular endothelial growth factor (VEGF), which contributes to improved short- and long-term outcomes in tissue regeneration.

4. PDRN is a pharmacological agent derived from DNA fragments. Its genetic components are directly involved in tissue repair, serving as substrates for nucleic acid synthesis in regenerating tissues.

While several agents are known to induce tissue regeneration, another reason PDRN is gaining traction is its recognized clinical efficacy and excellent safety profile. Pharmacologically, PDRN can be administered regardless of age or gender and is not contraindicated in pregnant women. It has not been associated with adverse events in patients with chronic conditions such as diabetes and hypertension. Due to its minimal interaction with concurrently administered medications, PDRN can be used safely in patients on polypharmacy regimens. Moreover, it is not known to cause significant adverse events even when inadvertently injected into the bloodstream.

Recently, the application of PDRN in dentistry has increased, particularly in Korea. Clinicians have begun using PDRN in the management of periodontal diseases, peri-implantitis, and chronic TMJ disorders, with several clinical case reports supporting its use. However, because most of these cases lack long-term follow-up data, further research is necessary to establish its efficacy and safety in dental practice.

Case Report

Study on injection therapy for patients with chronic TMJ disorders

This study aims to present two clinical injection treatment methods for patients with chronic TMJ disorders and to compare their outcomes. The first method involves injecting high-concentration dextrose into the affected TMJ area. The second method involves injecting a combination of high-concentration dextrose and PDRN. A total of 40 patients were included in the clinical study. Of these, 20 patients (Group 1) were treated with high-concentration dextrose, while the remaining 20 patients (Group 2) received the combination of high-concentration dextrose and PDRN.

Patients with chronic TMJ pain were selected for both treatments based on the following criteria. These criteria were applied consistently to both Group 1 and Group 2.

· Individuals with TMJ-related pain persisting for more than a few months

· Individuals with multiple recurrent episodes of TMJ pain over the past few years

· Individuals who experienced a single episode of TMJ pain that did not resolve with medication, physical therapy, or splint therapy

· Individuals referred from another hospital for TMJ treatment due to a lack of improvement

· Individuals with severe pain radiating to the head, neck, or shoulders

· Individuals showing pronounced osteophytic changes around the TMJ on radiographs, accompanied by pain

· Individuals with TMJ sounds and mandibular deviation on mouth opening

· Individuals with painful or habitual dislocations that impair jaw opening

· Individuals with significant occlusal changes coinciding with the onset of TMJ symptoms

Patients presenting with these symptoms were included in the study. In contrast, individuals with mild pain, a limited range of pain, or pain that responded to medication or physical therapy were excluded.

Clinical procedures

While several injectable agents have been used to treat TMJ disorders, this study compares the clinical outcomes of two agents: high-concentration dextrose and PDRN.

The first agent, high-concentration dextrose, is typically administered as a 10% to 20% solution when applied to the musculoskeletal system. When injected into the cellular environment surrounding an injury, the extracellular space attains a higher dextrose concentration relative to the intracellular space. This differential creates a hyperosmotic environment, prompting rapid osmotic fluid shifts that the body interprets as temporary cellular damage. Consequently, an immune-mediated regenerative response is triggered at the site. The second agent, PDRN, exerts its effect by acting on the adenosine A2a receptor in cells. Upon injection into the injured area, it inhibits inflammation and promotes the recruitment of regenerative cells to the site. The rationale for comparing these two agents is that high-concentration dextrose is the most extensively studied and longest-utilized agent in prolotherapy. PDRN is one of the most widely used prolotherapy agents in Korea and is commonly utilized by healthcare authorities.

1. Clinical procedures and outcomes using high-concentration dextrose

a) Preparation of the injectable agent

Prolotherapy agents for TMJ disorders are not commercially available as ready-to-use products. Therefore, injectable solutions must be prepared on-site. Fortunately, the preparation process is straightforward.

To prepare a single dose of high-concentration dextrose, the following materials are required **(Fig. 2):**

- 20% dextrose - 20 mL
- 2% lidocaine (without epinephrine) – 20 mL
- 5 mL or 10 mL disposable syringe
- 30G, 25 mm needle

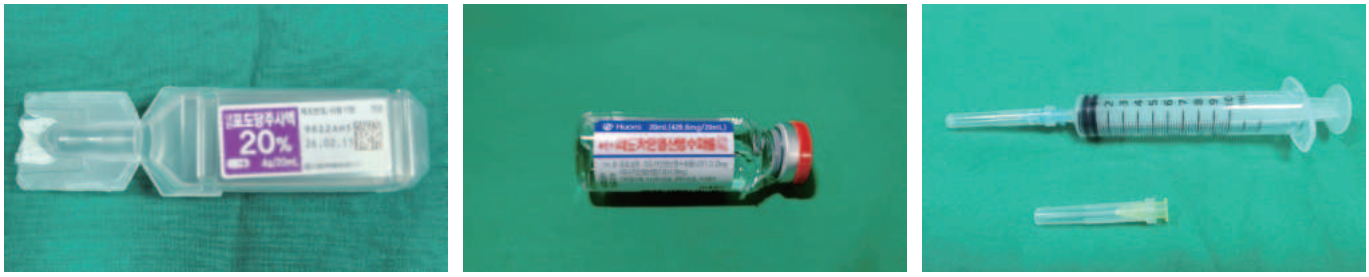


Fig. 2. Materials required for dextrose prolotherapy (left to right: 20% dextrose, 2% lidocaine, 10 mL disposable syringe, and 30G, 25 mm needle)

Mix the prepared 20% dextrose solution with lidocaine **(Fig. 3).** Combine 6 mL of dextrose and 1.5 mL of lidocaine in a disposable syringe, maintaining a 4:1 mixing ratio. The final volume of the injectable solution is 7.5 mL. Although PDRN and dextrose serve therapeutic purposes, a small amount of lidocaine is added to minimize injection related pain. The resulting concentration of dextrose after dilution is 16%.

Typically, dextrose concentrations used in prolotherapy range from 10% to 25%.

b) Clinical procedures & methods

Prolotherapy with dextrose was administered around the TMJ in 20 patients.

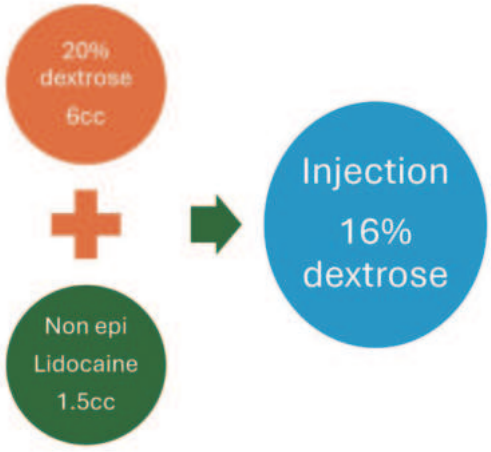


Fig. 3. Diluting 20% dextrose with lidocaine in a 4:1 ratio results in a final dextrose concentration of 16%.

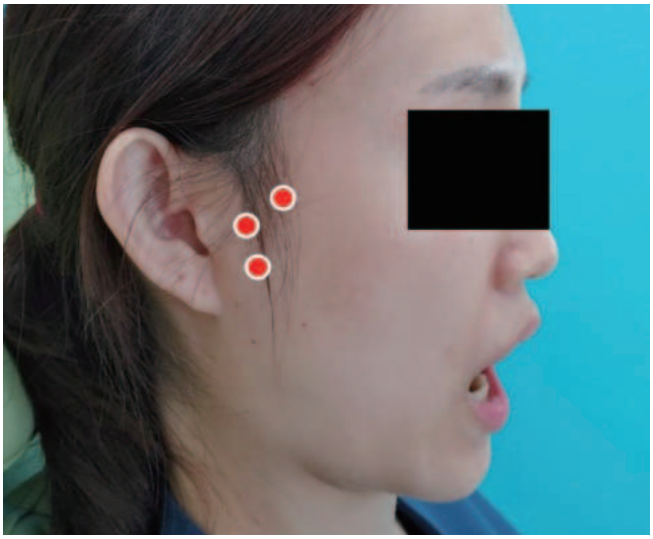


Fig. 4. Injection sites include the mandibular condyle, condylar neck, and the outer surface of the zygomatic arch proximal to the condyle

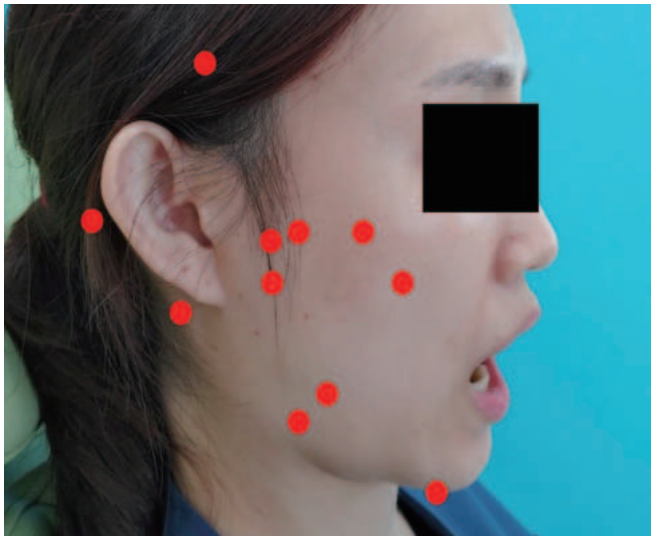


Fig. 5. Injection sites include bony attachment areas around the mandibular condyle, masticatory muscles, and cervical (neck) regions

The results of the patient responses to the first question regarding changes in pain are summarized in the table below **(Fig. 6)**.

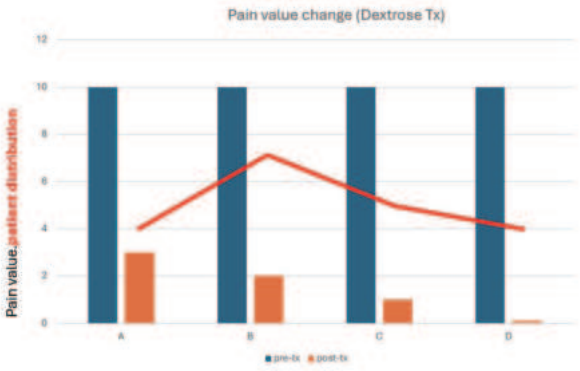


Fig. 6. Patient responses regarding changes in pain following dextrose prolotherapy

Initially, the TMJ and surrounding musculature were palpated to identify the site of pain. Based on the pain distribution, injections were administered according to the landmarks shown in **(Fig. 4)** or **(Fig. 5)**. **(Fig. 4)** shows the injection points used when the pain is primarily localized around the TMJ, while **(Fig. 5)** shows the injection points used when the pain extends to the TMJ and associated muscles. Approximately 0.5 mL was injected at each point using a 30G, 25 mm needle. The number of treatments was individualized based on the observed effectiveness in each patient. The treatment frequency per patient was as follows:
Average number of treatments: 8.6
Number of treatments per patient: 6 times (9 patients), 8 times (2 patients), 9 times (1 patient), 10 times (4 patients), 12 times (1 patient), 13 times (1 patient), and 14 times (2 patients)

c) Treatment outcomes for clinical procedures
Survey sample: 20 patients with chronic TMJ pain
Healthcare provider: Ulsan Woori Dental Clinic
Treatment period: January 2014 - October 2018
Survey method: Telephone interviews

Telephone interviews were conducted to collect data on clinical outcomes following treatment. The survey included two questions:
① If the worst TMJ pain you experienced before treatment was rated as 10, how much pain do you currently feel in your TMJ after treatment?

② What has changed since treatment, other than the reduction in pain?

· Vertical axis: Pain levels (green bars: pre-treatment; orange bars: post-treatment)

· Horizontal axis: The 20 patients were categorized into four groups (A, B, C, and D based on the level of pain reduction after treatment (Group A: 70% reduction; Group B: 80% reduction, etc.).

· Solid red line: Number of patients in each group: 4 in A, 7 in B, 5 in C, and 4 in D. The highest number of patients (7) were in Group B, indicating an 80% reduction in pain.

In response to the second question, "What has changed since treatment, other than the reduction in pain?", 10 patients reported a decrease in TMJ sounds.
In addition, the relationship between occlusal stabilizers and dextrose injection therapy was examined.
Of the 20 patients, 9 were using a splint. These patients showed improvement following dextrose prolotherapy and were able to function without the device thereafter.
Patients received treatment between 2014 and 2018, while follow-up phone surveys were conducted in 2019. This suggests that the improvements, including pain reduction, were sustained over time and not merely temporary.
This degree of symptomatic improvement observed is consistent with findings reported in the literature on "TMD prolotherapy with dextrose".

2. Clinical procedures and outcomes using high-concentration dextrose and PDRN

a) Preparation of the injectable agent

In the second method, high-concentration dextrose and PDRN injectable agents are used separately, depending on the injection site. The dextrose injectable agent is prepared as previously described. The PDRN injectable agent is prepared as follows:

Preparation for a single dose of PDRN **(Fig. 7)**:

- PDRN: 1 ampule (3 mL)
- 2% lidocaine (without epinephrine): 20 mL
- 5 mL or 10 mL disposable syringe
- 27G or 29G, 38 mm needle

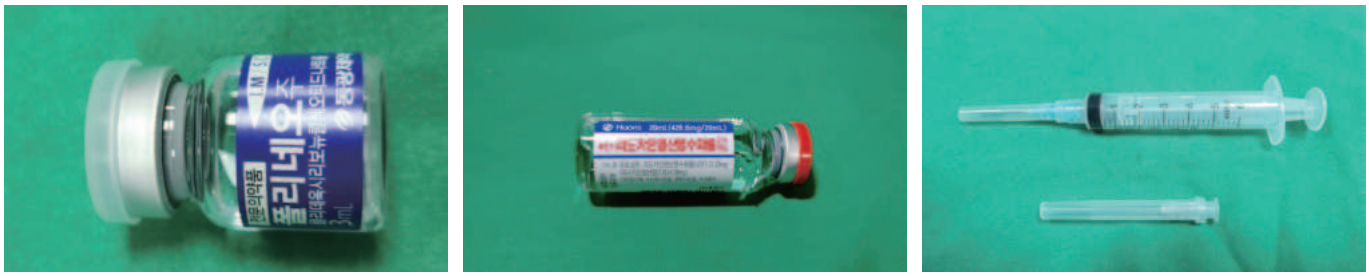


Fig. 7. Materials required for prolotherapy with PDRN (left to right: 3 mL PDRN, lidocaine, and a 5 mL disposable syringe with a 29G, 38 mm needle)

The PDRN and lidocaine were mixed by combining 3 mL of PDRN with 1 mL of lidocaine in a disposable syringe **(Fig. 8)**. The mixing ratio was 3:1, resulting in a final volume of 4 mL.

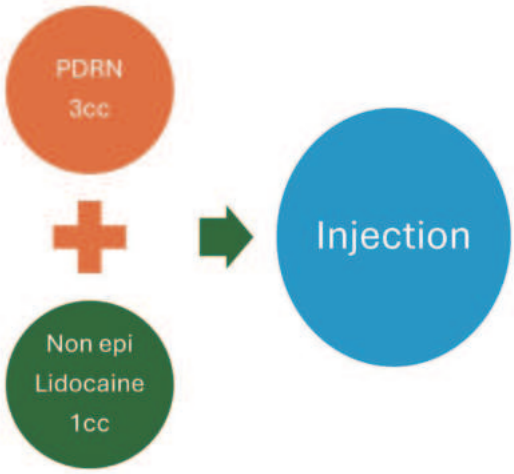


Fig. 8. The injectable agent is prepared by mixing 3 mL of PDRN with 1 mL of lidocaine.

b) Clinical procedures & methods

The prepared PDRN and dextrose injectable agents for prolotherapy were administered to 20 patients.

Most previous clinical studies have used dextrose by identifying and targeting injection points around the condyle, as described in the initial method above.

However, the authors have recently employed the following new clinical approaches:

- Prolotherapy with PDRN in the TMJ
- Use of a 38 mm, 25G or 27G needle in the TMJ, allowing access to the medial side of the condyle
- Injection of 16% dextrose into the mastoid process and occipital region, in addition to the TMJ
- Ultrasound-guided injections in the TMJ region

In summary, PDRN was injected around the TMJ, and dextrose was injected into the neck region. Ultrasound-guided injections were performed around the TMJ using a 38 mm needle to access the deeper areas of the joint. This method differs significantly from the conventional clinical approach. In addition, unlike the first method, which involved a broad distribution of injections along the pain area, the second method used only three specific injection points, even in cases of widespread facial pain **(Fig. 9)**.

The injection points for the second method are shown in the figure below.

PDRN was injected at injection point 1, and dextrose was injected at injection points 2 and 3. The dosage was 2 mL of PDRN per side of the TMJ, and 0.5 mL to 1 mL of dextrose at each injection point.

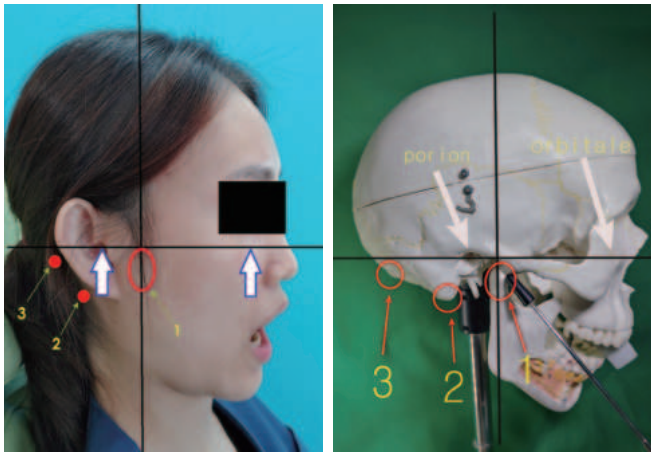


Fig. 9. Injection points used for TMJ prolotherapy
Injection point 1 - Periarticular ligament of the TMJ
Injection point 2 - Mastoid process
Injection point 3 - Specific sites within the occipital region of the neck

c) Treatment outcomes for clinical procedures
Survey sample: 20 patients with chronic TMJ pain
Healthcare provider: Ulsan Woori Dental Clinic
Treatment period: June 2022 - May 2023

d) Clinical procedures & methods:
Average number of treatments: 5.05
Number of treatments per patient: 3 times (1 patient), 4 times (7 patients), 5 times (3 patients), 6 times (8 patients), and 7 times (1 patient)
Survey method: Telephone interviews

The survey followed the same procedure as the first survey described above. The results are presented in **(Fig. 10)**.

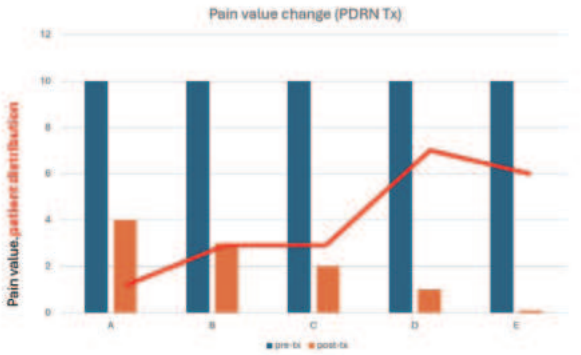


Fig. 10. Change in pain after prolotherapy with PDRN
The vertical axis represents pain levels. Blue bars indicate pain levels before treatment, and orange bars indicate pain levels after treatment. The horizontal axis shows the classification of patients into Groups A, B, C, D, and E based on the degree of pain improvement following treatment.

Patients in Groups D and E experienced the highest levels of pain reduction. Specifically, most patients reported a 90-100% reduction in pain following treatment, in contrast to the 80% reduction observed with dextrose alone. One additional point of note is the number of treatments required.
The average number of treatment sessions using dextrose combined with PDRN was 5.05, compared to 8.6 sessions with dextrose alone.
In conclusion, these new clinical approaches demonstrated that, relative to conventional prolotherapy with dextrose, the revised procedure not only streamlined the procedure by reducing the number of injection points, as well as the duration and frequency of treatments, but also resulted in greater pain reduction after therapy.
In addition, treatment with PDRN yielded the following clinical outcomes: reduced TMJ sounds, increased range of motion, improved dislocation stability, restored mastication confidence, and fewer headaches.

As such, there was a significant difference in clinical outcomes between the first method using glucose and the second method using PDRN. However, the second clinical method differed from the first not only in the use of PDRN but also in the introduction of three new injection points, the use of a 38 mm needle, and the application of ultrasound-guided injection into the TMJ. Therefore, this section aims to describe the differences in clinical methods that contributed to the observed variation in outcomes, including the new injection points and techniques.

Three new injection points and an ultrasound-guided injection technique for TMJ disorders

There are two injection methods used for the TMJ: palpation and ultrasound-guided techniques.
he primary injection points are located within the TMJ, while points are in the neck region, specifically at the mastoid process and the occipital muscle attachment.
The injection points are as follows.

Injection point 1: TMJ ligaments and tendons of the lateral pterygoid muscle

The mandibular condyle was palpated as the patient opened and closed the mouth to identify the injection point (Fig. 11). The Frankfort horizontal (FH) line, connecting the porion and orbitale, and a vertical line passing through the center of the sideburn typically intersected at the location of the condyle. The injection point was estimated to be approximately 3 to 4 mm inferior to this intersection.

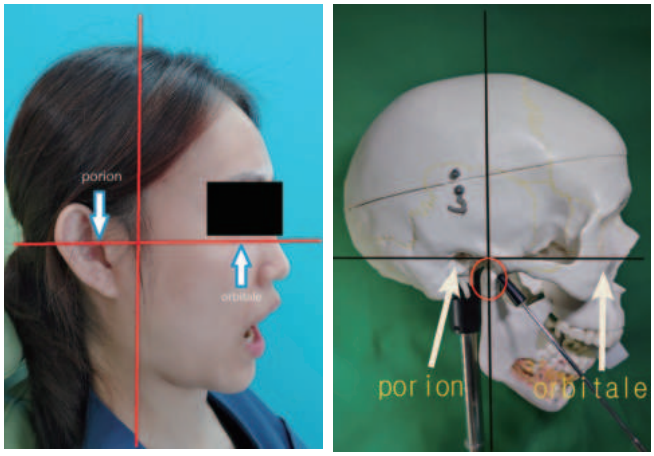


Fig. 11. Injection points used for TMJ prolotherapy: One injection point is located below the intersection of the Frankfort horizontal (FH) line and a vertical line drawn through the sideburn. However, because the exact location may vary between individuals, it should be confirmed through palpation.

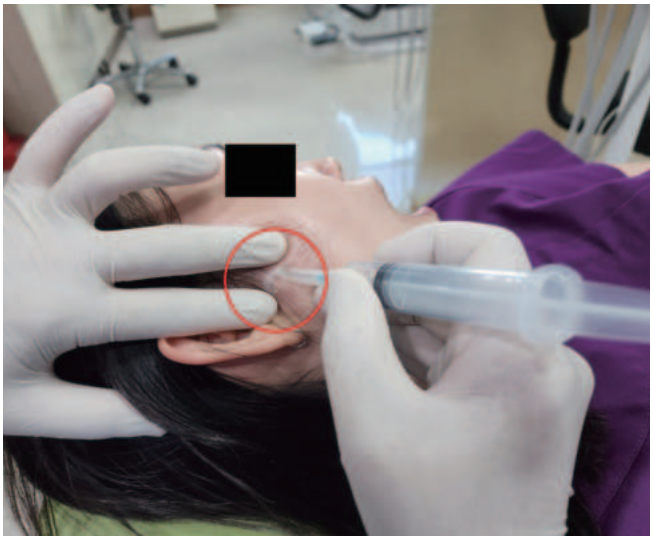
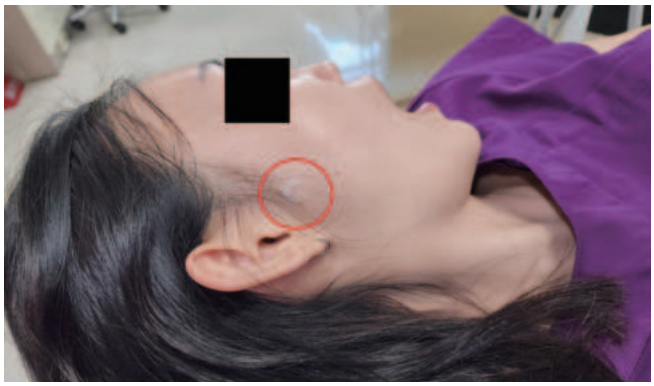


Fig. 12. The location of the condyle was marked with a white pencil. The area was palpated using two fingers, and the needle was inserted between them.

Although this is a rough estimate of the location, it is essential to accurately identify the injection point for the procedure.
There are two methods to locate the injection points around the TMJ.

First method: Injection by palpation

In this method, the location of the condyle is identified by palpation, and the injection is administered into the lateral pole or anterior aspect of the condyle **(Fig. 12)**.
While the patient repeatedly opens and closes the mouth, palpate the condyle and position two fingers as if stabilizing the mandibular condyle. The injection is delivered between the two fingers without removing them from the palpation site.



The methods for locating the mandibular condyle by palpation have been described. Once the injection point is determined using the two methods outlined above, use a 27G 38 mm needle and position it vertically on the skin surface for injection. The depth of injection ranges from 25 to 36 mm.
The mandibular condyle is covered by the skin and the masseter muscle. Although precision is limited due to individual variation in masseter muscle thickness, inserting the needle to a depth of approximately 25 mm reaches the lateral pole of the mandibular condyle, while an insertion depth of approximately 35 mm passes the lateral pole and approaches the medial side of the condyle. Approaching the medial side positions the injection near the tendon of the lateral pterygoid muscle for therapeutic purposes.
If it is clinically determined that the lateral pterygoid muscle contributes to the TMJ symptoms, a deeper injection is recommended. Such cases include suspected disc displacement, habitual dislocation, or limited lateral jaw movement.

Second method: Ultrasound-guided injection

Another method is ultrasound-guided injection **(Fig. 13)**.
Although ultrasound-guided injections are widely used in general medical practice, they remain relatively new in dentistry.
However, ultrasound-guided injection into the TMJ offers several advantages over palpation-guided injection. :

1. The mandibular condyle is easier to locate, reducing procedure time.
2. Needle entry is visible on the monitor, decreasing procedural errors.
3. The needle can be visualized as it advances, allowing for targeted injection into the lateral pole of the condyle, the medial side of the condyle, and the condylar neck.
4. The needle approach is controlled, minimizing the risk of damage to blood vessels and nerves.
5. The injection direction can be adjusted to reduce pain.
6. Patient anxiety related to facial injections is reduced.

In addition, ultrasound-guided procedures involve no radiation exposure, unlike computed tomography (CT) or X-ray examinations, making them suitable for repeated use and side-by-side comparisons.

Fig. 13. The mandibular condyle should be located at the intersection of the ultrasound probe's scanning path and the needle's insertion trajectory.

Ultrasound-guided injection offers several advantages. However, challenges associated with this procedure include the cost of acquiring ultrasound equipment, the need to develop proficiency in interpreting ultrasound images, and limited data regarding the use of ultrasound in the TMJ region in previous studies. Each injection method has its own advantages and disadvantages, and no single approach is universally applicable. Nevertheless, ultrasound-guided injection is becoming increasingly relevant in dental clinical practice.

Needle positioning for ultrasound-guided injections

An understanding of ultrasound imaging enhances the ability to accurately position the needle during ultrasound-guided injection. This can be achieved by comparing ultrasound images **(Fig. 14b**, corresponding to **Fig. 14a)** with CT imaging **(Fig. 15)**.

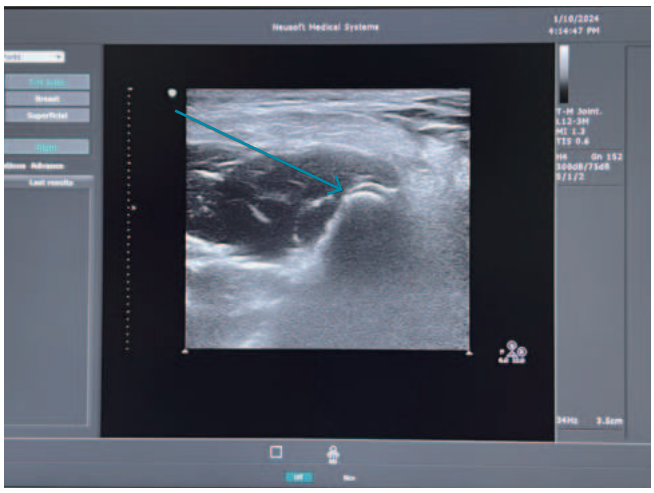


Fig. 14a. The mandibular condyle should be located at the intersection of the ultrasound probe's scanning path and the needle's insertion trajectory.

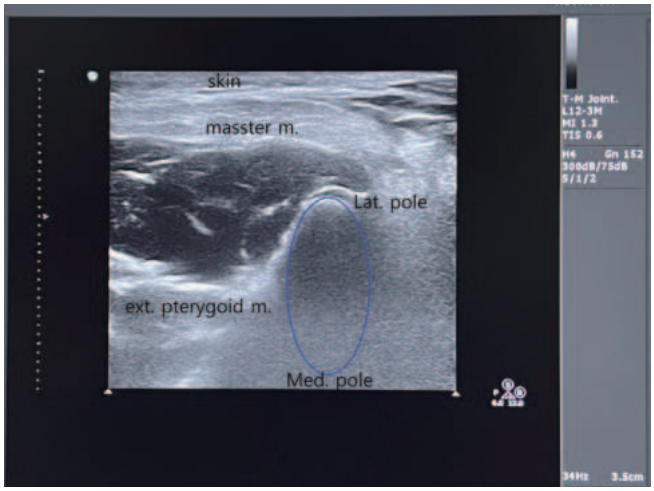


Fig. 14b. Annotated image identifying each structure to aid in the interpretation of Figure 14a.

Let us assume that the needle is retracted in the direction of the arrow shown in the ultrasound image above. (The needle is represented by an arrow because its movement is visible in the dynamic image but appears blurred in the static image.)

When the injection is performed in this manner, the needle appears on the CT scan as follows.

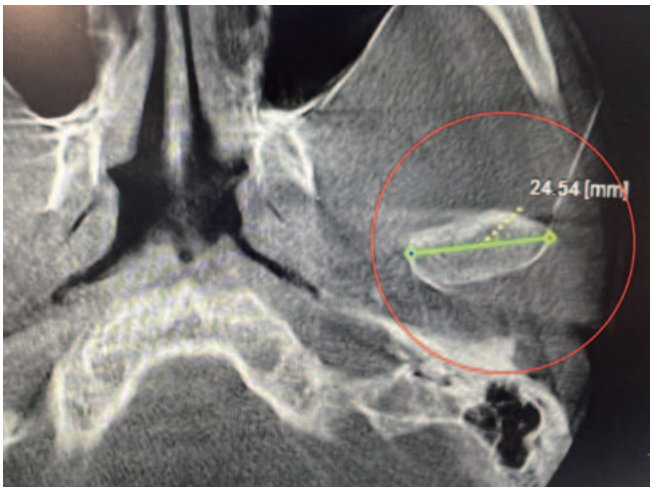


Fig. 15. The needle is positioned close to the lateral pole of the condyle.

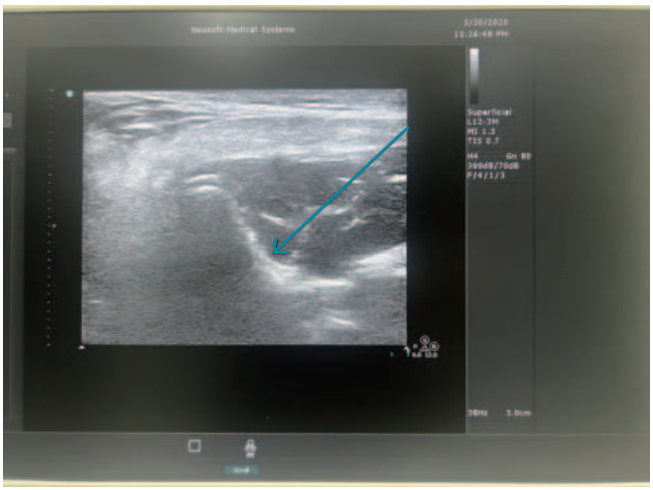


Fig. 16a. Image obtained from the transverse scan shown in Figure 14a, the orientation varies due to the right mandibular condyle, resulting in a different needle position. The needle is positioned between the lateral pole and the medial pole of the condyle.

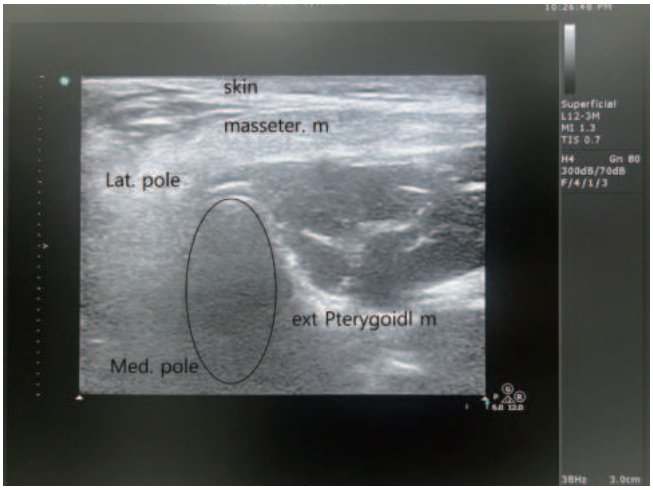


Fig. 16b. Annotated image identifying each structure to aid in the interpretation of Figure 16a.

Unlike the ultrasound image in **Fig. 14a**, the transverse scan of the right mandibular condyle in **Fig. 16a** shows the needle's direction has shifted slightly downward **(Fig. 16a and 16b)**.
It is important to note that ultrasound imaging alone can distinguish between left and right sides, and a downward movement on the ultrasound screen corresponds to deeper penetration into the tissue in real life.
This can be verified using the CT image **(Fig. 17)**.

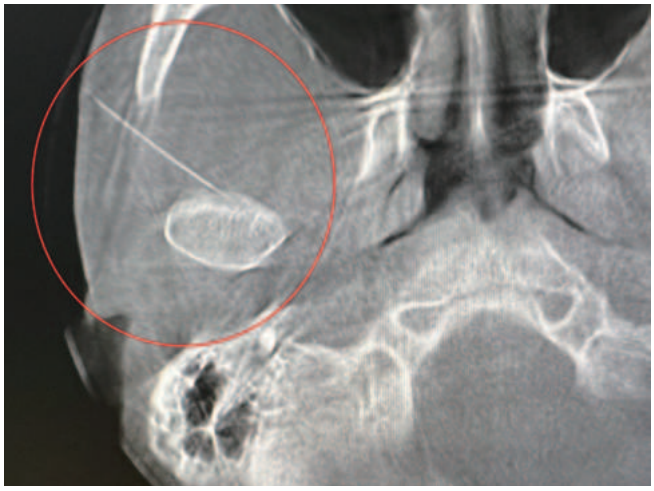


Fig. 17. The needle has shifted slightly toward the medial pole of the condyle, away from the lateral pole, and is now positioned near the center of the condyle.

Once clinicians understand the ultrasound image, they can move the needle laterally or medially to the condyle, or upward or downward.
This allows adjustment of the needle direction based on the treatment objective. It also facilitates identification of anatomically safer areas for injection.

Let us now examine the safety aspects of ultrasound-guided injection in more detail.

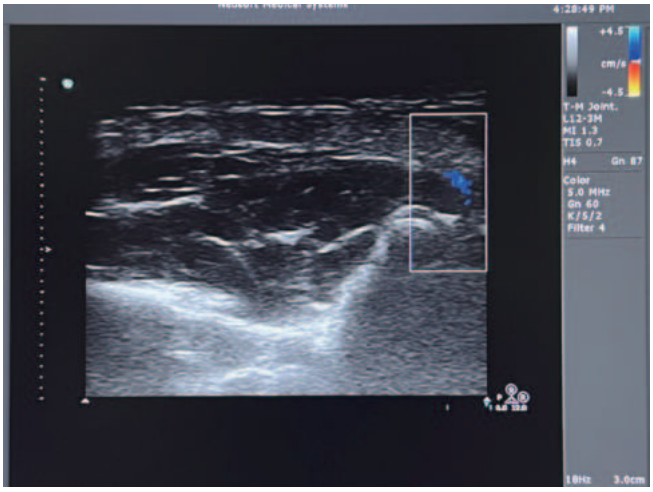


Fig. 18. Blood vessels flowing away from the probe, or located deeper, are visualized based on the BART (Blue Away, Red Toward) principle.

Ultrasound can activate Doppler mode. When Doppler mode is enabled, a rectangular area appears on the screen. Blood flow within this area is typically displayed in blue and red. Blue represents fluid moving away from the ultrasound probe, while red represents fluid moving toward the probe (BART: Blue Away, Red Toward).
In this image, the veins are observed running laterally to the condyle and are presumed to be branches of the superficial temporal vein.

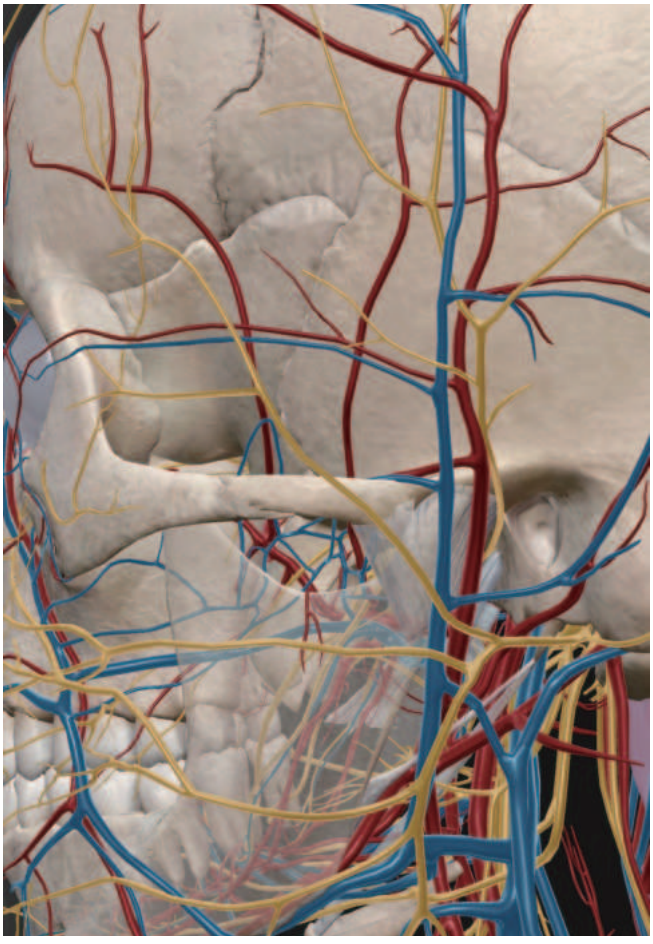


Fig. 19. The largest vessels near the capsular ligament surrounding the condyle are the superficial temporal vein and artery. The artery runs upward and deeper, anterior to the external auditory canal.

Since the distribution of blood vessels can be visualized on the ultrasound screen in real time, the needle can be guided accordingly during the procedure.
TMJ injections were performed even before the introduction of ultrasound. The author also has extensive experience performing TMJ injections without ultrasound. However, the availability of new techniques does not justify rejecting them. Ultrasound-guided injection is both safer and more efficient.

Injection point 2: Mastoid process

Problems with the jaw joint are often closely related to issues in the neck region. A thorough understanding and clinical application of these two injection points in the neck can significantly aid in the treatment of TMJ disorders.
Ultrasound-guided injection of the TMJ has been discussed above. However, the mastoid process and occipital region of the neck are relatively superficial and can be easily palpated, allowing for injection based on palpation alone.

The first anatomical landmark to consider is the mastoid process.

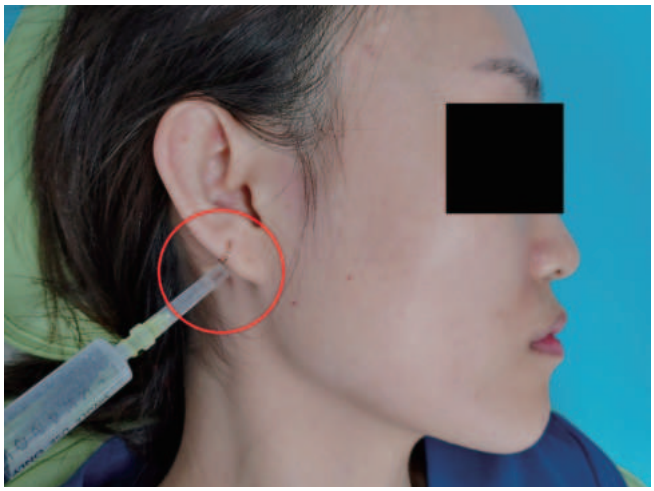


Fig. 20. The mastoid process is a small bony projection that can be felt when palpating behind the earlobe. The size of this projection varies widely.

It is straightforward to determine the injection point in this area **(Fig. 20)**. When palpating just behind the earlobe with the fingertip, a distinct bony projection can be felt beneath the skin.
The area just below this projection, where the muscles attach to the bone, should be targeted for injection.
A 30G, 25 mm injection needle is used to access the area to a depth of approximately 15 mm.

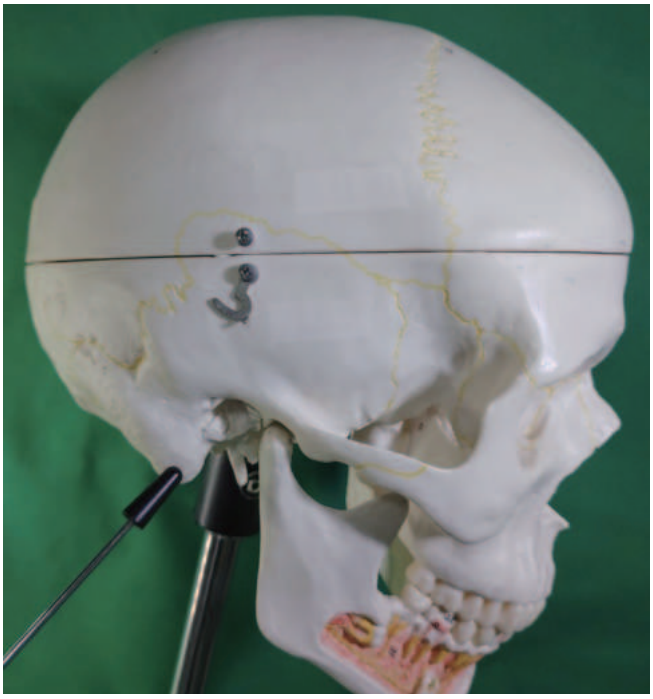


Fig. 21. The mastoid process is a bony projection located on the posterior-inferior part of the external auditory canal.

Why is the area in **Fig. 21** considered a major injection point in the neck region?

The mastoid process is a bony structure on the lateral aspect of the skull **(Figure 22)**.
Notably, the sternocleidomastoid muscle attaches laterally to this area, contributing to the side-to-side balance of the head. Anteriorly, it is connected to the posterior belly of the digastric muscle, while posteriorly, a portion of the splenius capitis muscle is attached. Thus, the sternocleidomastoid aids in lateral stability, and the anterior and posterior muscle attachments help maintain front-to-back balance.

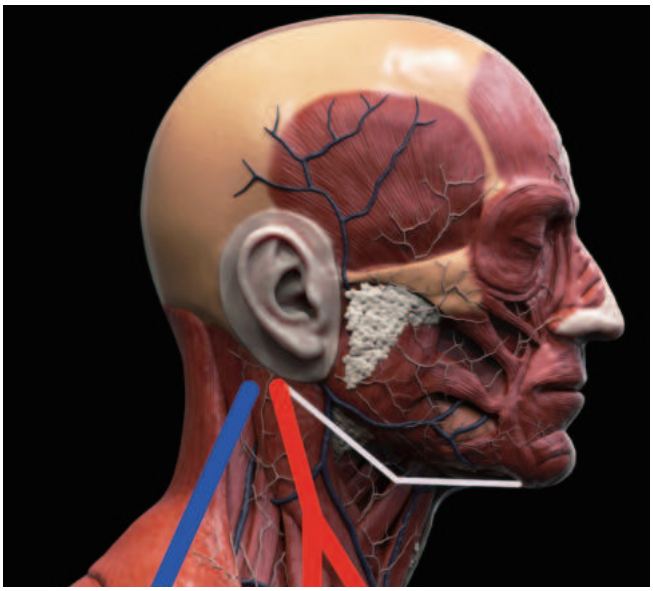


Fig. 22. Several muscles attach to the mastoid process and influence the positioning of the head and jaw.

Injection point 3: Occipital region

There is an additional injection point to consider in the occipital region, located at the back of the skull **(Figure 23)**. This injection point is typically unfamiliar to dentists and can be identified through palpation.

The first anatomical landmark to consider is the mastoid process.

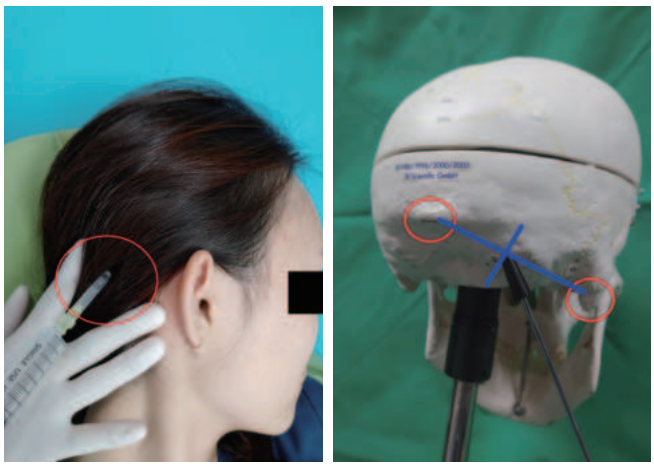


Fig. 23. The midpoint of the line connecting the mastoid process and the external occipital protuberance is the recommended injection site in the occipital region. This area serves as the attachment point for several muscles that connect the skull to the spine.

There are two areas to check first. One is the occipital protuberance, located in the center of the occipital region. It is a bony projection at the back center of the skull. The other is the mastoid process, described above. These two bony projections can be identified by extending the palm and using the index and middle fingers. The midpoint between these two areas should be determined as the injection point.

The injection is administered in this area because it is a common source of pain in the occipital region of the neck. Anatomically, several muscles in the posterior neck region (splenius capitis, semispinalis capitis, and portions of the trapezius) are attached to this area.
Clinically, TMJ disorders are often associated with changes in head posture. The so-called "turtle neck," commonly linked to excessive mobile phone use, prolonged sitting, office work, and studying, has been associated with head and neck pain and TMJ disorders.
For this reason, the author considers this an essential area for treating neck-related conditions.
A 30G 25 mm needle is used for injection in this region. The injection depth is approximately 7 to 8 mm.

Clinicians should consider the following factors when determining the injection point:

- Is the injection in the area effective?
- What are the associated risks?
- Is the procedure simple and straightforward?
- Is the procedure easily reproducible and standardized?
- What is the expected level of pain and patient cooperation?
- Is the procedure widely supported in the literature?

These considerations are essential. Based on these criteria, the three injection points mentioned above have been selected. They have been reported as effective by some clinicians over time; however, research in this area remains limited. Additional retrospective studies are needed.

Conclusion

For patients with chronic TMJ pain that does not respond well to conventional treatment methods such as physical therapy, medications, and splints, TMJ injections may be a viable alternative. Among these, prolotherapy using high-concentration dextrose and PDRN has demonstrated promising results. In particular, the literature has emphasized the use of high-concentration dextrose injections around the TMJ. However, in the author's clinic, better clinical outcomes were observed when PDRN was administered in addition to high-concentration dextrose. Modifications to the injection technique, such as the use of a 38 mm needle, ultrasound guidance, and injection points in the neck region, are also considered to have clinical relevance.

The injection points in the neck region and the use of ultrasound are areas that have not been fully explored in dentistry and require further investigation. Furthermore, there appears to be no established model for TMJ treatment that effectively integrates physical therapy, splint therapy, and the injection approach described in this study. This area would also benefit from futher retrospective research and long-term clinical studies.

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