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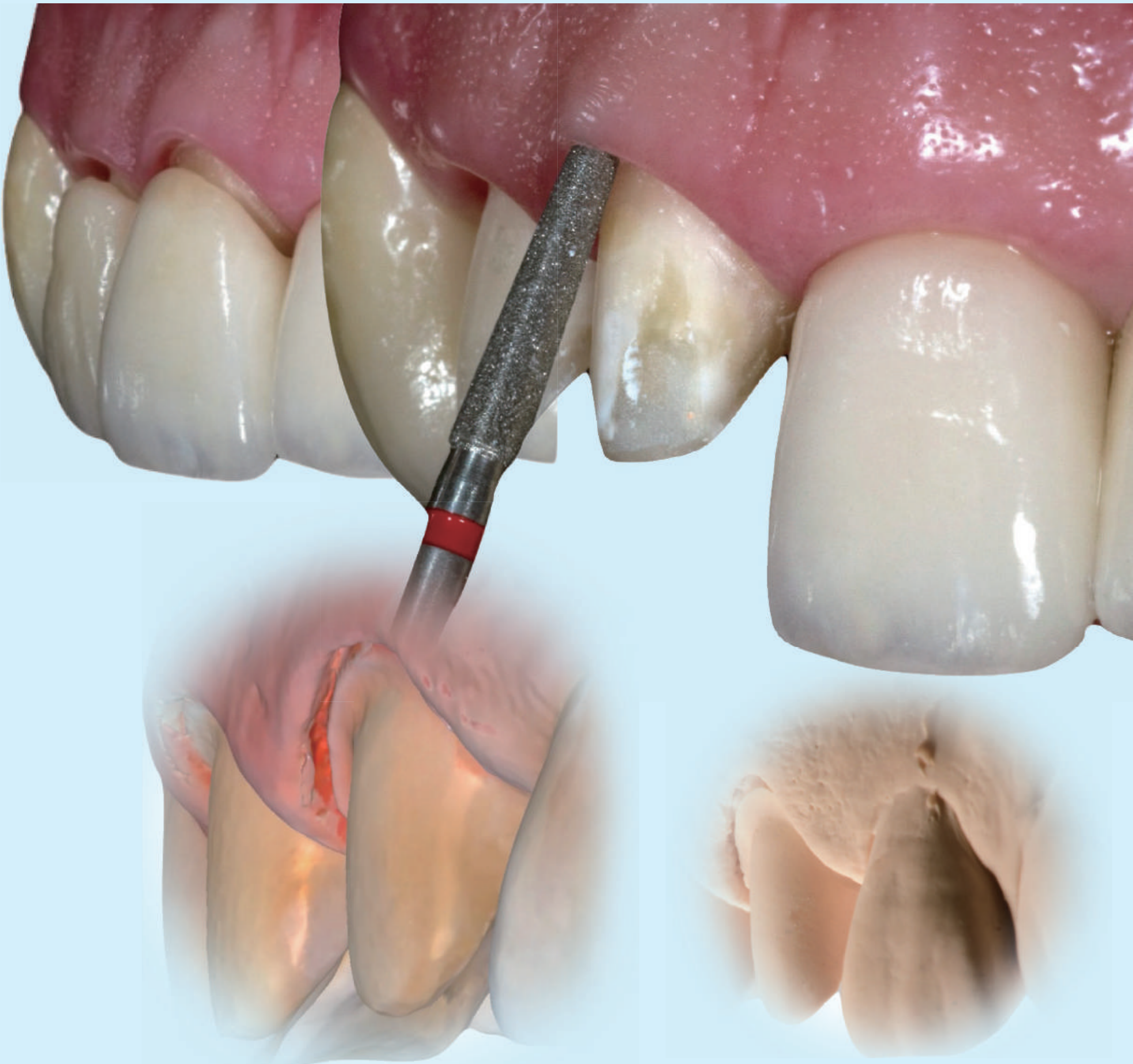
JCDD

Journal of Clinical & Digital Dentistry



Cover Images from Joe GA · Cha Gj (J Clin Digit Dent 2019;1(2):6-14)

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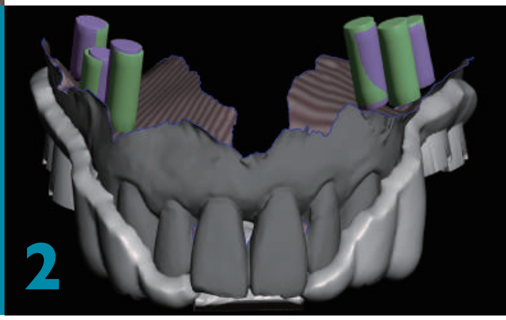

JCDD
Journal of Clinical & Digital Dentistry

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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

Satisfaction in our Profession through Continuous Learning

Everyone pursues happiness, but what is happiness? Is it having enough money or honor? If you have these but are unable to achieve something through them, you will probably feel that something is missing in your life. Money and honor are just tools for finding happiness — not the sources of happiness. That said, I find the following biblical passage to be true: "A man can do nothing better than to eat and drink and find satisfaction in his work" (Ecclesiastes 2:24).

Making money is important. However, we will attain greater joy and satisfaction than through money alone if our patients are satisfied with their dental treatment and demonstrate their appreciation to us. We dentists will find true happiness only when we bring satisfaction to our patients.

There are some fields, in which people who focus on keeping tradition do not need to adapt to their field's changes. For them, mastering their craft relies on the practice and repetition of traditional methods. This is not the case with dentistry. When new technologies and products are developed, we must learn and apply them to our treatment methods. A lack of continuous learning will prevent us from offering the best treatment, which will result in dissatisfied patients and our inability to find happiness as dentists.

This issue of JCDD focuses on new technologies and products with papers on improving esthetic ceramic restoration through the use of digital technology based in analog methods, the accuracy of implant surgery through 3D printing-driven implant guide systems, and automated cephalometric diagnosis using AI and digital methods.

I hope that this issue of JCDD will facilitate our continuous learning and help us find greater satisfaction in our work.

Sincerely

Wongun Chang, DDS MS PhD

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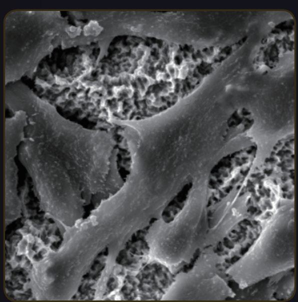

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DENTIS Spokesmodel
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How to secure subgingival margin in restorative crown therapy using oral scanner

Gyeongan Joe, DDS, MSD, PhD · Gukjun Cha, DT

Introduction

Dentists make great efforts in the selection and acquisition of precise tooth preparation, isolated margins, and the selection of appropriate impression materials, aiming for the best impression in restorative crown therapy. These efforts form the basis for the best fit of restoration and the physiological shape reproduction which are the priorities in restorative therapy.

Clinical use of oral scanner has been effective in various areas and is expected to increase. In order for the oral scanner to be effectively used for a fabrication of definitive prosthesis, it is necessary to improve the precision through the development of the scanner, but we also need to overcome the limitations of the current digital scanner.

In this regard, efforts can be made in minimizing the failure in taking the impression of the subgingival margin, which is one of the clinical limitations of existing scanners using optical systems.

Furthermore, we should use oral scanner for the anterior restorative therapy with high aesthetic demands, introduce clinical practice of taking the impression of the finishing line set in the subgingival space, and develop more advanced digital dentistry by sharing the cases and through active discussions.

New impression taking method by an intraoral scanner instead of conventional impression method become a new clinical tool in the future with the development of digital equipment. Dentists and dental technicians should effort to secure accurate data when using intraoral scanners.

Left) *Stone Model*
Right)*Digital Model of the Same Case*

Gyeongan Joe

Dr. Gyeongan Joe graduated from Chosun University, College of Dentistry, He completed his Master and PhD study in alma mater. He is a director of NAG study group and a famous lecturer internationally about occlusion and esthetic dentistry. He is a board member of Korean Academy of Esthetic Dentistry. He maintains a private practice in OK dental clinic, Yongin-Si, Kyeonggi-Do Republic of Korea. He is an author of 'Esthetic Harmony' and 'BPS - Biofunctional Prosthetic System'.

Requirements for Crown

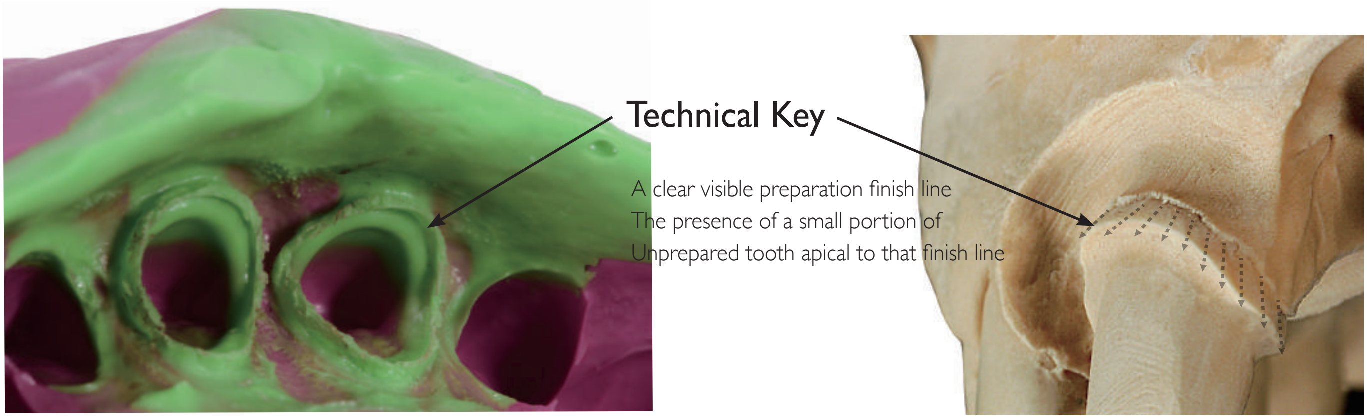
Understanding of unchanged biological principles requires the operator to have an understanding and approaches to clinical practice that is true to the basics. Among them, good marginal fit and suitable subgingival and supragingival reproduction will be the most important factors in the prosthodontics treatment. Precise tooth preparation for abutment considering biological environment should be achieved first, and based on this, the optimum fit and a shape that does not damage the biological environment will be a restoration that ensures positive prognosis.

There are various options for anterior restoration, and the abutment tooth preparation method matching for the options can be varied according to the criteria of an operator and the aesthetic needs of a patient. However, the formation of subgingival margins, which are frequently used in traditional full crown restoration, is not an easy process, starting from the abutment tooth formation, impression taking to shape reproduction. Dentists should be committed in forming a clear visible preparation finish line and smoothly polished teeth surface.

Principles of Impression Taking

In order to reproduce margin of accurate shape and physiological subgingival patterns, it is important to secure separate spaces around margins in clinical practice. To this end, various kinds of cords and techniques have been developed to secure this space. This is the most important key to maintaining the physiological stability of the gingiva around the restoration and can be described as the technical key of impression taking.

In the VPS silicone impression taking technic, these spaces around the margins provide the dental technician with clear information on the regions around the restoration and, as a result, this space serves as a safety device that ensures the best restoration. The technique is the very basic treatment process that a dentist must acquire.

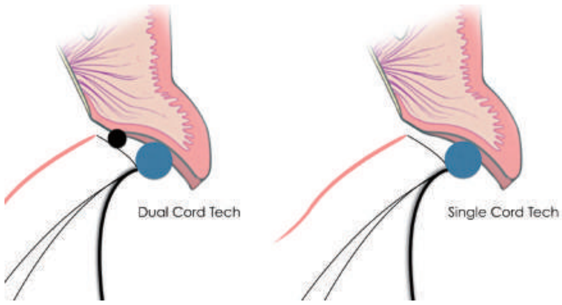


As the impression material goes deep into the margins and surroundings, especially into lower direction, in the stone model, clear information on the shape of margin and emergence profile can be read, allowing the dental technician to reproduce the subgingival shape with ease. In clinical practice, dentists should make continued efforts in achieving the desired outcome.

How to secure space around subgingival margin using retraction cord

In the past, gingival retraction using the retraction cord has been used most effectively in an effort to secure such space. In general, the securing of sufficient space for the penetration and curing of impression materials used recently and the control of exudate are the most influential factors for precision, and the improvement in manufacturing and clinical technology for such enhancement of precision are required.

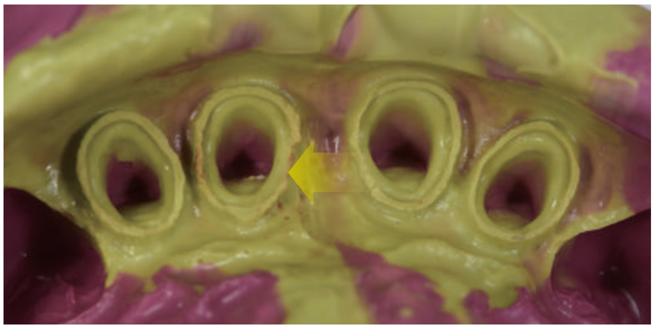
For the gingival retraction using the retraction cord, dual cord technic and single cord technic are commonly used, and an appropriate technic should be selected depending on the periodontal environment around the abutment tooth. However, for general impression with VPS silicone material, it is thought that dual cord technic can be effective in achieving the goal of impression taking mentioned above.



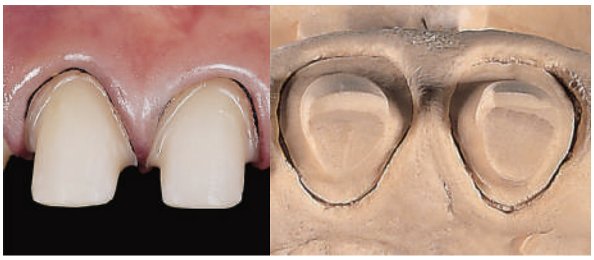
In dual cord technic, the 1st cord plays an important role in ensuring vertical depth and blocking the rise of exudate. However, in case of thin biotype gingiva or shallow sulcus, tissue can be damaged during the process. The 2nd code serves to secure horizontal space. The thickness and depth of the 2nd cord is very important. The thickest part of the 2nd cord should be placed at the margin to ensure horizontal width.

Left) *Dual Cord Technic*
Right) *Single Cord Technic*

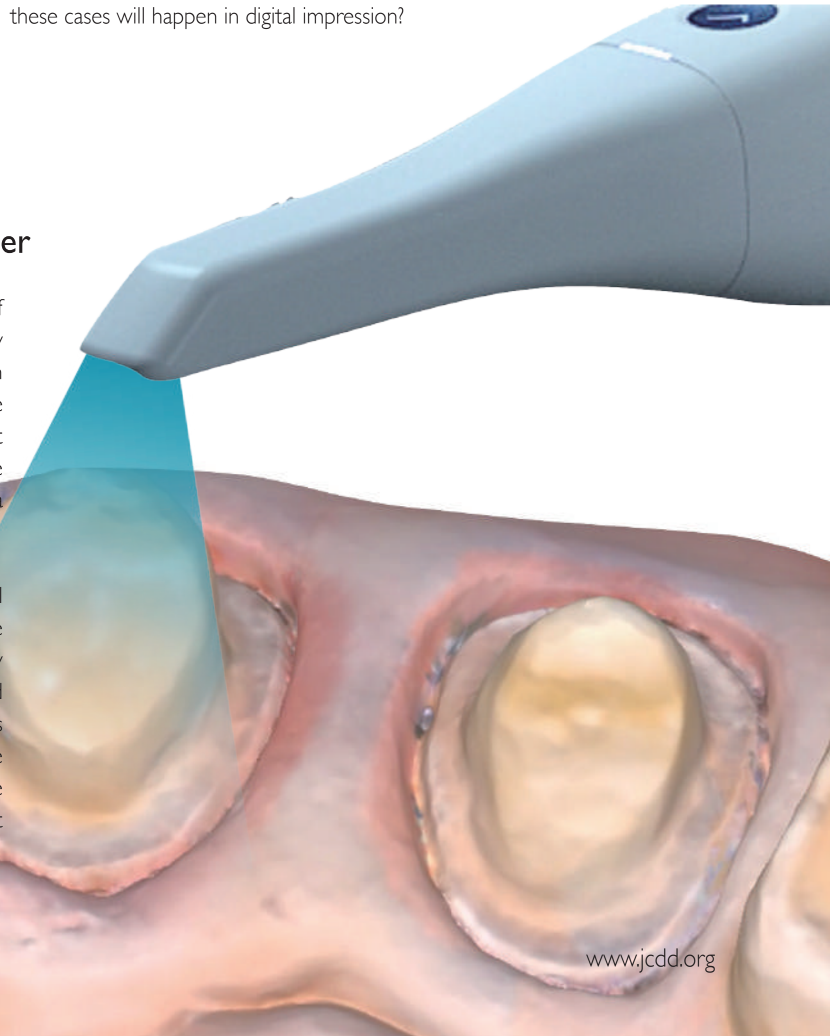
The figure shows gingival retraction being performed using dual cord technic. The thickest part of the 2nd cord should be located in the margin. The 2nd cord in the yellow arrow region in the figure above is inserted too deep and the cord is covered by the gingiva.



The impression taking in this type of situation is shown to be disconnected, not being able to secure the technical key at the same site.



Another example of not being able to secure space around margins is that the 1st code is inserted too shallow or embedded too deep, and when a cord is too thin, there is no clear securing of space around the target margin. How these cases will happen in digital impression?



Taking subgingival margin using the Oral scanner

The doubts on the possibility of proceeding with these steps of restoration using digital impression have gradually turned into a reality with the development of the oral scanner. According to the restoration option, the position of margin may be different, but as seen in the previous cases, if appropriate space can be secured around the margin, it opens the possibility of securing effective margin through an appropriate technic in digital impression using oral scanner. This will also serve as a chance to expand the scope of the work of digital dentistry.

The difference between the VPS silicone impression and the digital impression is that while the rubber impression material secures the space with physical pressure, the digital impression secures space by obtaining the margin shape with the optical system using light and reflection, although there are differences according to the manufacturers of the equipment. As the method is based on such optical system, there are both precautions to take and usefulness to be employed. Using the method with good understanding these properties is expected to result in effective outcomes, and a case presentation is given as follows.

Case Presentation

In order to restore the missing maxillary right central incisor, a 4 unit full zirconia fixed partial denture will be constructed using the maxillary right lateral incisor, left central incisor, and left lateral incisor as abutment teeth. No other technics in specific are required. Rather, more rigorous and meticulous compliance of various principles required in restorative therapy is required.

A dentist should ensure that during the tooth removal stage, no undercut should be formed and qualities such as roundness, high polished surface and sharp finishing line, etc. should be achieved.

In order to secure the space around the margin, a stable periodontal tissue must be secured first and the gingiva should be retracted within the physiological range by using a retraction cord of the appropriate size on the surrounding gingiva. The digital impression taking method that follows may be slightly different depending on the model of each company, but the method may be similar between models. The model used in this case is i500 of Medit. This device uses an LED light source and operates on the optical triangulation scanning method that two cameras take impressions by analyzing three-dimensional differences of reflected light. Impression taking technology true to the basic clinical practice is thought to be more important than the method according to the model difference and the procedure is introduced as follows.

Fig. 1. Avoiding sharp edges during tooth removal is the principle of restorations that must be followed in the case VPS silicone impressions. Even in digital impressions, sharp edges can cause distortion of the data on the part called Edge Loss on the STL Data, which can be a significant factor in the fit.

Fig. 2. The position of the finishing line was set to about 1 mm of subgingival region. In order to clarify the shape of the margin in bridge abutment tooth formation as shown in the above figure, the undercut is often formed when the angle of bur is finished at a different angle from the path of insertion. In the final step, the angle of bur should be parallel to the path of insertion.

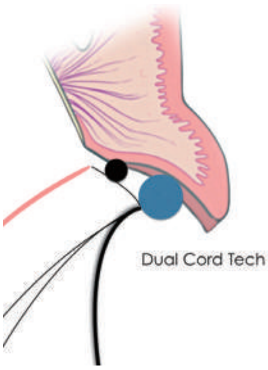


Fig. 3. After the tooth removal, the retraction cord is inserted around the margin using the dual cord technic. The 1st cord used 2-0 black silk for suture and the 2nd cord used # 2 Bredent cord.

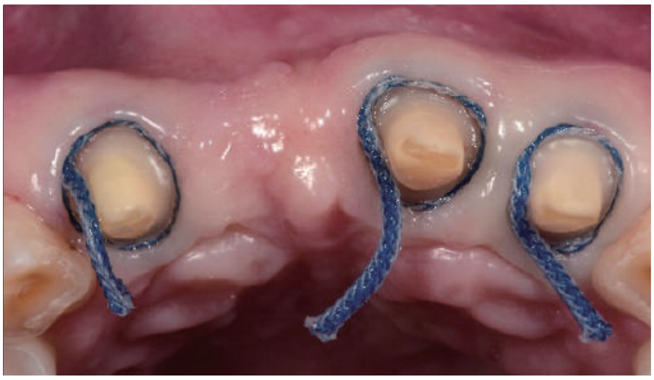


Fig. 4. The important point is that cord packing should be done in a healthy gingiva. In addition, one of the advantages of digital impression enable to take impression each tooth individually, if roots of the consecutive teeth are too close, rather than inserting the 2nd cord at the same time as shown above, inserting the 2nd cord only on the tooth taking the impression and passing to the next adjacent tooth will minimize the tissue damage and make gingival retraction easier.

Fig. 5. The above scan data is an image captured by the digital impression taken using the oral scanner. The 2nd code is shown in the captured image. The actual images taken were up to 1 molar tooth left and right considering the occlusion. The procedure of securing the space of the marginal part of the abutment tooth is performed after this data.

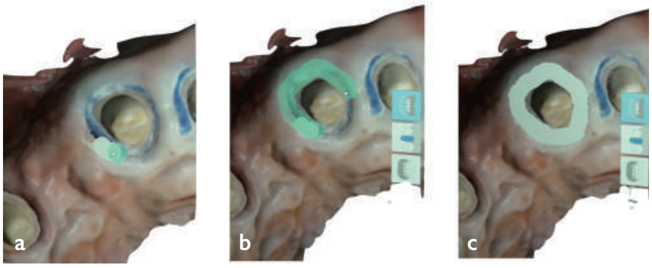


Fig. 6a-c. In the procedure, first you can erase the entire region around margin of the teeth you want to take the impression of, scan the erased area and the area will be automatically combined. If you are ready, dry the cord and its surroundings in the mouth and prepare to remove the cord.

Fig. 7. As soon as the cord is removed, the region is scanned quickly before the exudates come out. In the figure on the right, you can see the well-separated space around margin, and the area is scanned in the manner of 360 degree rotation as fast as possible after approaching the space as close as possible. It usually takes 1-2 seconds to scan using Medit i500. The important point is the appropriate gingival retraction according to the health of the periodontal tissue and the periodontal type around the abutment teeth.

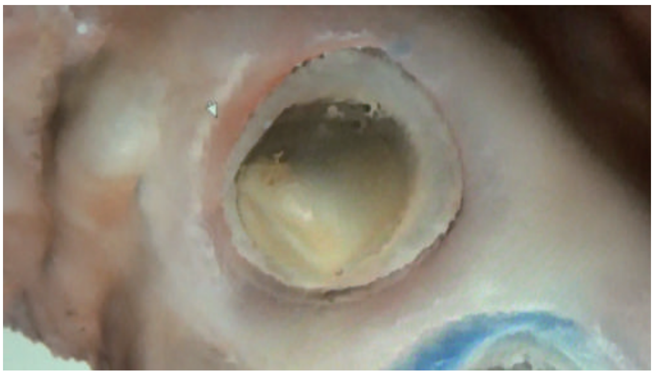


Fig. 8. The above figure is a maxillary left central incisor scan data acquired in this way. Although it is not clear because it is an image that captures the video screen, the shape of the overall margin is clearly visible without diffuse reflection by exudate. In order to obtain scan data of the margin of adjacent teeth, it is necessary to preserve the data of the maxillary left central incisor and for this reason, the set region is kept locked so that the corresponding region does not get exposed to the light sources.

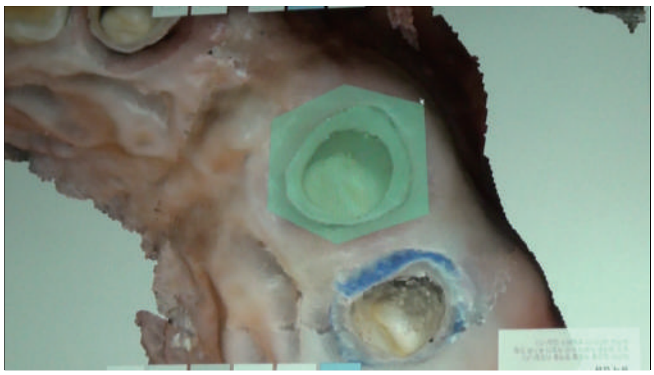


Fig. 9. The green pattern in the figure above is an area that is locked so that it does not get affected by the light source for scanning the margin of adjacent teeth. The procedure of scanning of the adjacent maxillary left lateral incisor is conducted as described earlier (Fig. 6a-c), followed by the procedure of (Fig.7).

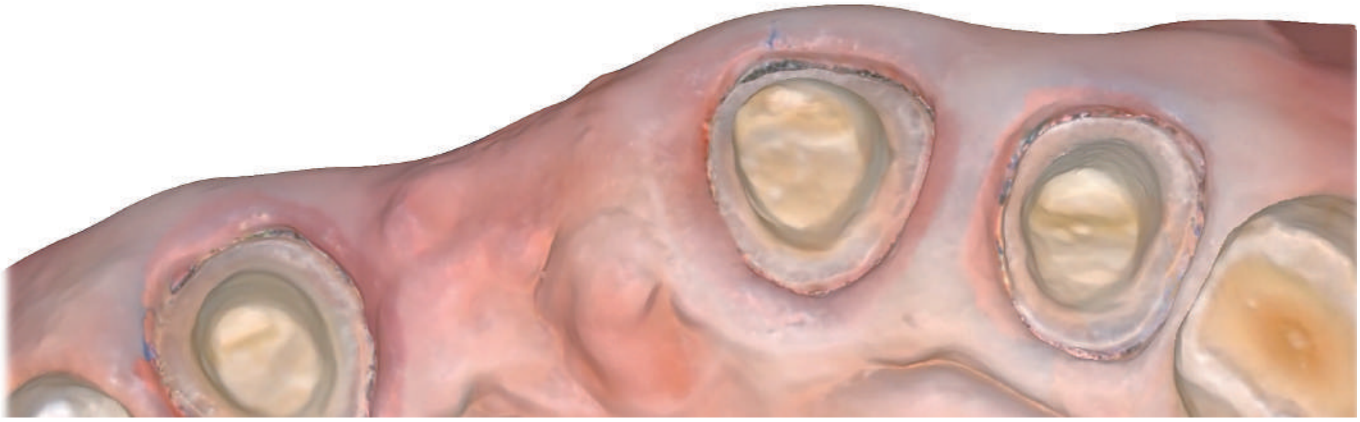


Fig. 10. You can see relatively clear images in the processed scan data. Digital impressions, like VPS silicone impressions, also show data that is not clearly separated from the gingiva in areas where the 2nd cord has no horizontal clearance of the space. In addition, although in part, 1st cord is near the finishing line and the cord image appears in dark-blue color. Therefore, it is thought to be advantageous to use thread as tightly twisted as possible. In case of healthy periodontal state or thick gingival type with a bit of depth in sulcus, scanning using only a single cold with some thickness can be an option.

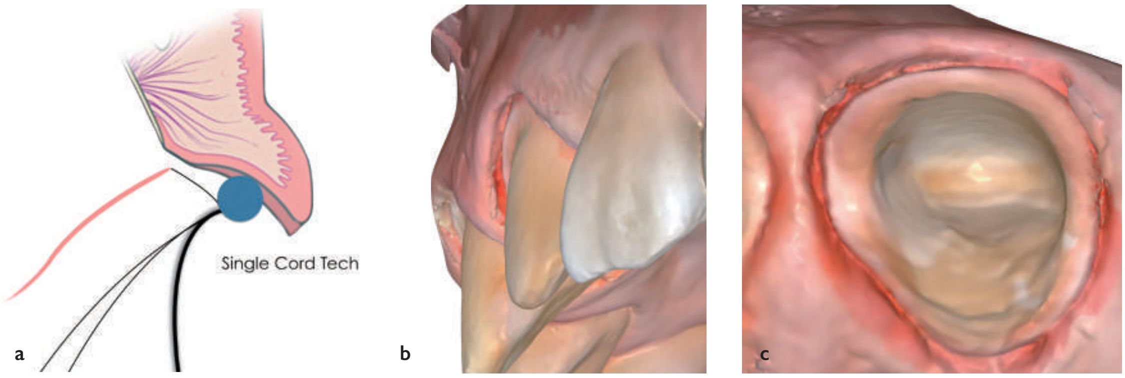
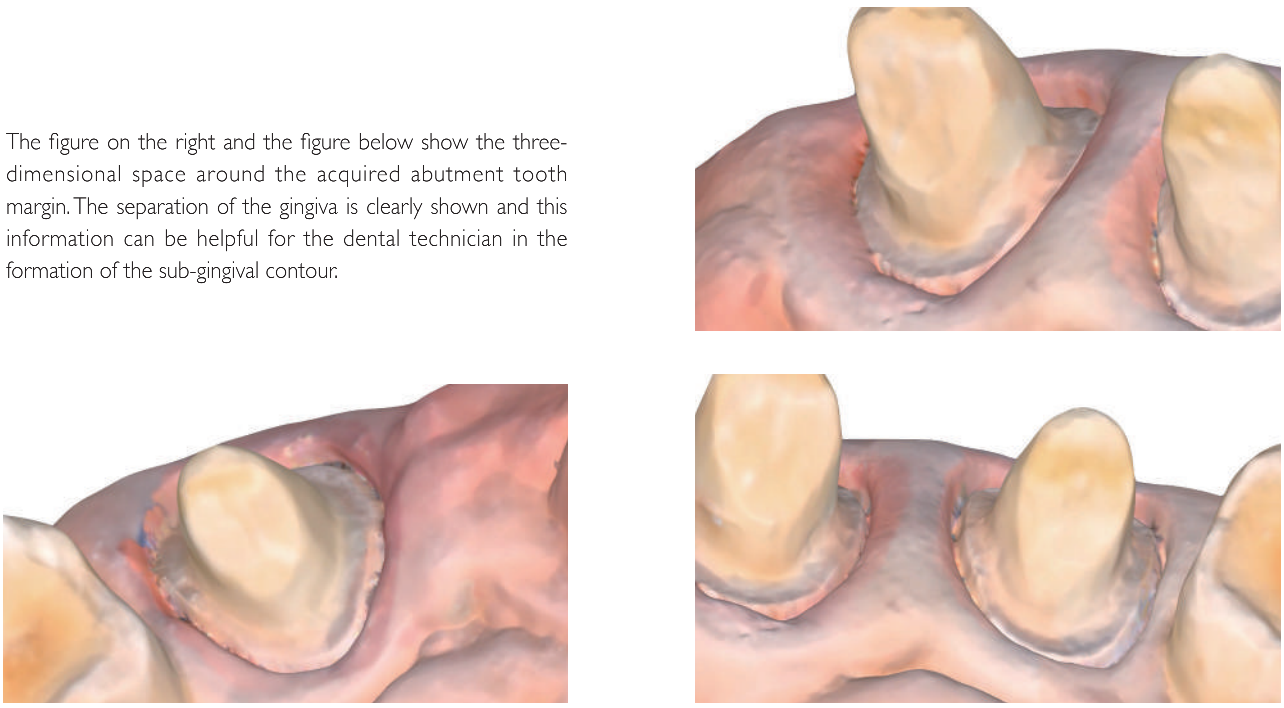


Fig. 11a-c. The above figure is scan data from a different case acquired with a well-controlled single cord technic. Compared with (Fig. 10), the image of the 1st cord on the subgingival margin is not seen and the area around the margin is very clear. This method is optionally used in the clinical practice.

Fig. 12. The figure on the right and the figure below show the three-dimensional space around the acquired abutment tooth margin. The separation of the gingiva is clearly shown and this information can be helpful for the dental technician in the formation of the sub-gingival contour.



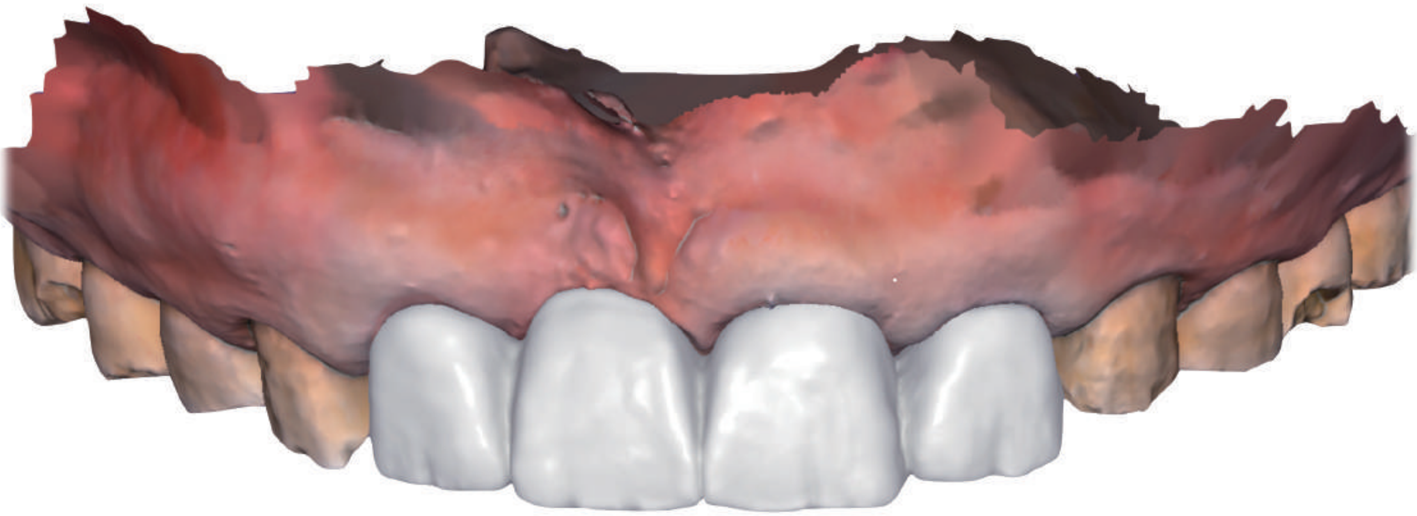


Fig. 13. 4-unit fixed partial denture is designed through CAD design.

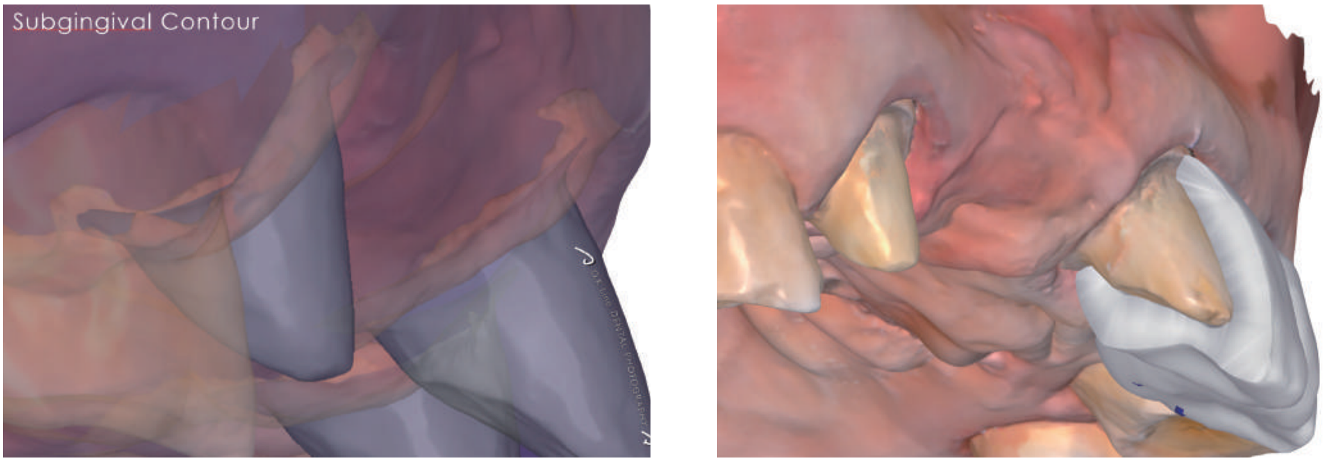


Fig. 14. Well-acquired subgingival margin impressions help in the best fit and reproduction of physiological subgingival forms.

Fig. 15. The state just before entering the furnace after coloring the cut bridge. The zirconia block used was KUWOTECH's ZIRMON A-2 Block, and the coloring liquid was also from KUWOTECH.

Fig. 16. This figure shows the state right after the furnace step. Staining and grazing are conducted in this state and the zirconia bridge is completed.

Fig. 17. To test the clinical fit of the completed zirconia fixed partial denture, a fit test was performed using light body type VPS silicone impression material. Adequate fit was verified across the entire margin. Many clinicians are suspicious of scan data from oral scanners. However, it is thought that the CAM software and the processing performance of the equipment and the problem of the plasticizer during the plasticization of the machined block have more influence on the fit among the procedures following scan data. The efforts in the clinical practice of dentists should be focused on the best possible formation of the abutment tooth and the clear impression taking of the area around the margin.

Fig. 18a-c. The figure shows functionally and aesthetically good outcome. Formation of subgingival margins and physiological subgingival shape maintain healthy gingiva.

Fig. 19. A state of healthy gingiva can be seen after 1 month.

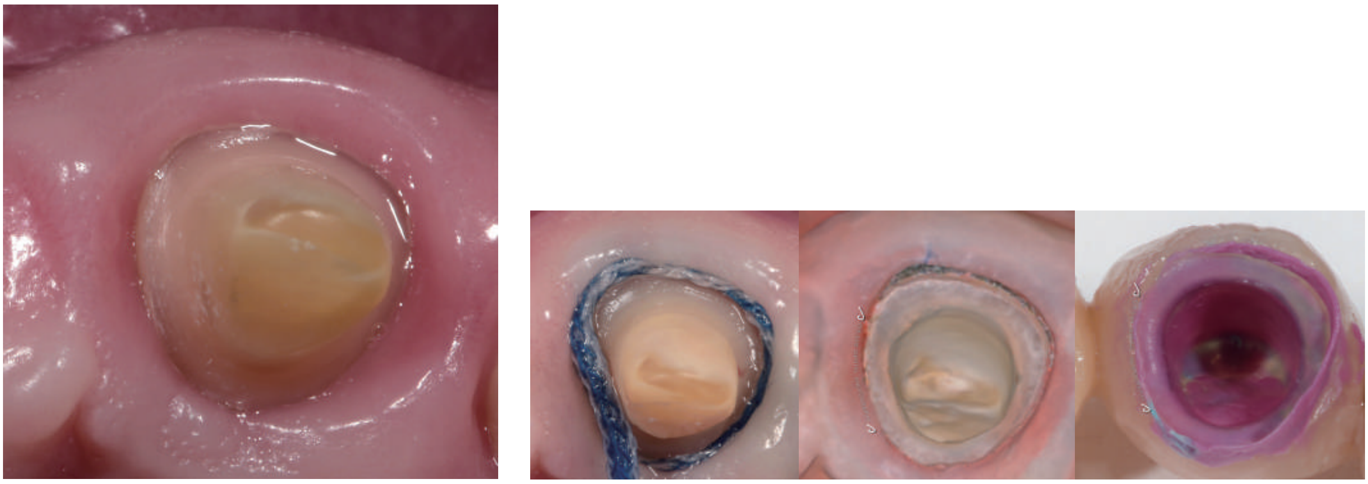


Fig. 20. A figure of healthy gingiva seen from occlusion surface after 1 month

Conclusion

A traditional method using retraction cord is introduced as a method for taking the subgingival margin impression in digital impression. It is thought that most clinical cases can be sufficiently resolved by appropriate cord selection and methods according to the type of surrounding gingiva in healthy periodontal conditions.

As seen from the above, although oral scanners are being incorporated into clinical practice, it is expected that the scanners will demonstrate its full effectiveness in clinical practice when the understanding and technical approaches are based on clinical practices faithful to the fundamentals of dentistry. More research and technology advancements will be required to make improvements on the areas that still have many limitations.

How to cite this article: Joe GA, Cha GJ. How to secure subgingival margin in restorative crown therapy using oral scanner. *J Clin Digit Dent.* 2019;1(2)6-14. www.jcdd.org

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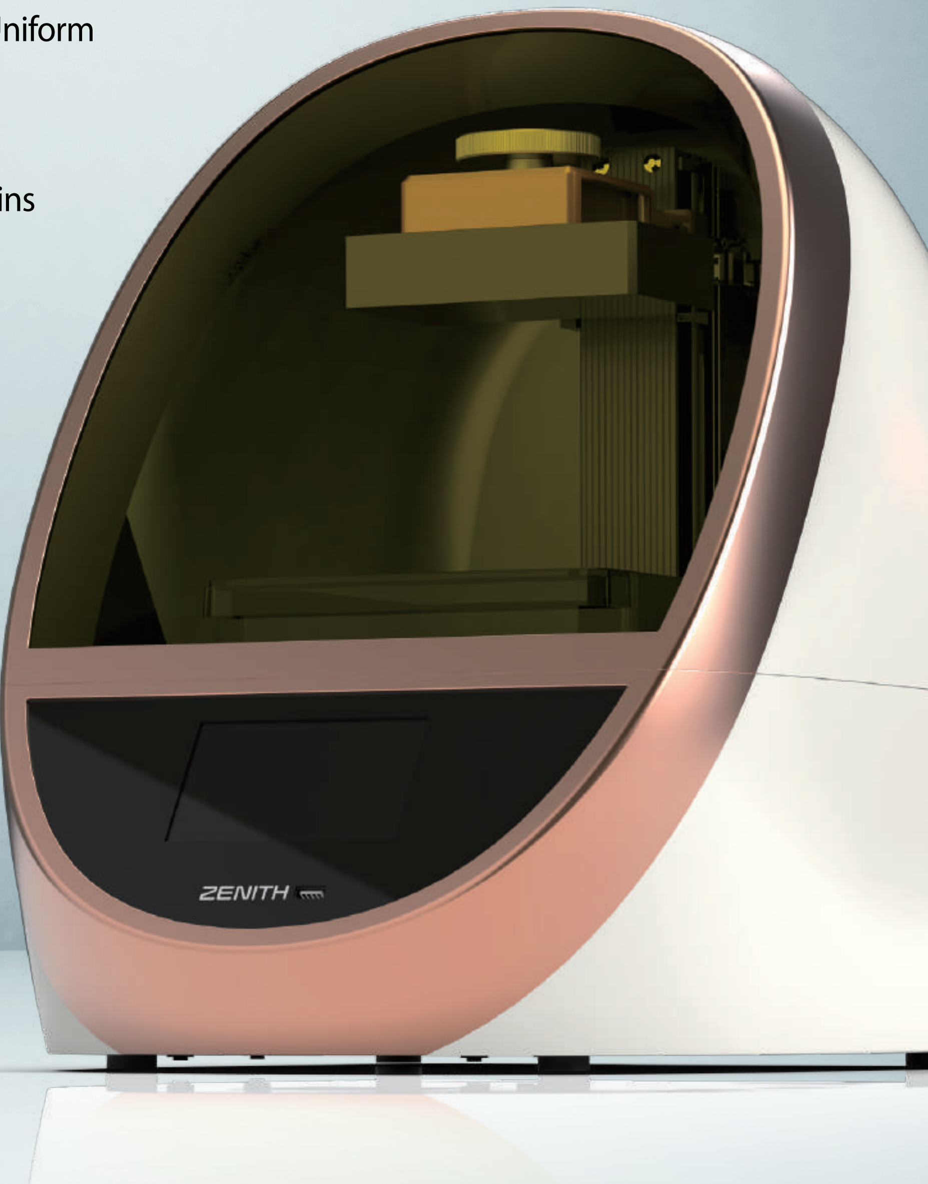

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Considerations for guided surgery accompanied by maxillary sinus floor elevation

Donghwan Kim, DDS, MSD

Introduction

Digital technology has been playing a more and more important role in dentistry for number of years, one of the most common used digitalized dental technique is digital radiography, which provides dental professionals potentially a better way of diagnosis and treatment for dental desease.[1-3] In the past several years, with the introduction of computed tomography (CT) and 3-dimensional (3D) printing into the field of implant dentistry, computer-aided design and computer-aided manufacturing (CAD/CAM) technology brought a great evolution of novel treatment concepts to dental implant treatment.[4] CT and 3D implant planning software can not only provide clinicians with 3D information of patient's anatomic structures, but also data regarding the patient's final prosthesis, these digital data can be combined with the CAD/CAM technology and further lead to a digital workflow ending with the production of stereolithographic (STL) template via a prototyping system.[5,6] The STL template can then be used to guide the position and direction of certain implants during surgery. By which, the whole surgical procedure is so called "guided dental implant surgery."

According to the consensus statement published in 2009,[7] the term "computer-guided surgery" is defined as the use of a static surgical guide that reproduces the virtual implant position directly from CT data and does not allow for intraoperative modification of the implant position. It has been demonstrated to be an established treatment,[6] which reduces the probability of damage to the adjacent critical structures such as bones, nerves, adjacent tooth roots, and sinus cavities. The main advantage of guided surgery is the ability to plan and optimize the implant position in a restoration-driven placement manner. Moreover, computer-guided technique can help to decrease postoperative discomfort and allows for immediate function, as they enable implant placement with minimal surgical trauma. In addition, this technique offers an alternative to bone augmentation in situation of severely resorbed alveolar ridges, as they facilitate optimal position of implants in available bones.[8-10] However, with the generalization of this technique, many doubts have risen on its usefulness and especially the accuracy.[11-15]

Accuracy in guided implant surgery is defined as matching the planned position of the implant in the software with the actual position of the implant in the patient's mouth.[13] It reflects the accumulation of all deviations from imaging over the transformation of data into a guide, to the improper positioning of the latter during surgery,[14] and the different types of errors include error during image acquisition and data processing, error during surgical template production, error during template positioning and movement of the template during drilling, and mechanical error caused by tolerance of surgical instruments. All errors, although seldom occurring, can be cumulative.

In recent years, several studies have been performed on different factors affecting the accuracy of guided surgery,[16,17] and systematic reviews[6,18-20] have evaluated these studies very well, focusing on the accuracy, clinical advantages, survival rates, complications of computer-guided surgery, and the influence of using different types of guide.

Clinicians must accurately evaluate the limitations of existing guided surgery systems based on these data and apply thesystemsin clinical settings. Evaluation of systems that are newly being developed may also provide useful data.

This paper reports a case of using a new guided surgery system and evaluates its results.

Donghwan Kim

Dr. Donghwan Kim was graduated from Seoul National University in 2000. He trained at the department of conservative dentistry, Seoul National University Dental Hospital. He gained a Master of Science in Dentistry at Seoul National University. He is one of best clinicians in digital dentistry. He is a key doctor of Arum Dentistry. He is a speaker of Vita and Dentium. He maintains a private clinic in Seoul, Republic of Korea.

Case Presentation

Planning Overview

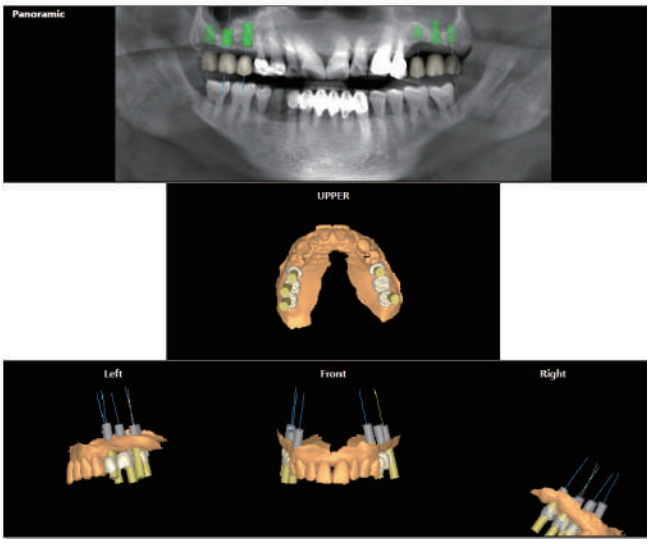

Fig. 1. Planning overview (a)Panoramic view (b)Implant planning

A 70-year-old male patient was wearing a partial denture due to loss of both maxillary posterior teeth. The patient visited my clinic to replace the denture that he had been using for 3 years with implants. CBCT (Dentri, HDX, Seoul, Korea) and intraoral scan(i500, Medit, Seoul, Korea) were performed in preparation of a guided surgery.

A guided surgery was planned using a softwareapplication(Dentiq Guide, 3DII, Seoul, Korea). An implant (SQ Implant, Dentis, Daegu, Korea) surgery was planned on all six lost teeth. The patient's bone density was measured between D2 and D3.

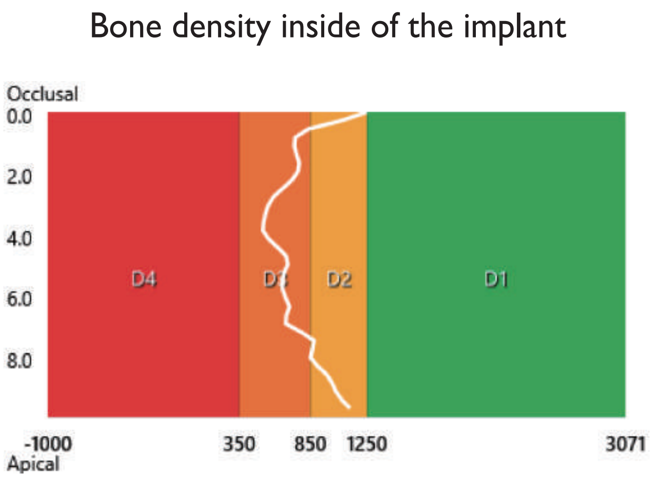

Fig. 2. Bone density of patient

This paper discusses the following:

1. Considerations to make when performing maxillary sinus floor elevation using a guided surgery system.
2. Evaluation of deviations in guided surgery.

1.Considerations to make when performing maxillary sinus floor elevation using a guided surgery system

In the posterior maxillary sextants, the insertion of implants of desired length and diameter may be limited by the dimensional alterations of the bone crest that occur after tooth loss,[21] partly due to the pneumatization of the maxillary sinus.[22] Transcrestal maxillary sinus floor elevation(tSFE) represents an effective surgical option to vertically enhance the available bone in the edentulous posterior maxilla.[23]

• Characteristics of the SQ GUIDE System

1. Sleeve

a. Offset (distance from the fixture): 9mm (can be changed to 8-14mm)

b. thickness : 4.5mm(default), 3.5mm

c. Hole offset (gap between the drill) : 50um

· Different combinations of offset (A) and thickness (B) may be used to produce a greater range of lengths with a limited number of drills.

· Smaller hole offsets (C) are expected to decrease deviations in the drill axis.

2. Only three rounds of drilling using a step drill of SQ GUIDE KIT and a tapered fixture are required for implant placement.

3. The groove on the SQ GUIDE KIT drill stop allows for efficient cooling.

We now discuss the considerations to be made when planning an implant(SQ Implant, Dentis, Daegu, Korea)surgery for the six teeth accompanied bymaxillary sinus floor elevation.

#15 (Implant: 5.0x10.0, Sleeve offset: 9.0 mm, Sleeve thickness: 3.5 mm, Drilllength: 10 mm, Fixture driver marker: 0 mm)

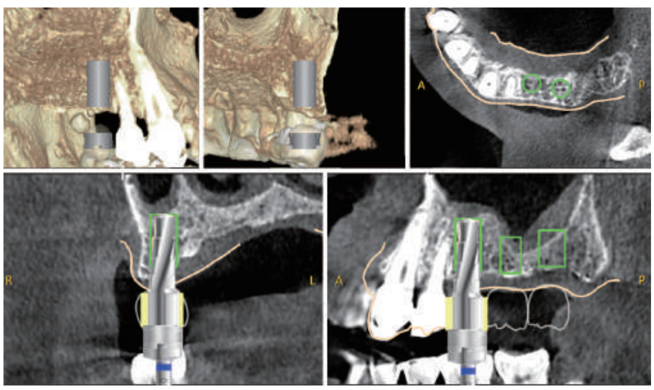

Fig. 3. Implant planning of #15

This part has a sufficient bone mass for placement of a 5.0x10.0 implant. A regular guided surgery can be performed here without the need for maxillary sinus floor elevation. Other parts could be compared with this part as the reference.

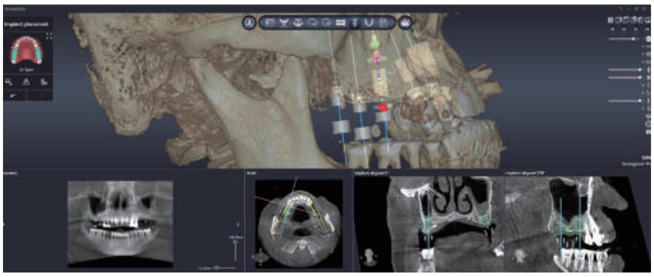

Fig.4. Screen shot of Dentiq Guide

1. A 5.0x10.0 implant(SQ Implant, Dentis, Daegu, Korea) is placed under the prosthesis. A virtual placement is completed by adjusting the vertical position of the implant to 1mm deeper than the alveolar crest.

2. The default sleeve offset of SQ GUIDE System is 9.0mm and can be moved vertically. In general, the sleeve position is moved by 2mm since the drill length changes by 2mm. The intrusion of the sleeve into the upper gingiva by 1mm can be resolved by reducing the sleeve thickness by 1mm. The default sleeve thickness is 4.5mm and can be changed to 3.5mm.

3. Drill Sequence: The drilling order is determined by considering the horizontal width and vertical height of the remaining bone, the selected implant size, gingival thickness, and bone quality. To secure early fixation in patients with D3 bone density, a 4.5mm final drill, which is thinner than the 5.0mm implant, is chosen. An advantage of using this drill is that it allows for implant placement with only three rounds of drilling using a step drill and a tapered implant.

4. An implant is placed until Marker 0 of the fixture driver. The install torque was 27 Ncm.

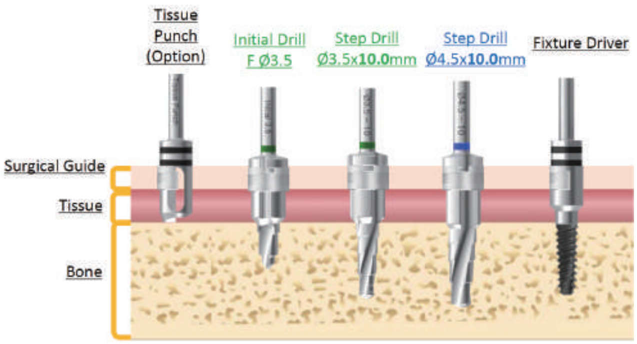

Fig. 5. SQ GUIDE KIT drilling sequence of #15

#16 (Implant: 5.0x7.0, Sleeve offset: 12.0 mm, Sleeve thickness: 4.5 mm, Drill length : 8 mm, Fixture driver marker: 3 mm)

The shortest implant (5.0x7.0) was chosen since the vertical distance of the bone was about 5mm. The bone is drilled up to the cortical bone of the sinus inferior border for maxillary sinus floor elevation. A limitation of this system is that the drill length starts at 8mm. To solve this problem, we can move the sleeve deeper by 3mm so that the 8mm drill reaches 5mm deep.

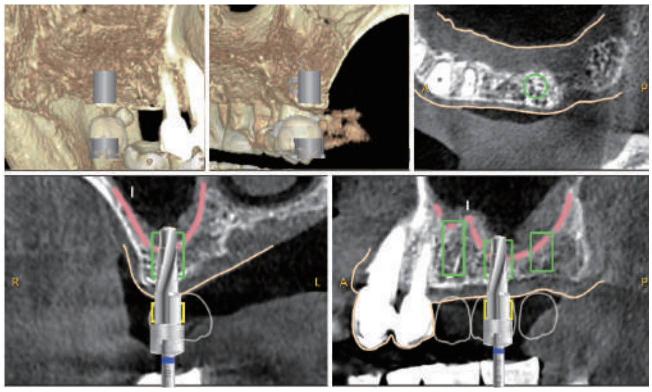

Fig.6. Implant planning of #16

1. A 5.0x7.0 implant is positioned in the under the prosthesis. A virtual placement is completed by adjusting the vertical position of the implant to 1mm deeper than the alveolar crest. The implant intrudes into the sinus inferior border and is placed 2mm deep in the upper portion.

2. Using an 8mm drill will cause the fixture to intrude deeper into the sinus inferior border by more than 3mm. The sleeve is pulled downward by 3mm (total offset 12mm) so that the 8mm drill just touches the sinus inferior border.

3. An osteotome sinus lift was carefully performed instead of an aqua sinus lift, which is also used these days. The lift was completed with final drilling using a 4.5x10.0mm drill.

4. The fixture driver of this system does not have a stop but has vertical height marks drawn with a marker. Although these marks do not guarantee accurate height measurements, they allow for flexible ways to cope with various situations. They also reduce the number of drills inside the surgical kit. An implant is placed until Marker 3 of the fixture driver. The fixture install torque was 46 Ncm.

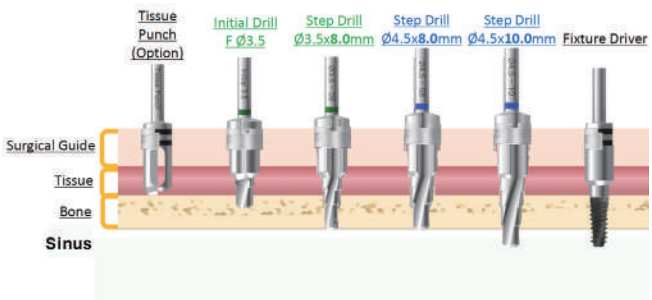

Fig. 7. SQ GUIDE KIT drilling sequence of #16

#17 (Implant: 5.0x7.0, Sleeve offset: 12.0 mm, Sleeve thickness: 4.5 mm, Drill length: 8 mm, Fixture driver marker: 3 mm)

The height of the remaining bone is 5mm just like #16. The same procedure was performed as the one performed on #16. The implant insertion torque was 42Ncm.

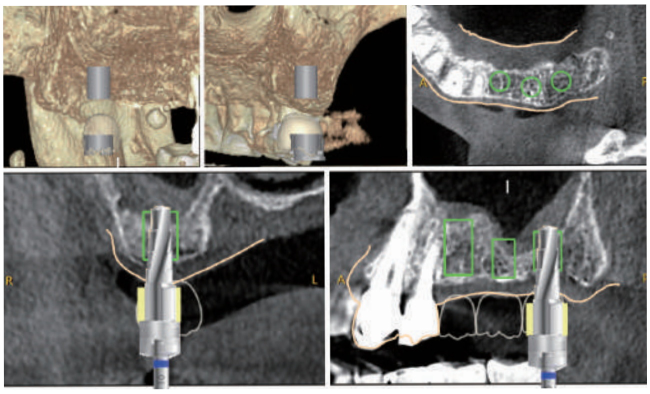

Fig. 8. Planning of #17

#25 (Implant: 5.0x10.0, sleeve offset: 13.0 mm, Sleeve thickness: 3.5 mm, Drill length : 14 mm, Fixture driver marker: 4 mm)

This part has a sufficient bone mass for placement of a 5.0 x10.0 implant just like #15. One difference from #15 is that the gingiva is thick and inclined in this part. The sleeve must be moved by 4mm and its thickness changed to 3.5mm to prevent it from touching the gingiva.

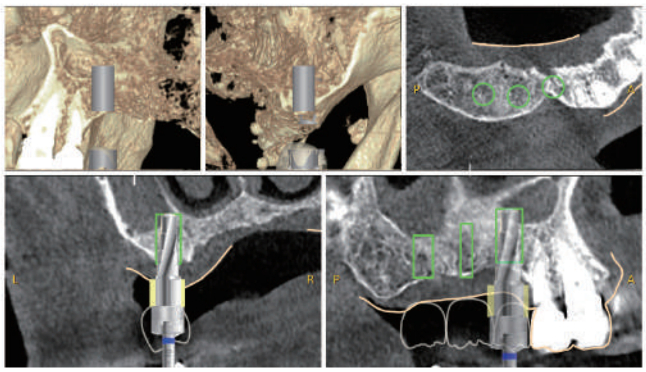

Fig. 9. Implant Planning of #25

An implant can be placed after removing the bone with a 14 mm drill and placing a fixture driver 4mm deep. The implant insertion torque was 35Ncm.

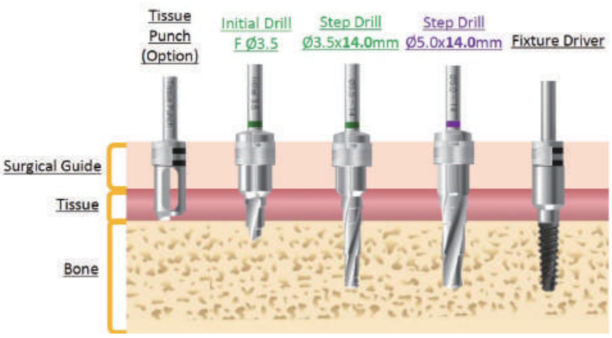

Fig.10. SQ GUIDE KIT drilling sequence of #25

#26 (Implant: 5.0x10.0, Sleeve offset:.9 mm, Sleeve thickness: 3.5 mm, Drill length : 10 mm, Fixture driver marker: 0 mm)

The height of the alveolar bone in #26 ranges from 8mm to 10mm since the sinus inferior border is inclined. A 5.0x 10.0 implant must be partially placed in the sinus floor to perform bi-cortical fixation for promoting early fixation. Since there is a 1mm overlap between the sleeve and the gingiva, a 3.5mm sleeve is used to evade the overlap. An implant was placed to Marker 0 of the fixture driver. The implant insertion torque was 47 Ncm.

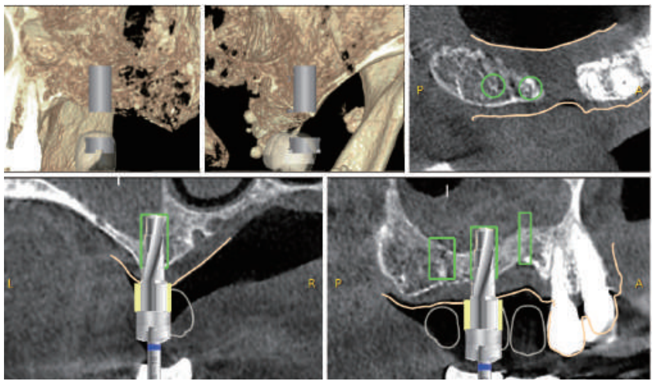

Fig. 11. Implant planning of #26

#27 (Implant: 5.0x8.0, Sleeve offset: 11 mm, Sleeve thickness: 4.5 mm, Drill length : 10 mm, Fixture driver marker: 2 mm)

The height of the alveolar bone in #27 was 6-8mm as was the case in #26. A 5.0x8.0 implant was selected for bi-cortical fixation. Since the overlap between the sleeve and the gingiva was around 2mm rather than adjusting the sleeve length. For this reason, a 10mm drill was used, and an implant was placed to Marker 2 of the fixture driver. The fixture insertion torque was 41Ncm.

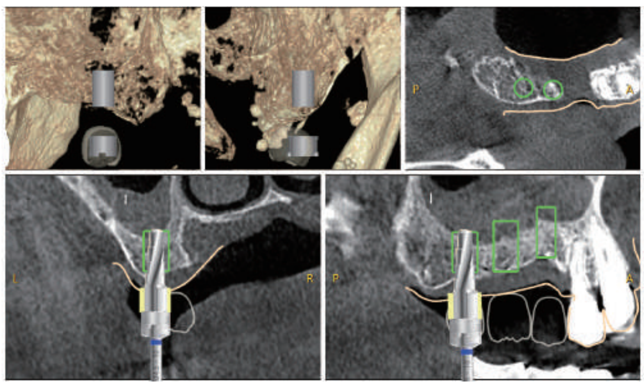

Fig. 12. Planning of #27

Table1. Summary of planning(SQ GUIDE System, Dentis, Daegu, Korea)

	Bone height (mm)	Implant (mm)	Gingiva thickness (mm)	Sleeve thickness (mm)	Sleeve offset (mm)	Drill length (mm)	Fixture driver marker (mm)	Install torque (Ncm)
#15	10+	5.0x10.0	3	3.5	9	10	0	27
#16	5	5.0x7.0	2	4.5	12	8	3	46
#17	5	5.0x7.0	2	4.5	12	8	3	42
#25	10+	5.0x10.0	5	3.5	13	14	4	35
#26	8-10	5.0x10.0	3	3.5	9	10	0	47
#27	6-8	5.0x8.0	4	4.5	11	8	2	41

2. Deviations of implants placed using the surgical guide

Meta-regression analysis from fourteen clinical studies revealed a mean deviation at the entry point of 1.25 mm (95% confidence interval [CI]: 1.22-1.29), 1.57 mm (95% CI: 1.53-1.62) at the apex, and 4.1° in angle (95% CI: 3.97-4.23). A statistically significant difference (P , .001) was observed in angular deviations between the maxilla and mandible. Partially guided surgery showed a statistically significant greater deviation in angle (P ,.001), at the entry point (P ,.001), and at the apex (P ,.001) compared with totally guided surgery. The outcome of guided surgery with flapless approach indicated significantly more accuracy in angle (P ,.001), at the entry point (P , .001), and at apex (P , .001). Significant differences were observed in angular deviation based on the use of fixation screw (P ,.001).[24]

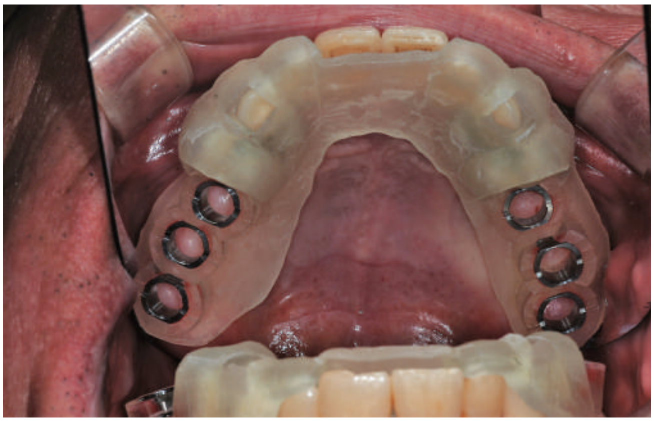

Fig. 13. Occlusal view of Dentiq surgical guide

Fig. 14. Intraoral photo right after implant placement.

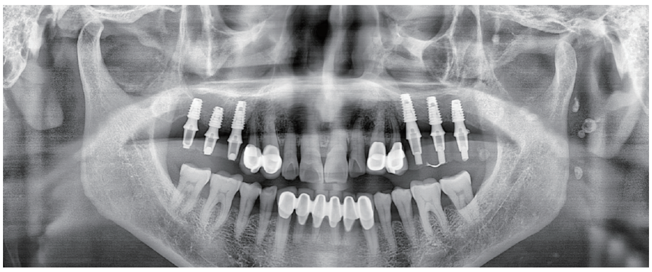

Fig. 15. Panoramic x-ray right after installation

We evaluated the guide system based on these evaluation parameters. First, we compared the deviations between the virtually placed implant and the implant that was actually placed.

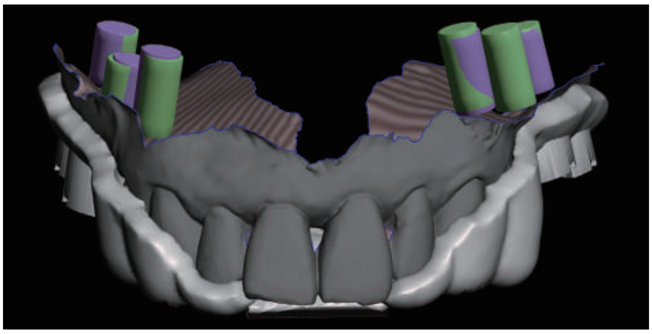

Fig.16. Comparison of deviations – Green indicates the virtually placed implant, and purple indicates the implant that was actually placed.

Table 2. Deviation of implant entry (mm)

15_Entry	x	0.24528	25_Entry	x	-0.16033
	y	-0.33729		y	0.00969
	z	-0.26289		z	0.6083
16_Entry	x	-0.26934	26_Entry	x	0.04329
	y	-0.03407		y	-0.13483
	z	-0.12977		z	0.12819
17_Entry	x	0.25168	27_Entry	x	-0.16831
	y	0.0968		y	0.08495
	z	-0.12026		z	0.21824

Implant apex deviation

The mean horizontal (x,y) deviation at the implant entry was 0.241 mm. This corresponds to 19% of the deviation found in the previous study. The mean vertical (z) deviation was 0.244m. The small deviations may be attributed to the fact that the fixture driver had no vertical stops.

Table 3. Deviation of fixture apex (mm)

15_apex	x	0.40428	25_apex	x	-0.16033
	y	-0.7591		y	0.00969
	z	-0.18287		z	0.6083
16_apex	x	-0.75175	26_apex	x	-0.03096
	y	-0.1325		y	-0.45751
	z	-0.05349		z	0.1721
17_apex	x	0.29535	27_apex	x	-0.04701
	y	0.13862		y	0.10487
	z	-0.13549		z	0.25549

Fixture apex deviation

The mean horizontal (x,y) deviation at the implant apex was 0.491mm. Although this was a 0.250mm increase from the deviation at the implant entry of 0.241mm, it corresponds to only 31% of the deviation found in the previous study of 1.57mm. The mean vertical (z) deviation was 0.234mm, differing very little from the mean deviation at the implant entry of 0.244m.

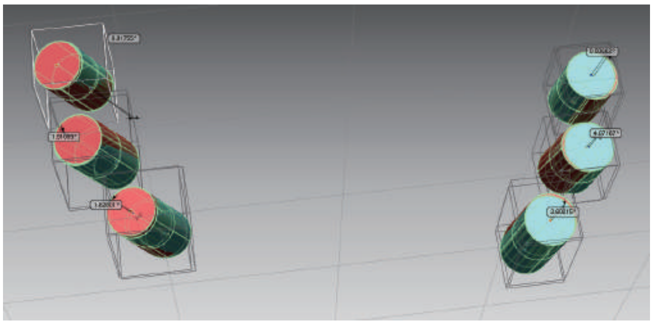

Fig. 17. Difference of angle

Table 4. Difference of angle(degree)

	angle
15	1.62801
16	1.91099
17	0.91755
25	2.60215
26	4.07167
27	0.50682
degree average	1.939532

The implant angle deviation was 1.9 degree s, corresponding to 46% of the deviation reported in the previous study of 4.1 degrees.

Discussion

When planning an implant surgery, a implant must be chosen based on bone width and height. By elevating the sinus floor in the posterior maxilla, it is possible to overcome the vertical limits to a certain extent. The goal of transcrestal maxillary sinus floor elevation (tSFE) is to eliminate the bone precisely up to the compact bone of the sinus inferior border without severing the Schneiderian membrane, and this can be achieved by using an appropriate combination of drill length and sleeve offset of the digital surgical guide. A fixture driver must have a flexible stop in order to place a fixture with a single guide. The system used in this study has markers in place of stops. Even with the guide system used in this study, there were still many things that need to be considered during the planning process. It is hoped that the system will be improved for more intuitive and simple planning and surgery.

The system used in this study had a mean deviation of 0.241 mm at the entry and 0.491 mm at the apex, and a mean angle 1.9 degrees. Although a sample size of six fixtures is too small to make an accurate comparison with previous studies, the deviations improved by 81% at the entry, 69% at the apex, and 54% at the angle relative to the deviations and angle reported in a previous study. The most likely reason for these improvements may be that the internal offset of the sleeve hole was 50um and was much smaller than the deviations in existing systems (around 100um).

However, further reduction in deviations is needed in order to make prosthesis prior to surgery, and this may be achieved through guide fixation.

Fig. 18. Provisional prosthesis that is made by milling PMMA disc will secure immediate loading.

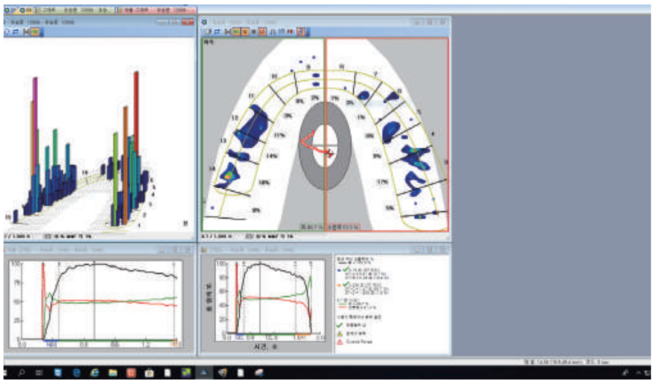

Fig. 19. Result of T-Scan

The higher install torques in #16, 17, 26, and 27 may be attributed to bicortical fixation. A sophisticated provisional prosthesis is important for early fixation and immediate loading. By producing a temporary prosthesis using CAD/CAM, a better internal fit and more even occlusion can be achieved than using conventional techniques(Fig.18.).

Conclusion

When performing a guided surgery accompanied by maxillary sinus floor elevation, a implant size must be chosen based on the alveolar bone width and height, and a guide that includes a sleeve offset and thickness, and drill length is created based on the chosen implant length, location of the sinus inferior border, and gingiva thickness. This is a very complex process that clearly needs improvement. Although an accurate comparison was difficult due to the small number of cases studied, the new guide system significantly reduced implant placement deviations by using a sophisticated sleeve. Additional guide fixations may further reduce deviations to enable prefabricated prostheses.

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SQ GUIDE

DENTIS Digital GUIDE System for SQ IMPLANT

Application of Irrigation

Reduce bone heating with innovative irrigation-type drill design

Fixture Placement is Possible with Only Three Drillings

Application of multi-pass drilling makes 2-point fixation possible with increased accuracy due to minimal tolerance

Sleeve with Biocompatible Material

Increased stability with titanium sleeve

Stress Free! Use SQ Implant

DENTIS SQ implant with strong initial fixation

DENTIS

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Web based and Artificial Intelligence driven Orthodontic Analysis System

Yehyun Kim, DDS, MSD

Introduction

With the development of artificial intelligence technology, various attempts have been made to utilize artificial intelligence technology throughout the industry. In an academic or industrial field based on statistical analysis of data, it is expected that artificial intelligence technology can assist experts to reduce errors with the continuous development of related artificial intelligence technology. Orthodontics is a clinical field in which experts make comprehensive decisions based on the quantitative analysis of the human skeleton and dentition. Therefore, artificial intelligence technology is expected to play an important role especially in the field of orthodontics due to its clinical and academic characteristics that depend on numerical and statistical data analysis. In particular, image recognition and image processing are the basis of data analysis and artificial intelligence has achieved remarkable achievements in this area. Recent emergence and development of deep convolutional neural networks (CNNs) has shown excellent performance in the ability to learn and extract important features of images.[1,2] The performance of artificial intelligence in image recognition has begun to outperform human cognitive abilities.[3] Attempts have been made to introduce such artificial intelligence driven image recognition technology in medical image field. In orthodontics, there also have been many attempts to utilize digital image recognition and image processing technology especially for the cephalometric analysis, and the performance has been dramatically increased with the recent development of artificial intelligence technology.[3-12]

In this paper, I will present a web-based artificial intelligence driven orthodontic analysis system that supports automated cephalometric landmark detection using machine learning algorithm, examine the system's main functions and how clinically it can be used. Through this, we will take a glimpse into the future of digital orthodontics.

Case Presentation

MACHINE LEARNING

Machine learning is a subset of artificial intelligence that processes data to build a mathematical model(Hypothesis), which accepts input data to make prediction output.

Fig. 1. Basic Concept of Prediction System

In conventional programming, researchers had to program the hypothesis using a complex conditional formula, based on their experience or logic. However, this rule-based conventional programming has limitation in simulating the complicated natural and social phenomena of the real world.

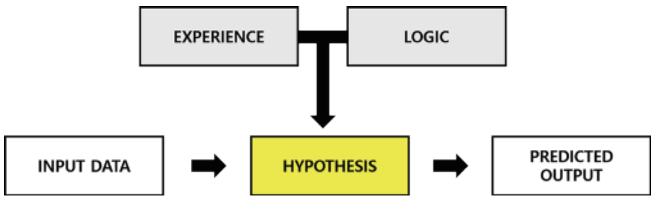

Fig. 2. Schematic Drawing of Conventional Programming

Yehyun Kim

Dr. Ye Hyun Kim graduated from the College of Engineering, Seoul National University in 2007. He got Master's degree and D.D.S from the School of Dentistry, Seoul National University in 2011. He completed residency training at the Department of Orthodontics, Seoul National University Dental Hospital. He worked as a fellow in the Department of Orthodontics, Seoul National University Dental Hospital in 2016. He is currently a board-certified orthodontist, member of the Korean Association of Orthodontists, international member of American Association of Orthodontist and Fellow of World Federation of Orthodontists. He is running a private practice in Gimhae, Republic of Korea.

Machine learning is not a logical process of finding a predictive model by humans, but rather by putting a lot of data into the input, the computer finds this hypothesis (prediction model) by itself.

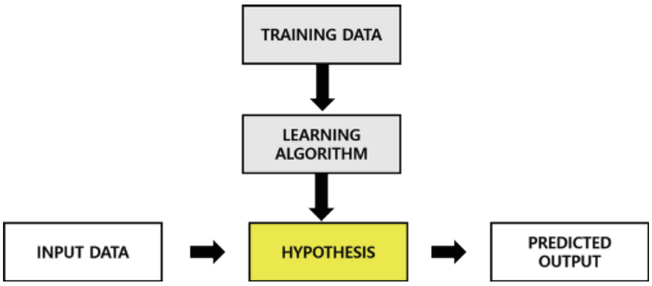

Fig. 3. Schematic Drawing of Machine Learning

Before feeding data into the learning algorithm of machine learning, preprocessing of data, that is, extracting the key features of data, can be added, thereby making it possible to generate a more accurate prediction model. After a prediction model is created, when new input data is given, the predicted output data can be produced as a result. The overall flow of machine learning process is as follows.

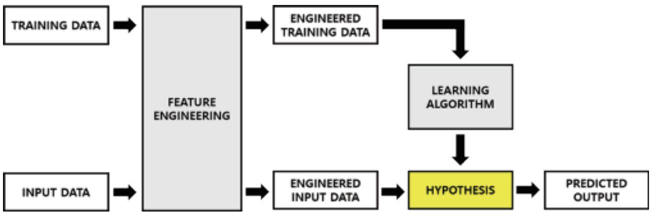

Fig. 4. Overall process of Machine Learning

Various machine learning algorithms exist according to the nature of the data and statistical methodology (ie, whether data type is continuous or discontinuous). Decision tree algorithms which have many derivative forms have shown relatively good results until the recent advent of deep learning. Neural network is a method of making prediction models using multiple perceptions which simulate the human brain and neurons. Deep learning is a type of neural network in which layers of this network are stacked in many to improve its inference ability.

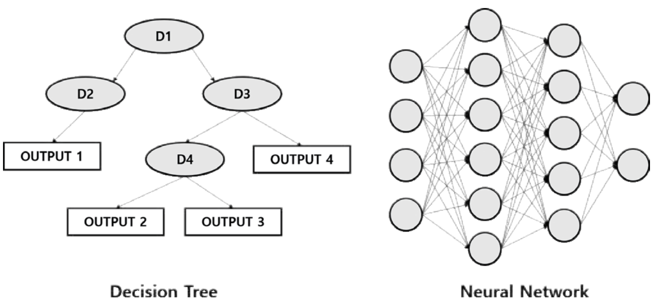

Fig. 5. Two types of Learning Algorithms

MACHINE LEARNING IN LANDMARK DETECTION OF LATERAL CEPHALOMETRIC RADIOGRAPH

Localizing anatomical landmarks of cephalometric radiograph requires deep understanding of the anatomy of the skull, requires concentration of orthodontists. In addition, there may be some inconsistency depending on the person digitizing it. There have been many attempts to detect anatomical landmarks using machine learning algorithm.

I introduce basic principle of automatic landmark detection of a web-based artificial intelligence driven cephalometric analysis system called WebCephTM (https://webceph.com). WebCephTM has two train models, facial area detecting model and landmark detecting model. After receiving a lateral cephalometric radiograph as input, prediction system of WebCephTM modifies the image with the Histogram of Oriented Gradients (HOG) algorithm to make boundaries of soft-tissue and hard-tissue be seen clear and recognition of lateral facial region more accurate. The first prediction model, the facial area detecting train model, scans the modified image and crop the detected facial area. This process ensures that the prediction system can reliably detect anatomical landmarks even when receiving cephalometric radiographs of varying specifications as input data. Thereafter, the cropped image is taken as an input, and the anatomical landmark detection process which is performed by the point detecting train model is automatically performed. The labels and coordinate values of each anatomical landmarks that have been detected by prediction models are given as output in the form of matrix. Finally, WebCephTM displays these results on the screen.

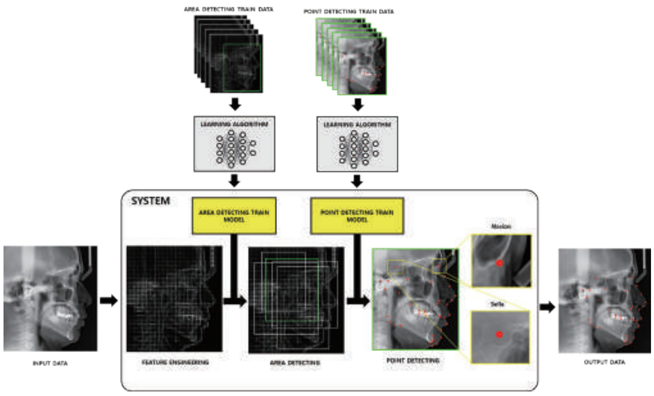

Fig. 6. Schematic Flow of Machine Learning driven Automated Landmark Detection

PRACTICAL APPLICATION OF MACHINE LEARNING BASED ORTHODONTIC ANALYSIS SYSTEM

In order to confirm whether the prediction system can be used clinically in actual practice, it is necessary for the system to be tested whether it shows consistent and reliable results in various different images.
In order to do this, a large amount of test dataset should be prepared by an orthodontist and compared with the output data of the same dataset by the prediction system in statistical methodology. In addition, there will be various experimental designs such as whether to use test dataset prepared by only one orthodontist or several orthodontists.
However, in this paper, I aimed to verify whether the prediction system produce reasonably good results for practical use rather academic purpose. The system was tested under the following two different conditions: 1. dataset of different skeletal patterns, 2. Dataset of different image settings.

Verification of detection performance on dataset of 9 types of different skeletal patterns

Lateral cephalometric radiographs of 9 types of different skeletal types (Hyperdivergent vertical facial pattern with Skeletal Class I, Hyperdivergent vertical facial pattern with Skeletal Class II, Hyperdivergent vertical facial pattern with Skeletal Class III, Normodivergent vertical facial pattern with Skeletal Class I, Normodivergent vertical facial pattern with Skeletal Class II, Normodivergent vertical facial pattern with Skeletal Class III, Hypodivergent vertical facial pattern with Skeletal Class I, Hypodivergent vertical facial pattern with Skeletal Class II and Hypodivergent vertical facial pattern with Skeletal Class III) were prepared and input into a prediction system to check whether the system produces consistent prediction results in various skeletal types.
Although the number of datasets is not sufficient and appropriate statistical techniques should be used for evaluation, the prediction system has shown clinically useful results for different skeletal types.

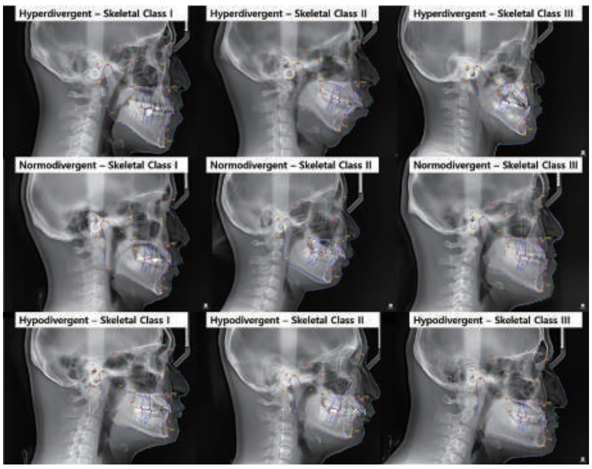

Fig. 7. Landmark Detection Results of 9 Different Skeletal Types

Verification of detection performance on dataset of different image settings

Test samples of cephalometric radiographs were modified to various image settings (brightness and gamma) to such a degree that it is difficult even for human eyes to accurately detect, and it is tested whether the prediction system make consistent and good prediction in such difficult conditions.
As a result of testing the artificial intelligence driven landmark detection system on images modified by various setting values, the system has also shown reliable and consistent results which is practically good enough and sufficient for use in the clinic.

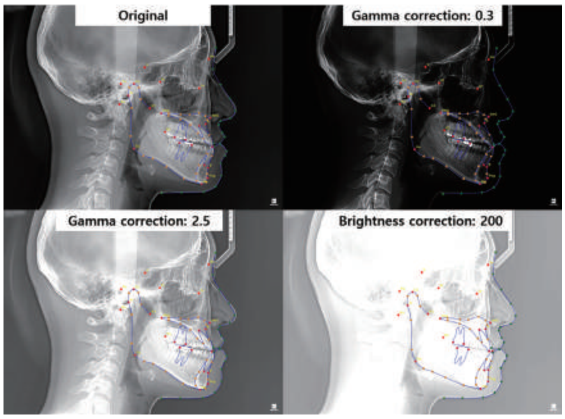

Fig. 8. Landmark Detection Results of Different Image Settings

Overview of Machine Learning Based Orthodontic Analysis System

In this section, I will overview the main features of WebCeph™, which is a web-based artificial intelligence driven orthodontic analysis system. This is an online system that is developed on the web cloud environment. Therefore, clinicians can not only access patients' record without any matter where the clinician is, but perform cephalometric analysis and diagnosis of each clinical case on spot. This system is developed with artificial intelligence-based technology which is based on the big data. It shortens the time of the individual steps performed in the diagnostic process and help clinicians analyze data more accurately and reduce errors.

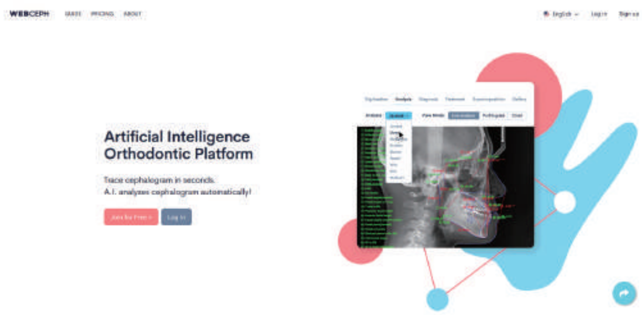

Fig. 9. WebCeph™: Web-based and Machine Learning driven Orthodontic Analysis System

1. **Automated Detection of Anatomical Landmarks and Cephalometric Analysis**
This online orthodontic analysis system provides reporting function which contains a line analysis, profilogram analysis and chart analysis of various cephalometric methods based on detected landmarks. It supports exporting as pdf format and printing.

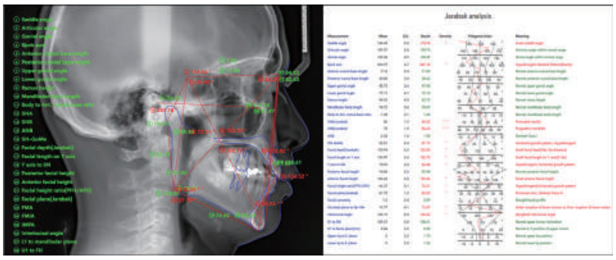

Fig. 10. Cephalometric Analysis by Machine Learning based Orthodontic Analysis System

2. **Automated Image Alignment and Visual Treatment Simulation**
The system utilizes artificial intelligence technology to automatically superimpose and align patient's lateral facial images to fit lateral cephalometric radiographs. Based on the detected points, the outline of the maxilla, mandible, chin, soft tissue and teeth is automatically generated and displayed on the screen. It can be translated and rotated individually to perform virtual orthodontic treatment and orthognathic surgery. When the virtual treatment is completed, the image warping function can be used to predict the change of the patient's soft-tissue outlines. This can be exported or saved as animation and video file. The treatment simulation results and video files can be shared with patients via e-mail or direct messengers to increase the efficiency of communication with patients.

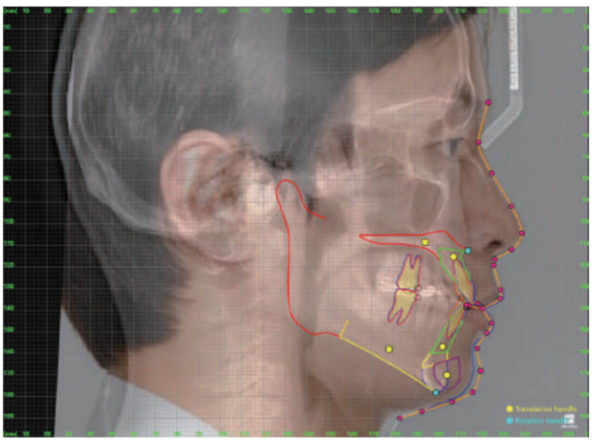

Fig. 11. Automated Image Alignment and Visual Treatment Simulation

3. **Automated superimposition of lateral cephalometric radiographs**
The system uses artificial intelligence technology to automatically perform the process of superimposing the cephalometric radiograph taken in the middle of the treatment or at the end of the treatment with the initial cephalometric radiograph. When the patient is wondering about the progress of the treatment, or when the orthodontist wants to check the progress of the orthodontic treatment, an orthodontist can increase the confidence and rapport between the patient and the dentist by completing the superimposition on the same day they took the record.

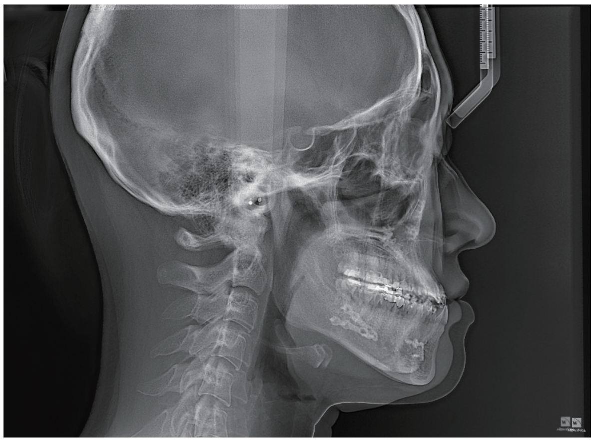

Fig. 12. Automated Superimposition of Cephalometric Radiographs

4. **Cloud storage and Clinical image gallery**
The system provides cloud storage and has a gallery function that automatically organizes images into templates. In addition, clinical images are placed on the both sides of the screen to be compared to help the patient in understanding the treatment progress and outcome. These templates can be saved or exported as pdf, which can be useful for clinicians even when consultation is needed in offline environment.

Fig. 13. Clinical Image Gallery

Discussion

Machine learning based orthodontic analysis system produced clinically useful and reliable results for different types of skull. It also showed consistent results in various image settings. This is possible because of the image augmentation technique of dramatically increasing the number of training dataset by randomly changing the brightness and gamma value of the images and by rotating images slightly in the process of training. Accuracy of the system is expected to increase further as the number of future training data increases and the artificial neural network algorithm becomes more sophisticated.

Artificial intelligence driven orthodontic diagnostic system helped to shorten the time it takes to find anatomical landmarks in cephalometric radiographs. In addition, as the system is built on web, clinical data and analysis results can be viewed from anywhere, maximizing the convenience of orthodontists. Visual treatment simulation and animation function were helpful in increasing the understanding of the treatment planning for patients.

Giving consultation on the day of recording with the result of superimposition of radiographs helped to increase the patient's understanding of the treatment progress and increase the confidence of orthodontists about their treatment.

Conclusion

Although more image conditions and more samples will need to be tested, artificial intelligence driven orthodontic diagnostic system has shown clinically acceptable accuracy in various image conditions and skeleton types. Artificial intelligence technology is expected to be used more in orthodontics, and play an important role in assisting professional decision making and reducing clinician's judgment error. With the advance of the cloud computing technology, clinical environment of dental clinic will gradually change to a web-based environment where dentists can review patient data and create treatment plans from anywhere in the world.

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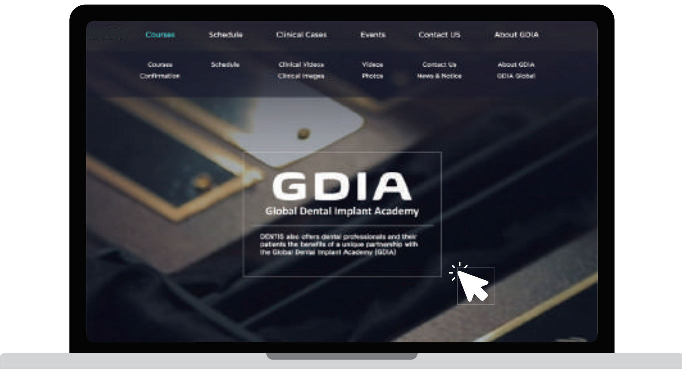
	21/22	Seminar	[DENTIS X DENTAL BEAN] Blue Course – Soft tissue grafting and full mouth for esthetics of maxillary anterior teeth	Insung Jeon/Sewoung kim	Seoul (Korea)
	28	Seminar	[DENTIS X DENTAL BEAN] Only On Suture Hands-on	Jaeyoon Kim	Seoul (Korea)
	29	Symposium	[DENTIS X DENTAL BEAN] DENTIS WORLD SYMPOSIUM in SEOUL		Seoul (Korea)
Oct.	5/6/19/20	Seminar	[DENTIS X DENTAL BEAN] Dental Bean Blue Course – Soft tissue grafting and full mouth for esthetics of maxillary anterior teeth	Insung Jeon/Sewoung kim	Seoul (Korea)
	12/13	Seminar	[DENTIS X DENTAL BEAN] Dental Bean Red Course - Start of Implant surgery and prosthetics	Yongseok Cho/Sewoung kim	Seoul (Korea)
	20	Seminar	Correct Implant Clinical concept seminar	Kibin Yang	Seoul (Korea)
	27	Seminar	SQ Guide Hands-on course	Sangjin Suh/ Youngmin Ham	Seoul (Korea)
Nov.	3	Seminar	GDIA China Seminar in SHANGHAI	Soonkyu Chung	Shanghai (China)
	21/22/23/24	Symposium	DENTIS WORLD IMPLANT SYMPOSIUM in SPAIN		Madrid (Spain)
Dec.	15	Seminar	LIVE Surgery	Insung Jeon	Seoul (Korea)



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