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The Surgical Guides for TADs: The Rational and Laboratory Procedures

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Abstract: The widespread and popular use of TADs for orthodontic anchoring has become a daily routine in clinical orthodontic treatment. However, as there have been many accidents over the past decade, safety action is needed to help reduce these accidents. We have advocated using the surgical guide and developed a procedure that can benefit patients and orthodontists. The first part of this paper is about the rationale for making the surgical guide for various implant placements that were observed. Due to their anatomical structure, some placements may require particular attention, which is focused on and discussed in length. The second part deals with fabricating the surgical guide in the laboratory procedure. The data from the intraoral SLT acquisition was extracted, and with the DICOM data from CBCT and in a 3-Shapes software, the guidance was designed. The detailed and step-by-step laboratory procedure, CAD/CAM, and 3D printers to make the surgical guide for TADs are explained. The procedure is performed in an easy-to-understand manner to make using the surgical guide possible for the daily practice of orthodontics (Pubmed).

Keywords: surgical guide; orthodontics; TADs; CBCT; DICOM; SLT; CAD/CAM; 3D digital printer; dentistry; miniscrews

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1. Introduction

Over the past two decades, temporary anchorage devices (TADs) have become important and essential armamentariums in orthodontic practice. TADs are now recognized as one of the most effective ways to conserve anchorage and move dental units in such a way as to reduce the need for extraction and surgical treatments [1,2]. Root collusion issues during TAD placement and surgical trauma have adversely affected the use of TADs [3–13]. One of the solutions for the safe placement of TADs is to follow step-by-step procedures and use surgical guides, which is possible with technological innovations. Most of the pioneers of surgical guides arise from those using the dental implant, a technique that has been used for decades [14–16]. A surgical guide for inserting single-standing TADs facilitates placement and is integral to safe clinical practice. Creating and making a surgical guide has become possible with the advanced application of CAD/CAM technology and the affordability of 3D printers [17].

This paper covers two main topics: the importance of using a surgical guide for TAD implantation and the process of creating the guide.

There have been numerous papers discussing the issue of TAD usage successes and failures. One of the critical areas is the placement itself, causing trauma to the tooth's root and damaging the periodontal membrane [18]. Such unwanted complications happen, especially in inter-root implantation. The average TAD's diameter is between 1.4 to 1.8 mm, and, often, the interdental bone may not be available to accommodate these dimensions [19–21].

The placement of TADs is required to be either in interdental bone or other safe anatomical sites of the maxilla and mandible. Accurately placing TADs without hindering dental roots and other structures is crucial for their safety and stability during dental movements. By having complete control over the placement, an orthodontist can conduct orthodontic biomechanics in an organized and optimized manner, resulting in reduced treatment duration and better quality of treatment outcome [22].

According to studies, implants placed using the freehand method had significantly higher errors. The risk of positioning errors was as high as 88% when using the freehand method. At the same time, single-type, mucosa-supported guides had the lowest error rate of only 6%, even when other factors were considered [23]. Orthodontists had the opportunity to learn from the past when prosthodontics and other disciplines started using surgical guides for dental implants [24–26]. A surgical guide for TADs is intended to reduce orthodontist challenges, and designing the procedure for practical use in daily orthodontic practice will benefit patients and the orthodontist practitioner.

The benefit for patients is less trauma and shorter surgical appointments. Using a surgical guide to place TADs precisely allows for accurately preparing a post-insertion appliance in the laboratory. The laboratory personnel must discuss with the orthodontist to ensure the success of the surgical guide. After the TAD insertion procedure, the post-insertion appliances, which are ready beforehand, are issued in the same appointment. The system using CAD/CAM metallic-printed appliances has been used as an example with a resin surgical guide [27–29].

The system will enable the transfer of the predetermined planning to placing the TADs. The same method can involve several TADs, making them parallel or placed on predetermined angulation when needed. The advantage of the system is to place an appliance immediately after the TADs' placement, as noted above. The system allows a possibility to elevate the search for dentofacial orthopedics to the next level, such as distraction osteogenesis, which is relatively less invasive than surgical orthodontics but may need complex design as several TADs should be placed accurately.

2. The First and Second Parts of Making the Surgical Guide for TADs

Several steps and considerations in preparing the surgical guides need to be discussed; the different placement of TADs regarding their use and the variety of intended uses of TADs should be understood, which is the purpose of the first part of this paper.

The second part is the procedure of making the surgical guide for TADs.

2.1. Part 1: Rationale for Using a Surgical Guide in the Implantation of TADs

General consideration before using TADs as anchorage in moving teeth:

1. The thickness of the mucosal layer in different areas of the mouth can affect the selection of the TAD's length [30]. When selecting a placement location, choose an attached gingival site rather than a flabby mucosa [31]. However, in some cases, implantation on a flabby mucosa cannot be avoided. Using a surgical guide makes locating the initial pilot hole made during the pre-drilling process easy. The surgical guide will save time and effort searching for the insertion point, as mucosa often covers it. For optimal results, it is recommended to utilize two surgical guides during the procedure: one for the pilot drill and another for the TAD. When placing them in the interdental bone between two teeth, having 0.5 mm of septal bone around the TAD is crucial [32]. In interdental placement, at least 2.4 mm of the interdental bone may be needed to avoid damaging the roots, considering that TADs usually have a diameter of 1.4 mm [33,34].
2. Different TADs come in various head designs and sizes, so it is recommended to create a surgical guide to match the chosen TAD's dimensions. Laboratory technicians and clinicians should communicate to design an appropriate surgical guide. While the body of the TAD may be self-drilling, it is still recommended to use a pilot drill surgical guide to minimize any trauma to the soft tissue [35]. The surgical guide is

particularly important for angulated insertion procedures to make it easier to enter the implantation site. The angle at which screws are inserted can vary depending on personal preference. Some people prefer an angle for stability, while others aim to avoid root collisions and position the screw tip apically. However, angled screw insertion is more challenging than straight insertion. A surgical guide can assist with accurate angulation insertion, and directional drilling requires a guide to prevent slipping. Designing the surgical guide insertion process for easy handpiece and bur manoeuvrability 1 during implantation is crucial.

3. Using a healthy tooth structure is necessary for a surgical guide to be in a stable position. If there is any doubt about the stability of the teeth in the intended placement, the number of teeth to be used as support for the surgical guide should be increased [36].
4. The force required to penetrate bone with a TAD varies from 20 N to 35 N, depending on the diameter. Placement typically occurs at a speed of 25 Rpm, while drilling occurs at 800 Rpm with water irrigation [37]. It is better to load immediately rather than waiting for weeks and leaving it unloaded [38,39].
5. It is mandatory to maintain sterilization and follow the aseptic procedure during the implantation process.

Although a surgical guide is an excellent support in the correct placement of the TAD, the clinician's experience is integral and crucial to the success of a TAD's placement. Researchers have mentioned the success and failure of TADs after their introduction [40].

2.1.1. Collecting Data, Planning, and Designing in Consideration of the Making of the Surgical Guide

The sites for, number, and types of TADs are influenced by the nature of the malocclusion and the treatment plan. However, the placement and design must consider the availability of quality and quantity of the bone at the proposed anatomical site. These are assessed with volumetric data of CBCT and other X-rays. Therefore, more than a panoramic X-ray or other 2-dimensional data is required [36].

The Hounsfield value at the site should be evaluated to determine bone density. For spongy bone, the value should be around 300 HU, while cortical bone should be above 500 HU. For optimal results, it is recommended that the thickness of the cortical bone should be at least 0.5 mm [37,38].

If the values are lower than these standards, it is best to check the surrounding sites. If the density is still unsuitable for TAD placement, another site for TAD placement should be explored until the minimum requirements are met.

Making a secure placement site will reduce failure risk and prevent reimplantation. The digital dental impression data obtained from the intraoral scan in SLT format and DICOM data of CBCT are shared with the professional outsourced laboratory or in-house laboratory for processing. The success and failure of TADs can range from issues with the mucosa and the bone condition, mainly density and the thickness of the cortical bone, to the TAD design itself [35].

The design of the surgical guide is created in the application software. Initially, designing can be performed by the dental technician and then checked by the doctor; therefore, communication is the key to success. Orthodontists should check the manoeuvrability to position the TAD toward the desired insertion location and preferred angulation. The final design by the doctor is crucial because only the doctor knows the patient's situation, such as how far the patient can open their mouth and the instruments required, keeping anatomical limitations in mind, especially the placement of the posterior region. Once the planning and design are completed, the laboratory will do the 3D printing of the pilot drill and the guide of the specific screw. Each placement might have a different pre-drilling and TAD size; therefore, the technician should fully know about the intended TADs, their design, and size. Two guides are advised to be fabricated for accurate implantation. A vertical direction of placement on a flat surface of bone can be performed easily with self-drilling TADs; however, when it comes to an angulated surface, it can be slippery to make a hole

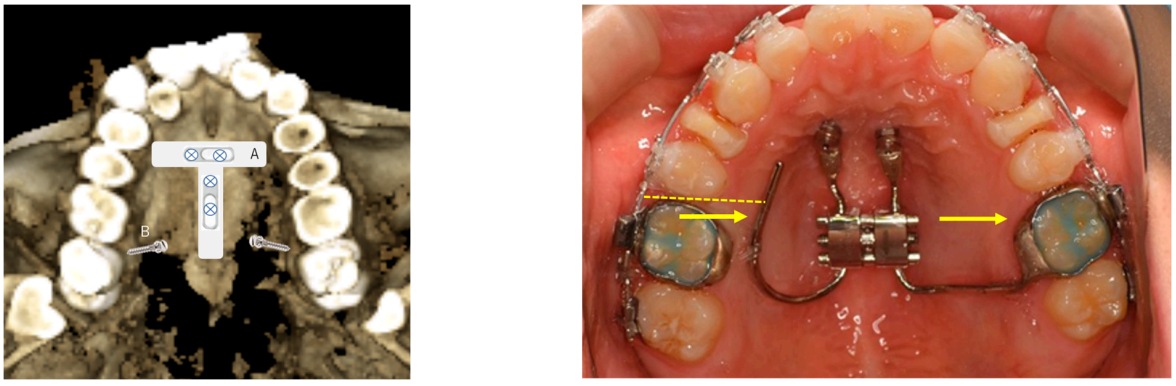
directly on the surface of the cortical bone. As explained in the last reference, several failure attempts could tear off the mucosa and affect the healing process. Therefore, two surgical guides are needed; one is for the pre-drilling to make the initial hole, and the other is for the TAD.

After the 3D printing, the technician will wash and cure these to finish the laboratory procedure. The surgical guides are then sent to the orthodontist's office.

The need to place the TAD for anchorage depends on the demand for specific treatment biomechanics. Generally, it is wise to avoid interdental space placement whenever possible and choose places without a tooth or away from the tooth. The point of selection is relatively easy on the maxillary but has fewer anatomical choices available in the mandible.

1. In the maxilla, CBCT is used to look for the ideal places and the palatal sites in the T-zone, as described by Wilmes [39]. The system's benefit is two screws being used to connect a plate to make it a sturdy anchorage for 3D movement of the upper teeth. Therefore, the two screws' placement is critical to insert the plate easily and quickly, such as parallel or close to the parallel to provide easy fixation [40–43]. The surgical guide will facilitate the parallel insertion of TADs. TADs are placed at the best bone density in the area intended to be the anchorage placement. The other option for the TAD's site in the palatal bone is between the first molar and the second bicuspid area; the first molar has only a single palatal root (two roots on buccal), and the distance to the second bicuspid's root is the widest space available between the root's placement in the posterior region [44]. The placement on the buccal side can also be performed with the surgical guide in the anterior teeth between the central and lateral teeth, interdental for the bicuspids, and the buccal ridge underneath the zygomatic process [45].

Figure 1a, explaining the location of Point A, is the area of the T-zone where plates with two screws are usually preferred rather than single-standing implantation. The reason is that the two screws will give more assurance to endure forces for en mass movement of various three-dimensional movements in space. Point B is the area of choice where there is less interference of the swallowing and deglutition but where it is still possible to perform en mass retraction of the whole teeth of the maxilla. Next, Figure 1b is an example of the use of the points of Figure 1a, a Hybrid-Hyrax, with its placement using the surgical guide for double TADs and an immediate appliance setting. The appliance aims to expand on one side of the maxillary alveolar bone to the left and move the opposite alveolar bone with the teeth palatally using an elastic tread (dotted line). This design is beneficial because it is used for one-side crossbite cases. The yellow arrows show the direction of the alveolar bone movements.



(**a**) (**b**)

Figure 1. (**a**) is the T-zone; (**b**) is the Hybrid-Hyrax.

Figure 2 shows several common points when placing TADs in the maxilla's buccal sites. Point C is a location between the lateral and canine to correct the gummy smile and

the canted anterior occlusal plane. The location also benefits underbite correction. Point D is the interdental root placement of the posterior buccal area, with its most preferable use for single-standing TADs in retraction of the anterior teeth, especially in bicuspid extraction cases. Point E is in the lower part of the zygomatic bone, a preference to retract the whole teeth without interfering with the root of the maxilla. Precautions should be taken to avoid irritating the flabby mucosa and buccal papilla.

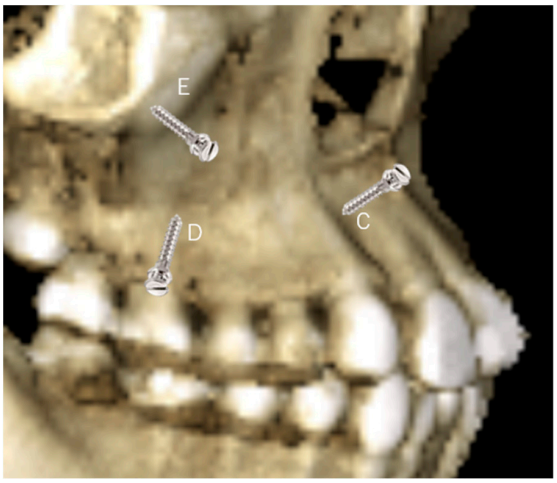
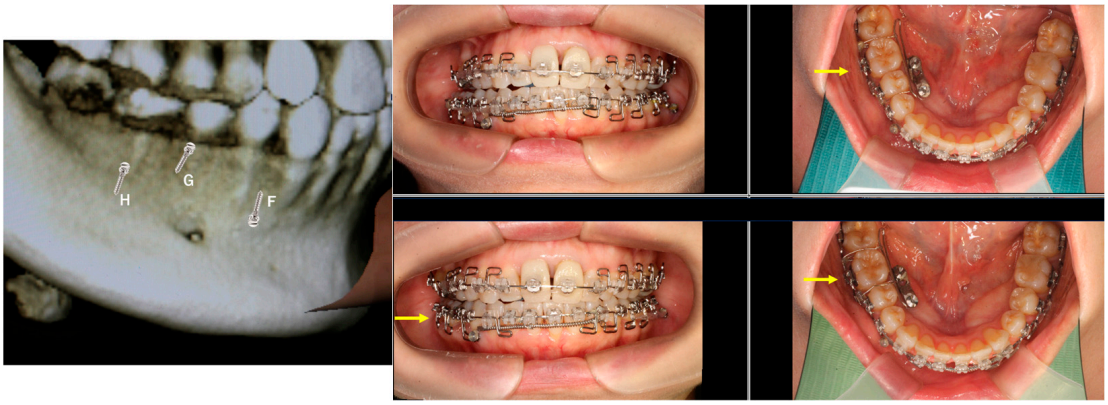


Figure 2. The common location of TADs in the Maxilla.

2. In the mandible, TAD placement on the lingual side of the mandibular arch be challenging; there is an advantage if there are lingual tori that are large enough to provide the TAD's implantation [46]. Most of the time, the buccal region is the only choice. The anterior part of the buccal dental arch will have limited interdental bone availability, and the quality of bone is often questionable. A critical evaluation of available bone width is necessary before the implantation. Interdental space can be more suitable when appropriately placing the brackets to flare the crowded roots. Changing angulation of the roots by adjusting bracket placement beforehand is a common practice in placing TADs in the anterior region.

The Figure 3a shows the most common buccal implantation is on three sides of the mandible; F is the inter-radicular point between the canine and the first bicuspids, G is the inter-radicular point between the second bicuspids and the first molars, and H is the symphysis of the mandible.



(**a**) (**b**)

Figure 3. (**a**) The common placement of TADs in the mandible; (**b**) The placement of TADs on the tori of the mandible.

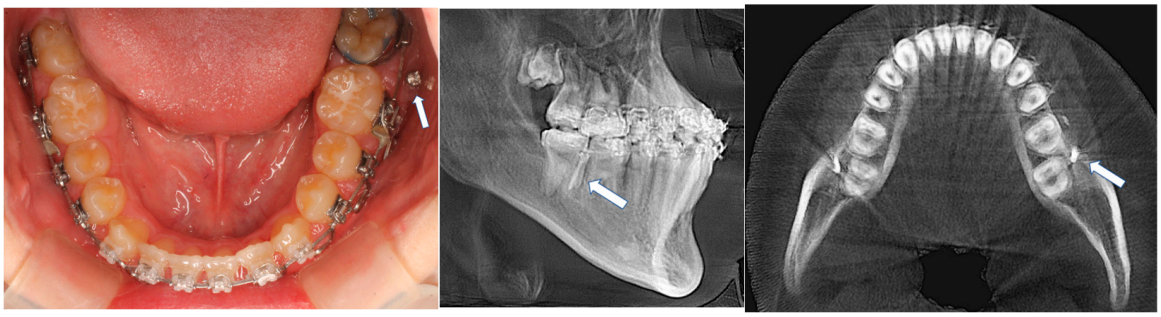
One of the most difficult cases in clinical orthodontics is correcting facial deformity in a shifted mandible in a crossbite relationship with the maxilla. The placement on the torus lingual of a plate fixed with double TADs and immediate appliance placement could help skeletal deformity in a mild posterior crossbite. This appliance is intended to constrict the arch form on the right side lingually, as shown in Figure 3b. Paralleling of the TADs calls for this kind of placement. The upper rows showed before, and the lower rows showed after three months after the placement of TADs.

3. The implantation in the interdental bone will limit the movement of the tooth, mesial and distal. Therefore, to avoid interferences with roots, the TADs are preferred on the mandible's ridge or the mandible's oblique line (Figure 3a, H), especially when en mass retraction of the arch is desirable. The ridge of the mandible between the body and the ramus of the mandible is a favorable site for TAD placement [47]. The tricky part is that the mandible ridge may seem insignificant in women relative to men, and modification may be needed in the surgical guide's design [48,49]. Since the placement location is a steep bone wall, manual placement will be challenging, so a surgical guide is preferred. The angulated placement of the TADs in this area and the flabby mucosa also necessitates using a surgical guide. Care must be taken during the intraoral scan as the superficial mucous membrane above the ridge must be gently stretched to record this critical area. Lack of recorded data in this area will affect the visibility of the area site, and the surgical guide cannot be planned. Implantation in this area is recommended using contra-angle motorized instruments, as the buccal cheek tissue prevents using a hand screwdriver and will obstruct the surgeon's vision. The buccal musculature, maxillary teeth, and mouth opening will limit the manoeuvrability of the placement procedure. These limitations should be evaluated during a clinical examination. Considering the hindrance of lower lip movements, placement between the four incisors should be avoided as much as possible. TADs in this area can cause painful lip ulcerations with delayed healing. The location of the canine and the first bicuspid (Figure 3a, F) is an area that can fit for the implantation choice. This location is between anterior and posterior dental arch segments and thus will provide an excellent place to resolve both anterior and posterior malocclusion. Depending on the extraction case or non-extraction case, considerations can be different, and placement in the extraction site of the bicuspid and adjacent area is required to avoid proximity to vital structures in the mentalis foramen. In Figure 3a, G location is possible when there is a need to retract the anterior teeth after an extraction case where placement of the ridge of the mandible is difficult or impossible due to the younger age of the patient. Placement at a young age, e.g., under 12, is risky as bone metabolism is still high in this area.

2.1.2. The Clinical Application of TADs Using the Surgical Guide, an Example Case

One of the problems faced in constructing surgical guides is the location of the mandibular angle on the mandible's oblique ridge. First, the flabby mucosa and second the insertion angulation should be planned so that a contra-angle handpiece can be used easily. The first problem is holding the mucosa during the implantation, especially when making the pilot hole; the surgical guide will manage to exert light pressure so the mucosa will be caught and injured in the drilling process. The second problem is that we must calculate the length of the screw of the TAD, the thickness of the head of the contra-angle, and the size of the surgical guide beforehand to ensure such a placement is possible.

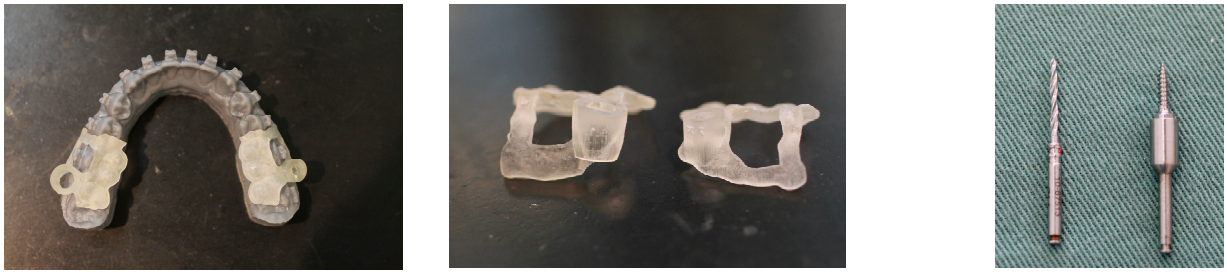
Figure 4a–c are photographs of TADs placement on the mandible's oblique ridge. Figure 4a shows the intraoral photograph, Figure 4b shows lateral X-ray with the TADs on the symphysis, and Figure 4c shows the occlusal X-rays CBCT views. The white arrows are pointed out at the TADs of each image.



(**a**) (**b**) (**c**)

Figure 4. (**a**) is the symphysis placement of TADs; (**b**) is the X-ray shows the vertical placement in the symphysis; (**c**) is the occlusal view of the CBCT shows the location of the TADs.

Figure 5a,b shows the surgical guides as received from the laboratory. Placed the surgical guides on the model to check for accuracy before inserting them into the mouth, as shown in Figure 5a. There are two kinds of surgical guides for each side of the mandible. The left side is the surgical guide for the TAD, and the right is the surgical guide for the pilot drill (Figure 5b). The surgical guide is viewed from the side and should be analyzed for the vertical height, which is the most critical part, as it should be adjusted whenever a problem arises before placement, as shown in Figure 5b. The two surgical guides are needed because the size of the drill and the driver are different (Figure 5c).



(**a**) (**b**) (**c**)

Figure 5. (**a**) is the surgical guides on the model; (**b**) is two kinds of surgical guides; (**c**) is the drill and the TADs.

A CBCT is also taken immediately after the surgical procedure to ensure the placement result. A clinical error can happen in the collection of data used for the device planning, even when it was made correctly, when there is an anatomical situation, such as the posterior region of the oblique ridge of the mandible where the patient cannot open their mouth as wide as expected. When the contra-angle cannot be used for the intended angulation, we must consider an alternate placement site [50]. The thickness of the surgical guide and the thickness of materials and sleeves on the guide are also limited. The clinician should understand those limitations. A surgical guide may need final adjustments in the mouth via selective trimming. The surgical guide must be positioned correctly in the mouth, and its location and accuracy must be double-checked before surgery. The collaboration between the laboratory technician and the clinician is necessary to make an excellent surgical guide.

Despite the advantages of using advanced technology, proper planning and sound clinical judgment of the clinician are essential for successful TAD implantation [51–56].

Table 1 compares the free-hand placement of TADs and the use of the surgical guide. Noted that in free-hand TADs placement, a panoramic X-ray may be sufficient. However, CBCT X-ray and Cad-Cam data are necessary in making a surgical guide.

Table 1. The advantages and disadvantages of using the surgical guide.

	Advantages	Disadvantages
Fee		More cost (laboratory): "300-600$."
Accuracy	Reliable and constant	
Time	Short appointment time in placement and direct appliance setting	Scanning and construction time
Prospect	Yes, a complex case is possible, paralleling 2 TADs and predetermined angulation feasible	
X-ray radiation		High doses of CBCT

2.2. Part 2: The Procedure of Making the Surgical Guide for TADs

Integrating CAD/CAM technology in dental laboratories has also helped orthodontics. CAD/CAM was introduced in dental prosthodontics, and in 1985, the first commercial system appeared on the market, made by Mörmann, and then quoted by present researcher [57], who gave the name CEREC to that system, and it has been developed since then. Integration of digital and CAD technology in orthodontics in diagnosis, treatment plans, and time scheduling of cases was first described by Impellizzeri et al. [58]. In orthodontics, digital technology, CAM, and 3D printing are used extensively in clear aligner therapy [59] and the position of TADs [60,61].

Now, the new development of TAD uses, and placement and development of software calls for re-evaluating the technique to provide an update on TADs' ability to be used in various anatomical areas and create safe clinical work for orthodontists. Orthodontists can safely place temporary anchorage devices (TADs) in various anatomical areas to improve treatment capabilities for complex malocclusion. The advancements in scanning technology, software capabilities, and 3D volumetric analysis of placement sites have enhanced clinical abilities and resulted in better outcomes.

2.2.1. The Surgical Guide Technique for TAD Placement

The use of TADs in orthodontics has notably increased in recent years. TADs have allowed for the simplification of several treatment plans by producing skeletal anchorage. Since these are easy to place and remove and require no cooperation from the patient, there has been an increased use of these devices in orthodontic practices. However, TADs' stability heavily relies on bone thickness both on a vestibular and palatal level. The critical concern is that TADs are also difficult to place correctly, and there is a risk of dental damage, sinus or nasal perforation, chronic sinus inflammation, and even anchorage loss [62]. However, the stability of TADs depends on factors such as bone quality and quantity, as well as biological, technique-related, and clinical variables. It is important to note that TADs are challenging to place accurately; using surgical guides based on acrylic provides sufficient control of orthodontic mini-implant placement, and guide extension involving the teeth will improve the accuracy of TAD placement [63].

By overlaying CBCT and digital models obtained from an intraoral scan, it becomes feasible to identify the optimal position for TADs. Once the ideal location has been determined, a surgical guide can be produced using a 3D printer. These guides ensure accurate and safe placement, reducing the risk of complications typically associated with the procedure.

2.2.2. Sequences of Digital Workflow to Make Surgical Guides

Table 2 Shows the sequences of the procedures to make the surgical guides. The above descriptions are explained below.

Table 2. Checklists of the procedures to make the surgical guides.

1.	Superimposed SLT and DICOM data
2.	Designing a surgical guide in 3Shape Ortho System 2021.1
3.	3D printing.
4.	Cleaning, washing, and cutting
5.	Checking and testing the surgical guides to the models

Explanations

1. We used an intraoral scan for the SLT (CEREC of Sirona Co., Erlangen, Germany) and a CBCT X-ray (Planmeca, Finland) machine for the DICOM data to obtain a digital impression. Afterward, we superimposed the STL and DICOM data using a commercialized application.
2. The 3Shape Ortho System 2021.1 Appliance Designer software completes the process of designing a surgical guide. By utilizing software, the diameter of the drill bur and screw holder can be determined, ensuring no contact with the roots during the procedure. The 3-Shape software simulates the screw placement within the bone's anatomic area. This simulation helps determine the tube design required for drilling and screw placement.
3. It is easy to print in a 3D printer (SprintRay Pro95: (SprintRay, Los Angeles, CA, USA) with the material of SprintRay Sugical Guide3 (SprintRay, Los Angeles, CA, USA).
4. Next, there is cleaning, washing, drying, and cutting of the supporting pillars, followed by post-curing (ProWash/Dry (SprintRay, Los Angeles, CA, USA).
5. After checking and testing the surgical guide of both the drilling guide and screw, the holder guide is then placed upon the model of the jaw to check its fitness. When there are brackets, holes can be made to avoid retentions.

2.2.3. Digital TAD Guide Production Process

Below is the procedure, devised with the help of an outside laboratory team of dental technicians. The application name software will be introduced, but another commercial brand can also be used. It was necessary to reveal the names of the products to make it easy to understand since otherwise practicing clinicians will find it difficult to follow the instructions. Our laboratories use intraoral scan data as follows:

1. For dentition, STL and CBCT (DICOM) data are superimposed using 3-Matic SLT10.0 (Materialize, Leuven, Belgium). The 3-Matic application has been used to evaluate the three-dimensional root monitoring of root movement during orthodontic treatment [64] without exposing radiation in controlling the position of the roots.
    a. STL and DICOM data are superimposed using a 3-Matic application, as shown in Figure 6.
    b. Mimics (Materialize, Leuven, Belgium) is used to extract the roots of the mesiodistal teeth where the anchor screws are to be implanted and converted into 3D as shown in Figure 7 The method has been described by Cassetta using a 3D surgical plate for corticotomy [65,66].
    c. Making three-dimensional images and analyzing them using the Geomagic Studio 5 software (Raindrop Geomagic, Inc., Morrisville, NC, USA) is necessary. We created cylinder data of the same size ($\varphi 1.6 \times 8.0$ mm) imitating the screw (product of TADs, brand OSAS by DEWIMED) to be placed as shown in Figure 8.
    d. The CBCT, intraoral scanner, and cylinder data are loaded into Mimics and a placement simulation is performed, shown in Figure 9.
    e. At this stage, the orthodontist performs the simulation to the best bone quality that will guarantee the success of the implantation. The process below shows the simulation performed by the doctors. The soft tissue thickness will also

dictate the length of the TADs used (Figure 10).TADs are adjusted to the ideal location using the 3D simulation program, and in the final stage, the hard and soft tissue is removed, so it is easy to see only the TAD and teeth relationship (Figure 10). The lower right-side figure shows the intended situation.

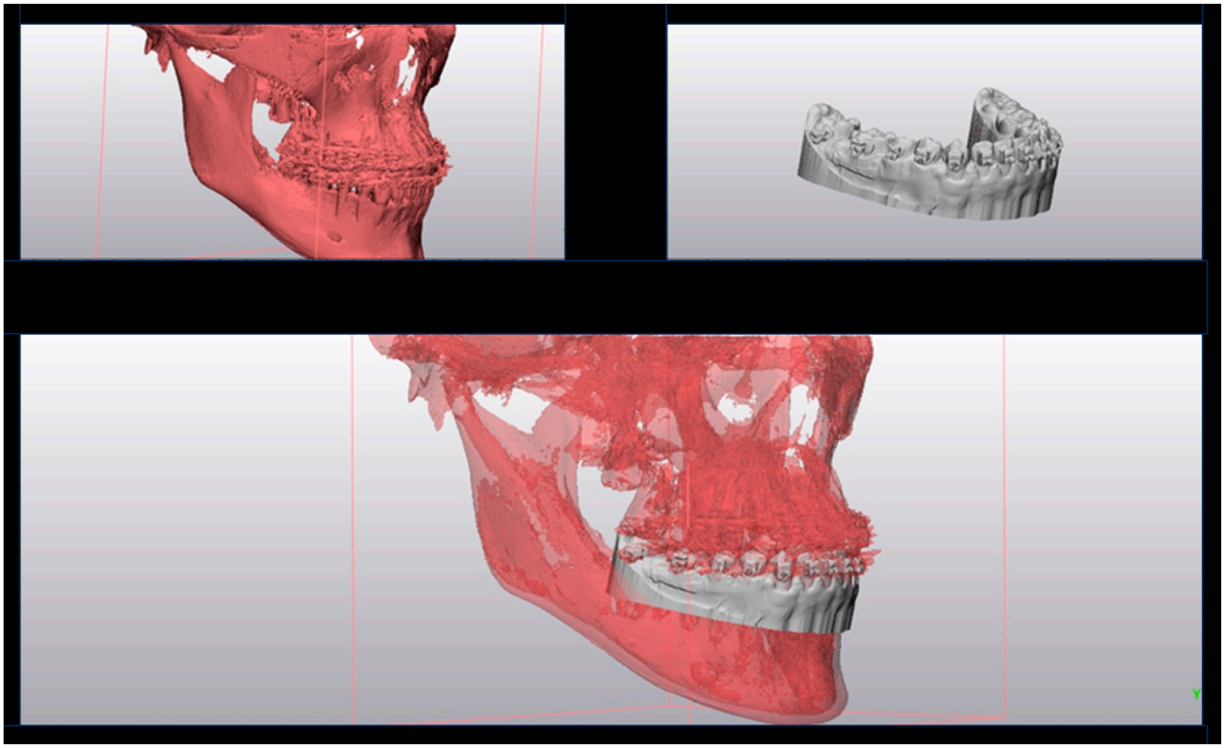


Figure 6. The design and planning of the surgical guide.

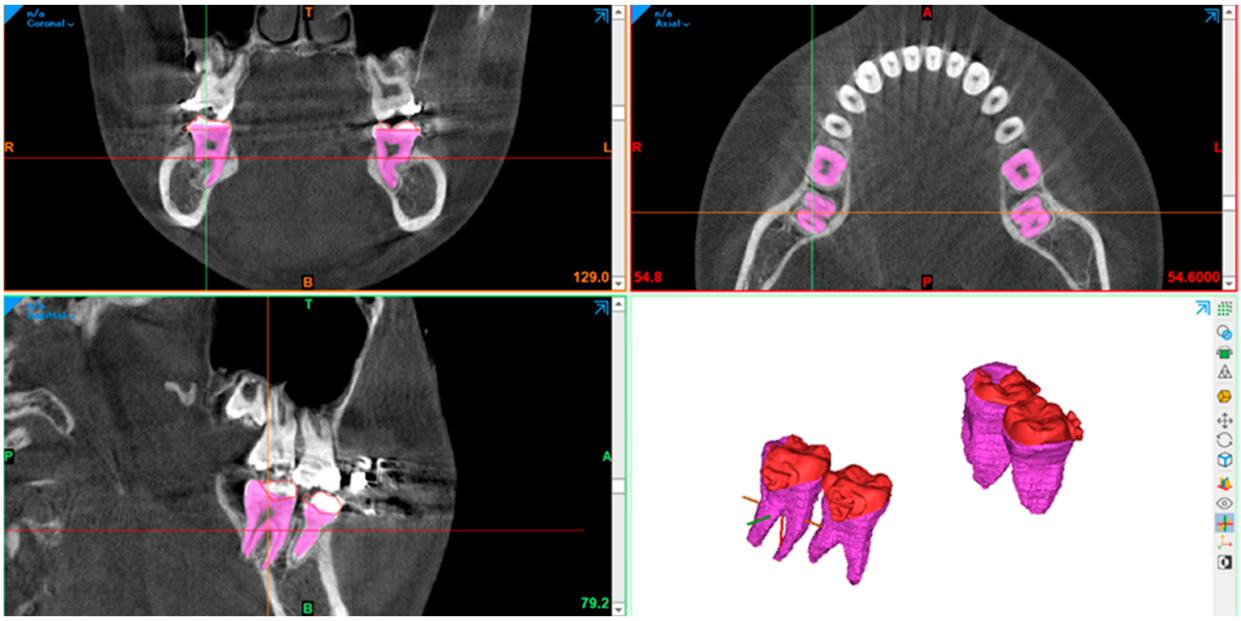


Figure 7. The positioning of the TADs in three-dimensional space.

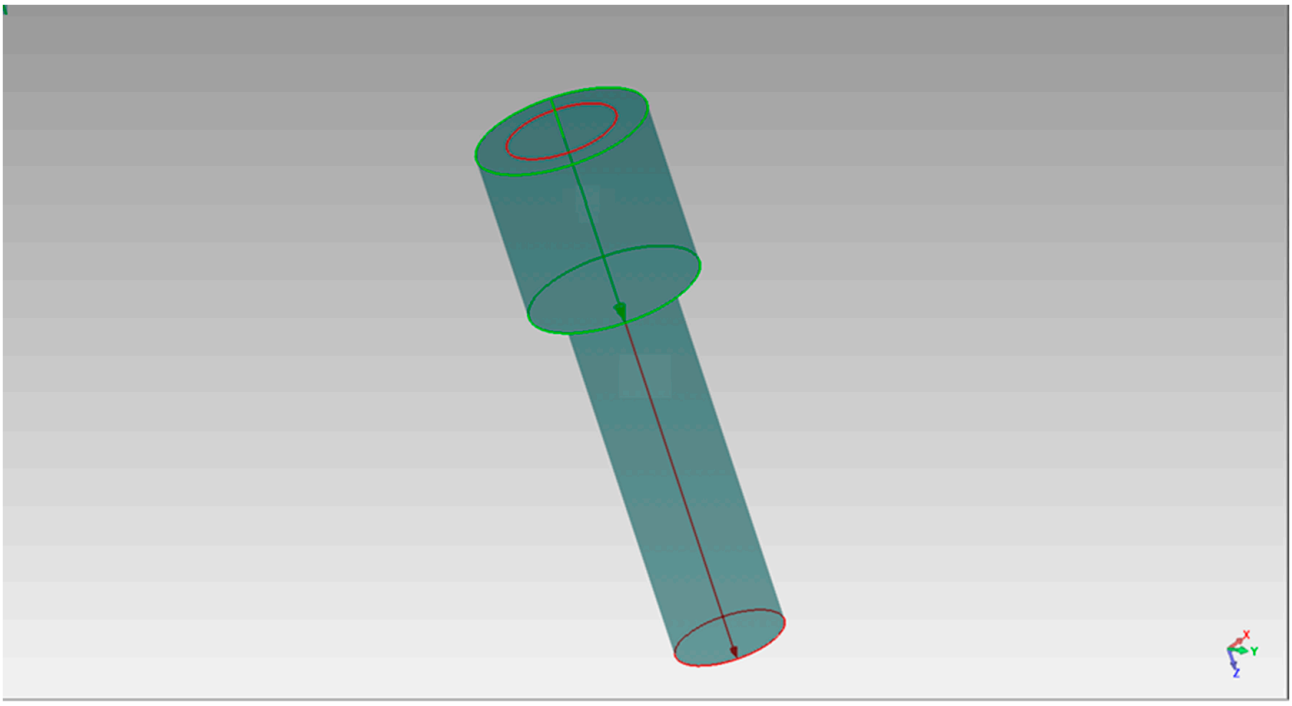


Figure 8. The virtual 3D image of the TADs was made according to the size of the screw itself.

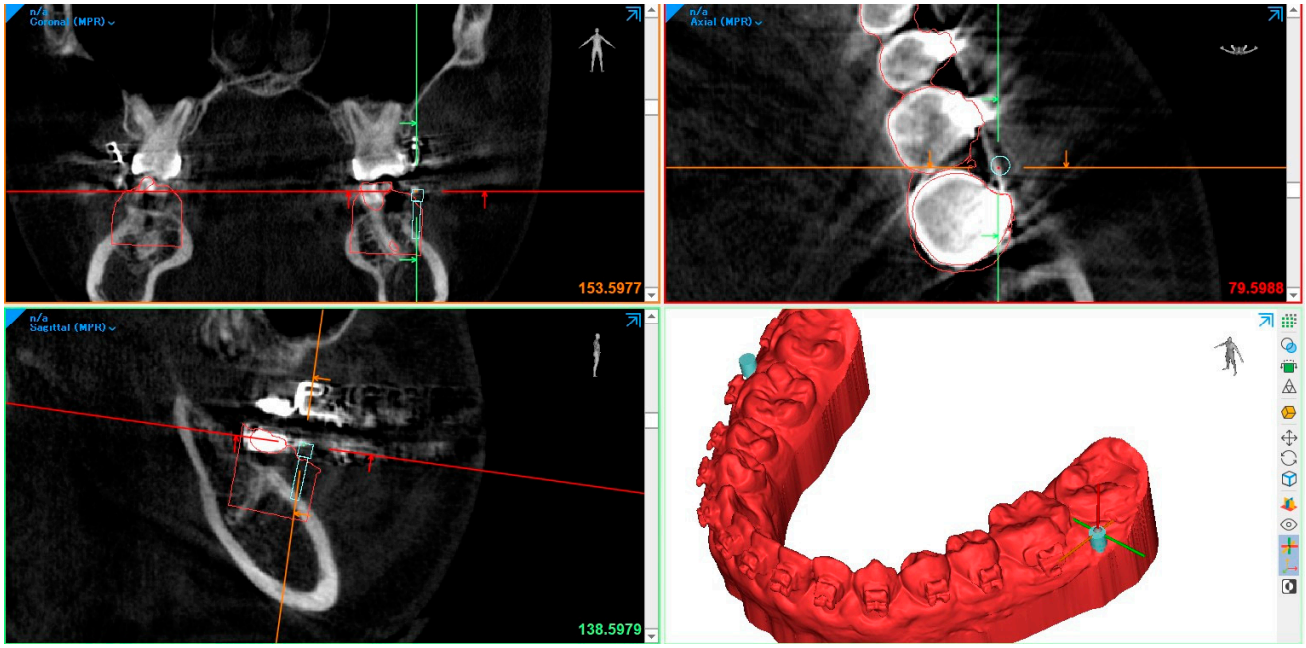


Figure 9. The simulation of the virtual TADs of the virtual model.

The plan is sent back to the laboratory, and the technician then confirms whether the simulation is visible for the 3D surgical guide printing.

Figure 11 shows that, to begin with, the printing, the first step is to apply the data from 3-Shape to an easy printing program.

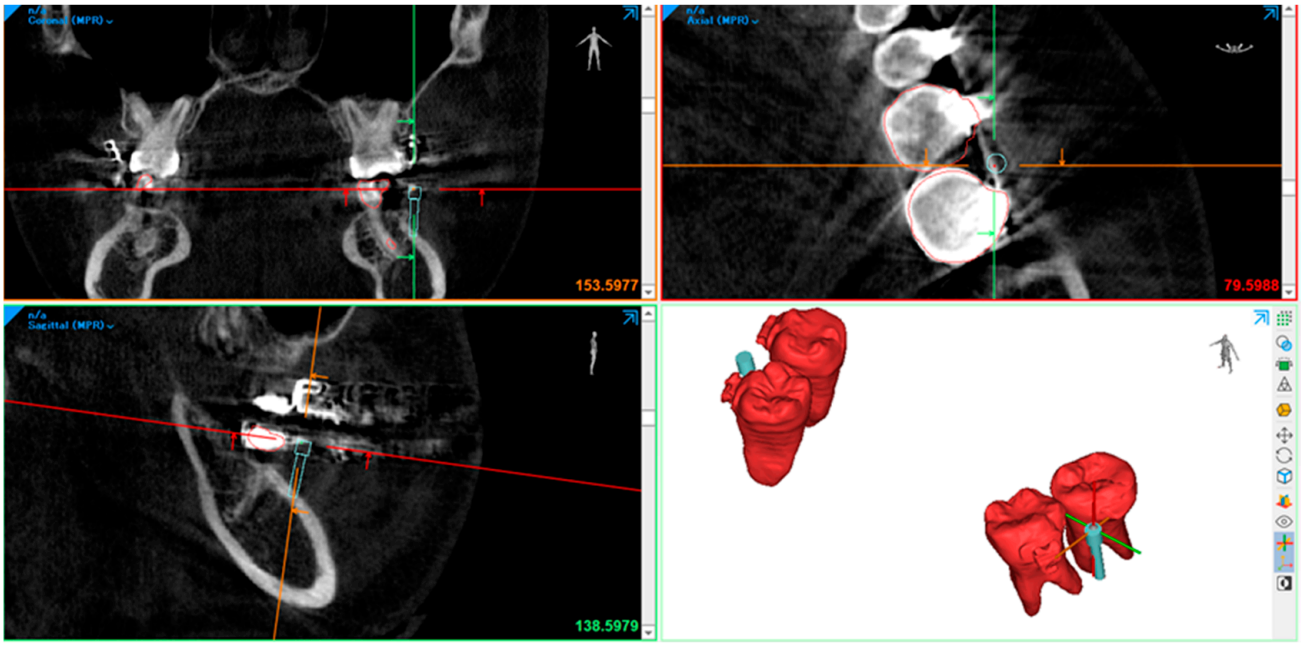


Figure 10. The TADs were manipulated in the program and the final stage.

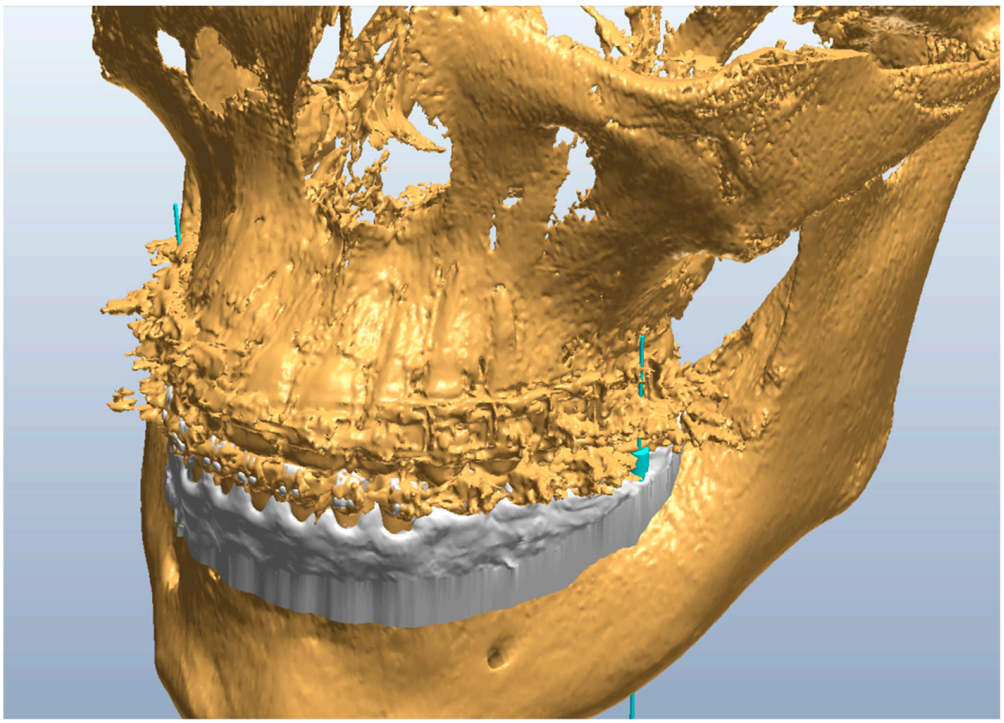
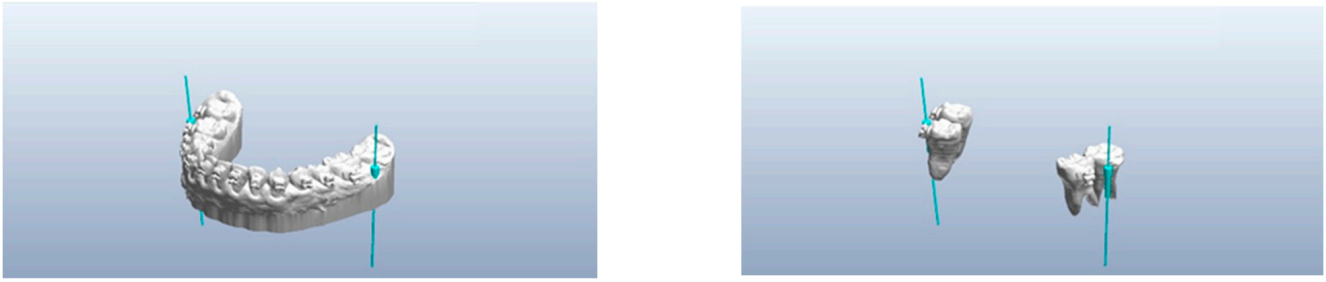


Figure 11. The data was transferred to the 3-Shape program.

a. Appliance designer of 3-Shape, Copenhagen, Denmark, was used to simulate the drill and the surgical guide to make the TAD placement position easy and straightforward, as shown below in Figure 12.



(**a**) (**b**)

Figure 12. (**a**) is virtual model of the mandible with the TADs in the symphysis; (**b**) is virtual model of the teeth and the TADs in space.

b. After the screw length and position are observed, the outer guide for both the drilling screw and the screw guide constructed. The occlusal surface is used for the guide to position the surgical guide. All brackets should be avoided by making a hole to make repositioning smooth. It is also important to check the mucosa below the drilling guide, which should fit or have light pressure without sacrificing the fitness of the guide to hold the mucosa when doing the initial drilling. Figure 13a shows the drilling surgical guide, while Figure 13b shows the TADs surgical guide virtual images.



(**a**) (**b**)

Figure 13. (**a**) is the virtual predrilling surgical guide; (**b**) is the virtual TADs surgical guide.

2. Printing

a. The designed data is printed using a 3D printing machine for the pre-drill guide and TAD screw guide. The 3D printer is a SprintRay Pro95: (SprintRay, Los Angeles, CA, USA) with the material of SprintRay Sugical Guide3 (SprintRay, Los Angeles, CA, USA).

The beginning of the printing is using the SpringRay printing machine as mentioned (Figure 14a), using acrylic (Figure 14b), and the result is shown in Figure 14c. The surgical guides are still attached to their base in Figure 14c.

b. The use of SprintRay Dashboard 2.0 software helps to monitor the printing process flow. Dashboard 2.0 is also used to communicate between designers and doctors and save the design in storage. After printing, it needs to be washed and dried as there is residue in the form of not fully cured resin. The washing and cleaning of the pre-drill guide and TAD screw guide is performed with ProWash/Dry (SprintRay, Los Angeles, CA, USA) to remove excess material and dry it (Figure 15a,b). The base and the surgical guide supports were then removed and trimmed (Figure 15c).

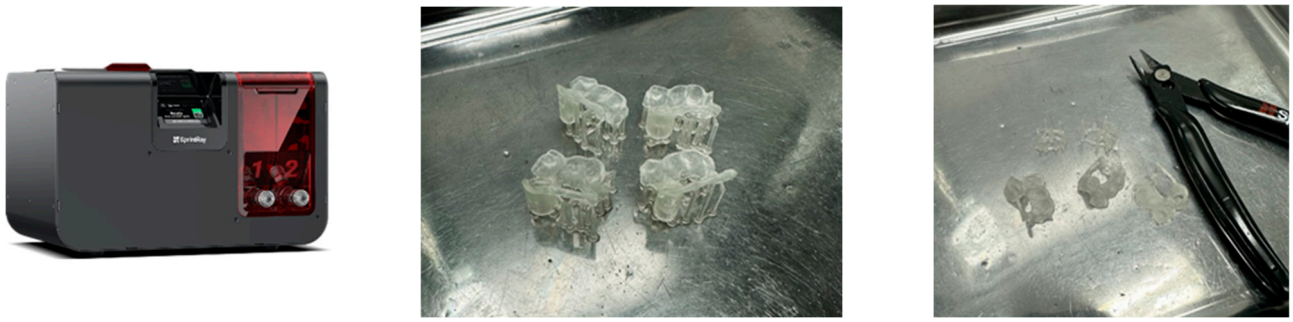
c. After cleaning/drying, the support is removed (Figure 16), and the guides are ready for the post-cure process as some part is not cured. The ProCure (SprintRay, Los Angeles, CA, USA) makes the guide's final cure (Figure 16a,b). The after-cured result is shown in Figure 16c.

d. The model is made from the STL to check the fitness of each guide to the model, paying attention to the area of the brackets to avoid any retention. In the bracket areas, window is made that also will benefit checking fitness during the implantation (Figure 17a,b). The surgical guide for both the pre-drilling and the screw placement guides are ready to be used at this point. The external oblique line, where the buccal shelf is, presents the most-used surgical guide: it has thick cortical bone, and, in many cases, the mucosa is an intact, attached mucosa. Even if the area is covered with flabby mucosa, the surgical guide's bottom side presses the mucosa. It prevents the mucosa from moving during the drilling and insertion of the TAD procedure. The buccal shelf is important as it is not an interdental placement and can simultaneously do the en mass retraction of the whole lower teeth.



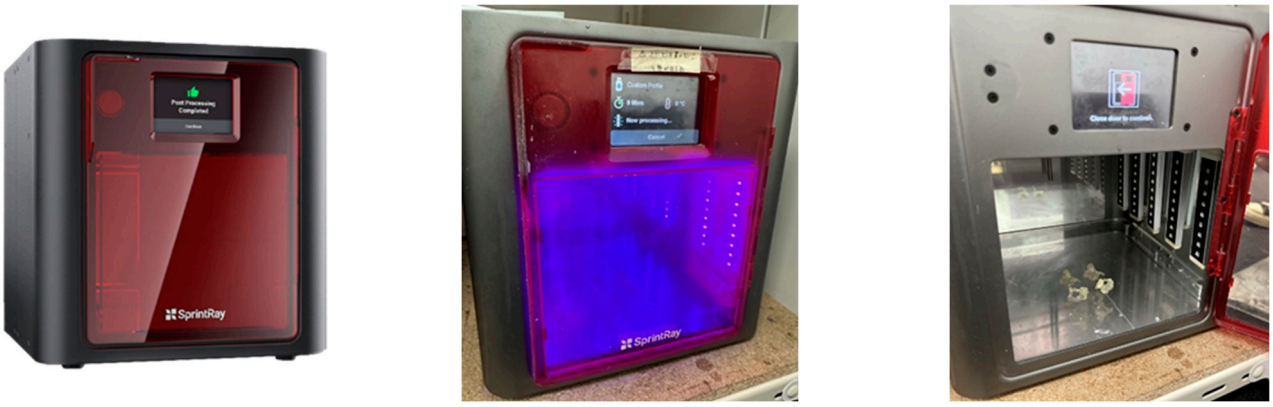
(**a**) (**b**) (**c**)

Figure 14. (**a**) is the printing machine; (**b**) is the acrylic substance; (**c**) is the printing result.



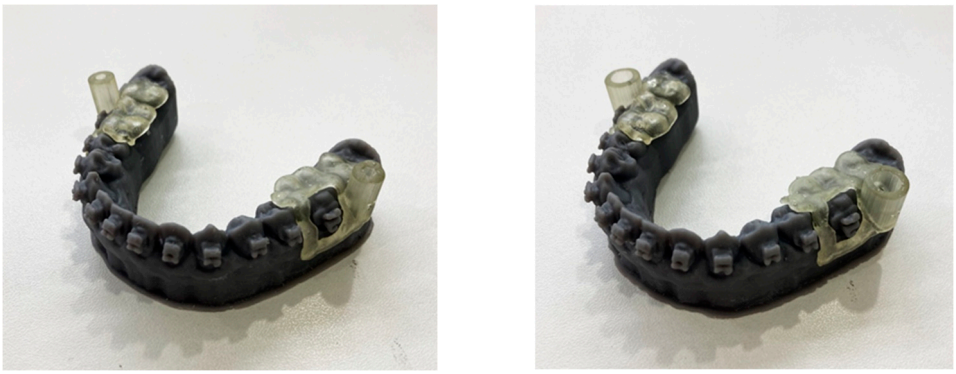
(**a**) (**b**) (**c**)

Figure 15. (**a**) is the washing machine; (**b**) is surgical guides after being washed; (**c**) is trimming.



(**a**) (**b**) (**c**)

Figure 16. (**a**) shows the curing machine; (**b**) is the curing process; (**c**) is after the curing process.



(**a**) (**b**)

Figure 17. (**a**) is the predrilling surgical guides; (**b**) is the TADs surgical guides.

Although the instructions for making the surgical guide use the lower jaw of the buccal shelf of the external oblique line as an example, all the jaw area and the maxilla surgical guide are modifications of this basic standard single-standing TAD. Double TADs, in more complex cases, may need surgical guides to make the TAD placement parallels an important aspect of making a surgical guide. The double TADs are intended to move teeth, possibly influencing the alveolar bone for camouflage treatment when the patient hesitates or refuses surgical orthodontics for skeletal problems. The case often indicates that the appliance's construction can be complex; a surgical guide could help place the TADs and the 454 CAD/CAM, which can help design specific appliances for every case. This basic introduction to making surgical guides could serve as knowledge for the future of treating complex orthodontic cases and widen the scope of the use of TADs.

In the future, it will be possible to do research using piezosurgery devices to do distraction osteogenesis. The promising, meticulous, and soft tissue-sparing system for bone cutting is based on low-frequency ultrasonic micro-vibrations [67] and TADs with the surgical guide to ensure the intended placement. Advanced research for a less invasive approach is possible, compared with the surgical orthodontics that need hospitalization [68].

3. Discussion

The limitation search focusing on making a surgical guide has limited the explanation of each area of the placements in the maxilla and the mandible. The number of TADs necessary on each anatomical area to resist the force direction and amount involved in en-massed movements are not explained. Future investigation could be conducted about surgical guides and their link with other important aspects, such as miniscrew diameter [69], geometric choice [70], and eventual damages to surrounding tissues [71].

4. Conclusions

The use of 3D printing is revolutionizing dental and orthodontic practice. TADs can be placed with complete control by orthodontists using surgical guides. The ability to generate the necessary force of applications for the treatment will depend on the accurate placement of TADs. It is crucial to emphasize the importance of a pilot drill guide, as it guides the first drilling step when clinicians desire an accurate entry point. The pilot guide increases the predictability of implantation surgery, which can be used to treat partially edentulous orthodontic patients to regain vertical occlusal height [72]. Using a surgical guide can reduce guesswork in TAD placement, make it less challenging for practitioners, and improve patient cooperation and comfort. Placement using the surgical guide is predictable, precise, and efficient over time, complementing daily practice. The advantages and disadvantages of the system are explained, and it is up to the practitioner to decide what is appropriate for their practice.

The surgical guide-making process has been explained in a step-by-step manner. The development of 3D printing has enabled the production of pre-drilling and surgical guides. It is time-consuming to make surgical guides in-house; it is still wise to order from a laboratory. It will be challenging for the orthodontic dentist to place TADs between orthodontic tooth movement adjustment appointments. It is wise to use a surgical guide to place the TADs because an accurate placement could easily be performed. The communication between laboratory technicians and orthodontists greatly influences the success of surgical guidance.

Summary

The paper discusses the advantages of surgical guidance in orthodontics, including its accuracy and minimally invasive nature. The contents also detail the laboratory preparation and the sequence of the procedure. A surgical guide on the symphysis of the mandible has been discussed as an example. The principle can be utilized for other placement points and linking two or more TADs in dental-alveolar orthopedics. The researchers hope to pursue research to advance future orthopedics and distracting osteogenesis.

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