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Original Article

Apex radicis dentis excision operation guided by template made by CAD/CAM

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Abstract: Objective: The aim of the study is to explore the clinical efficacy of apex radicis dentis excision guided by a template made by Computer Aided Design/Computer Aided Manufacture (CAD/CAM). Methods: Base on the CBCT image of oral cavity, a three-dimensional model of patient's oral cavity was built. Then the access way and excisional area were defined based on the model. Finally, the operative guide template was designed and made to help define the direction, depth, and area of the surgery. Results: One year after the operation with guide template, the two cases of apex radicis dentis with difficulty in cure were proven to have normal masticatory function and their pathological changes of apex radicis dentis disappeared as well. Conclusion: Utilization of CAD/CAM technology could well design the operative guide template for the resection of apex radicis dentis. Usingthis guide template could make the excision of apex radicis dentis more quickly and safer.

Keywords: CAD/CAM, apex radicis dentis excision, operative guide template

Introduction

After the pulp canal treatment of tooth pulp pathological changes, oftentimes there are still part teeth with pathological changes in apex radicis dentis. For example, the sick teeth would have some clinical symptoms such as chronic fistula, and it is sometimes necessary to have excision of apex radicis dentis by operation. The traditional excision of apex radicis dentis is relatively convenient for operation in anterior area of tooth, but is difficult for the operation in posterior area. Both in the anterior and posterior area of tooth, the detection of sick teeth are usually base on the image of *X*-ray film. The *X*-ray film could show the location of sick teeth, but the location is two-dimentional and is difficult to show the depth of pathological changes accurately. Moreover, the actual site and the location showed by *X*-ray film usually has difference. In fact, the long axis direction of tooth could sometimes make the location to have deviation. Unfortunately, the success of excision of apex radicis dentis is dependent on the exact location of apex radicis dentis' pathological site. Thus, in this study, an operative guide template was made by the CAD/CAM technology based on dental CT, and the operation was carried out by the guide of this template.

Materials and methods

Patients who need excision of apex radicis dentis in clinical situation must be proven to have no hematologic diseases. Also, the patient's main organs such as heart, liver, kidney should function well enough to be able to go through dental operation and patients should have no acute infection and mucosal disease. The patients who satisfy above conditions can be selected as the candidates for the operation.

When the patients took the dental CT, the jaw bone buccal three-dimensional model was built by the technician, and its three-dimensional anatomic structure model was obtained. Base on this model, the operation plan including operation route and the depth from the mucous tunic surface into the jaw bone were designed. According to the operation plan, the tooth surface support guide template was made, and at the same time, the bone drill with function of limiting the depth that could go into the jaw

Figure 1. The apex radicis dentis pathological changes in right low first molar of patient Ms Chen shown by X-ray film.

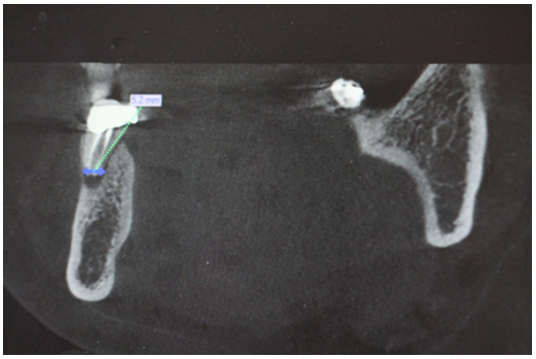

Figure 2. The pathological changes area of right low first molar shown by CT.

bone and hand grip with diameter limited were selected.

After finishing the making of the guide template, the guide template was put on the gypsous mold of patients' jaw bone in order to check whether it would shake and its size is suitable or not. After that, the guide template was sanded, trimmed, disinfected, and packaged. Before the operation, the guide template was initially tried on the patients in order to have a better location. After above preparation and making sure that no mistakes were made, the normal processes including oral cavity disinfection, draping, carving the whole mucoperiosteum after anesthesia would be carried out. After that, the mucoperiosteum would be opened and the guide template would be placed.

The assorted bone drill with limited depth was installed on slow dental handpiece, and the assorted hand grip was inserted into the fixed hole on the guide template, then the bone drill was inserted into the hole on the guide template. After the start on the foot pedal switch, the drill would get into the hole slowly until the limited plane on the drill touch the guide template, and at this time, the drill could not go deeper. After that, the drill would be set back, and the guide template and hand grip would be removed. Then, the excavator spoon would be stretched into the channel made by drill, and the granulation and bone chips would be cleaned clearly by the spoon. After the operation, the mucoperiosteum sutured would be washed by normal saline. Patients can have antibiotics and anodyne after operation if needed.

In this study, clinical operation was finished for 2 patients. And one typical operation was shown as follows:

Ms Chen, whose right first molar was with porcelain crown, and there is chronic fistula in her cheek side. As shown in *X*-ray film (**Figure 1**), her pulp canal has been filled but the pulp canal near the cheek side was over-filled. **Figure 2** showed the area of pathological changes in CT images. The patient requested to keep that tooth. She was informed that her sick tooth has to have the operation of apex radicis dentis excision and there are two ways for the operation: the first one is the traditional one and the other one is the new method mentioned above. After the introduction about the difficulty of traditional method and the idea of the new method, the patient decided to be treated by the new method.

Firstly, jaw mold was lift down, and the superhard plaster was primed for later use. After taking the dental CT image, the image was recorded by disc with DICOM format. Then the data disc and plaster mold was sent to the technician for the planning of the operation, including guide template design. After that, we input the CT image into medial image management software (MIMICS) and the three-dimensional mold was rebuilt. The sick part of patient's tooth could be shown clearly in the three-dimensional anatomic structure, and thus could define the three-dimensional area of excision conveniently and quickly, and help draw up the operation plan (see in **Figure 3**). In the plan design, the main requirement is that the access way of

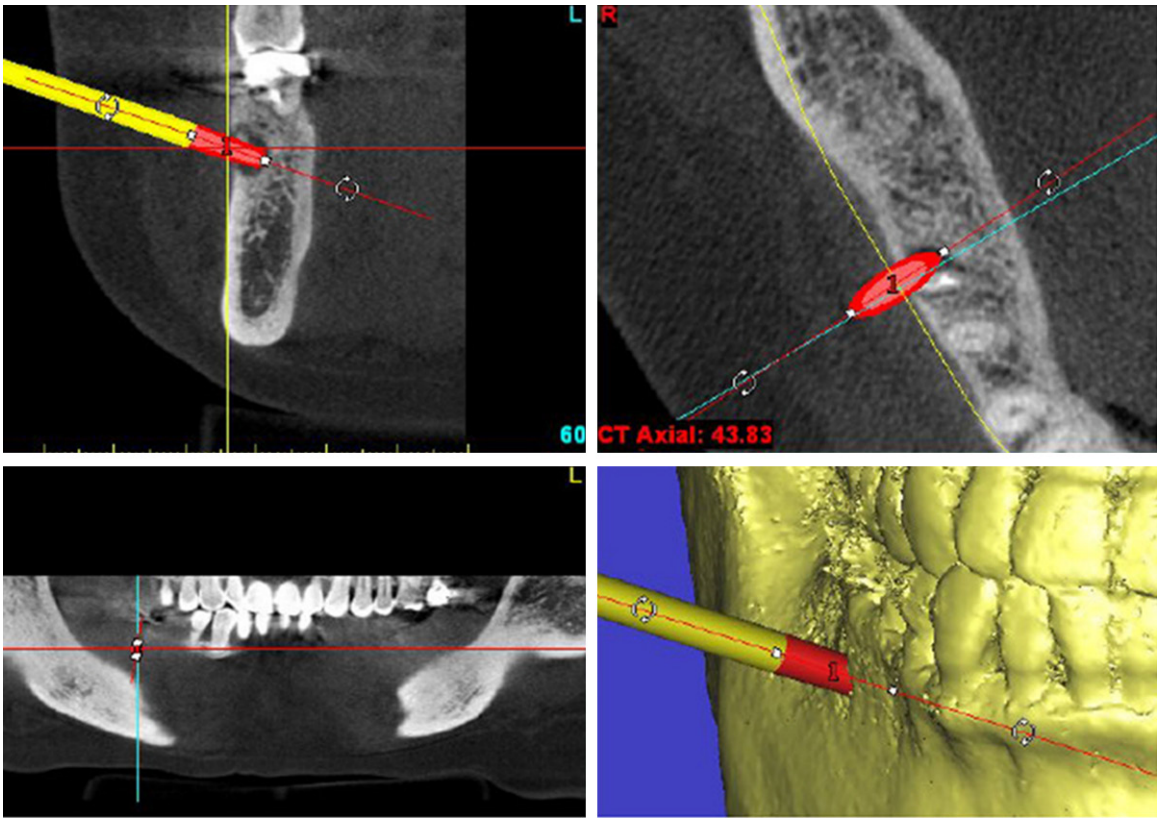

Figure 3. The route and operation depth of guide template designed by computer.

the operation must avoid the important anatomic structure to prevent the damage on the near important structure, and thus require the function of controlling the operation depth.

Base on the three-dimensional operation plan, the operation guide template was designed and made. The soft tissue could not be rebuilt according the CT image and CT scan data could not show the dental crown's detailed structure clearly, but the plaster mold is the direct copy of the oral cavity surface, thus could get both data exactly. The tooth mold data could be obtained by special scan machine and the data would be put into the software for medical image management to conjuncture with the skeleton mold (see **Figure 4**). Base on this, the tooth-supported guide template could be designed utilizing the design function of the software. Its supported surface completely coincided with plaster mold's surface and thus could help the locating in the operation. The locating hole was generated according to drill's centre line in the three-dimensional operation plan, and these holes could determine the drilling plan of operation. Finally, the initial shape of the guide template was built.

In order to limit the depth of the drill, and at the same time to determine the cooperation of guide template locating hole and drill's diameter, it is necessary to have detailed design of the guide template and got the final mold of the guide template and the assorted operation drill and hard grip's standard and type (see **Figure 5**). The data of guide template's detail design would be sent into the rapid form machine to finish the CAM manufacture, and finally the actual guide template was obtained. At Jun 17th, 2011, the operation was carried out. Firstly, the guide template was set successfully after anesthesia on right under jaw. Then the bone drill was put into the hole of guide template, and the motor was then started. The depth of bone drilling was limited by the template. After that, the bone drill was withdrawn and the guide template was removed, and overfilled parts and granulation tissue in root tip was shaved out by curette. Finally, the operation area would be cleaned and the mucoperi-

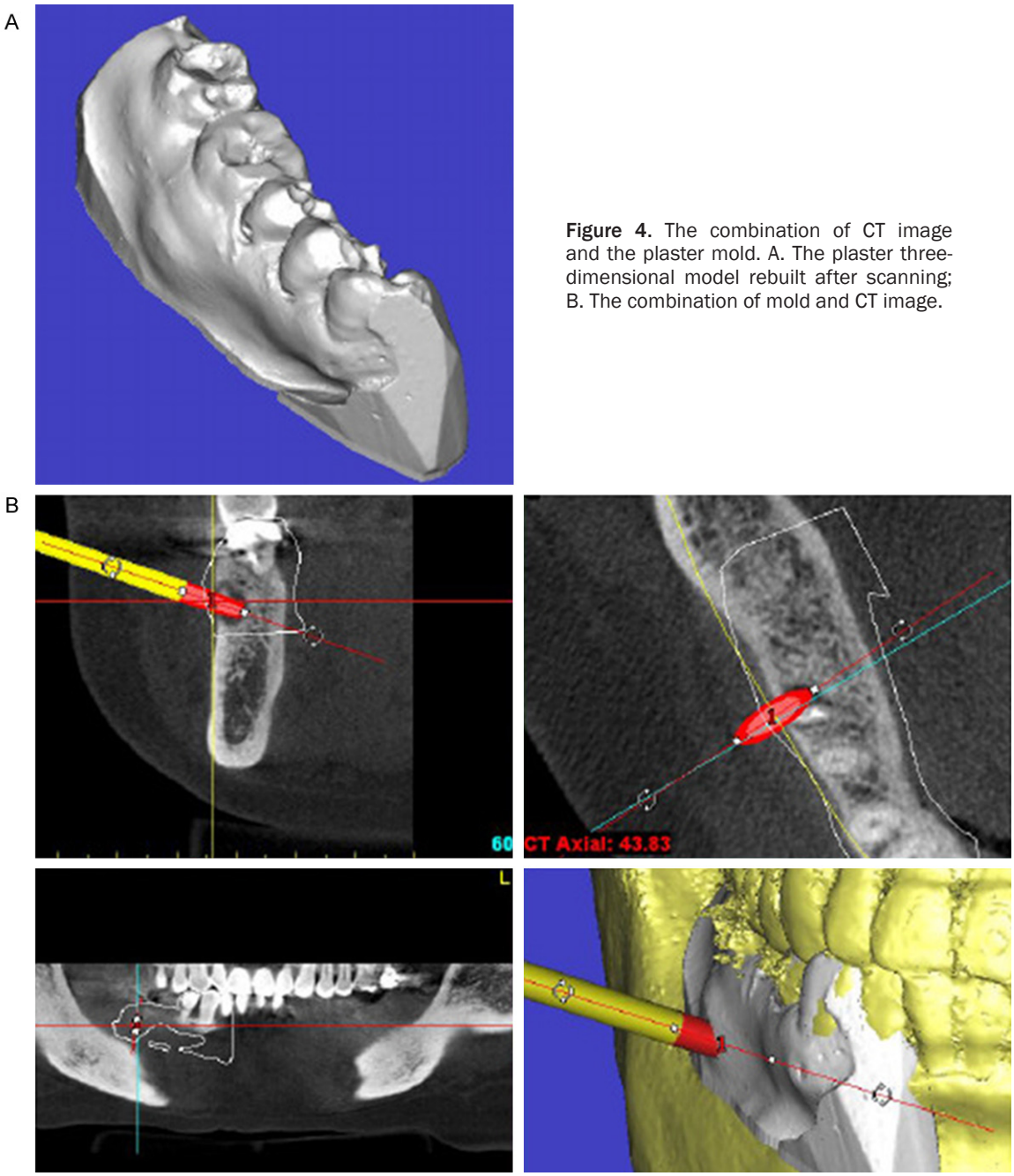

Figure 4. The combination of CT image and the plaster mold. A. The plaster three-dimensional model rebuilt after scanning; B. The combination of mold and CT image.

osteum would be sewed. All above steps were shown on **Figure 6**. The whole operation totally took less than 10 minutes.

Results

Five days after the operation, the stitches were taken out, and wound was healed well. One year after the operation, the patient came back to have her tooth checked: the wound was well closed up. The X-ray film showed that the part bone trabecula density hadno difference with around bone trabecula density (see **Figure 7**).

Discussion

Computer technology in the restoration field, including using CAD (Computer Aided Design) and CAM (Computer Aided Manufacturing) to design and make dummies, has been increasingly used [1]. It was also reported that computer technology was used to improve the con-

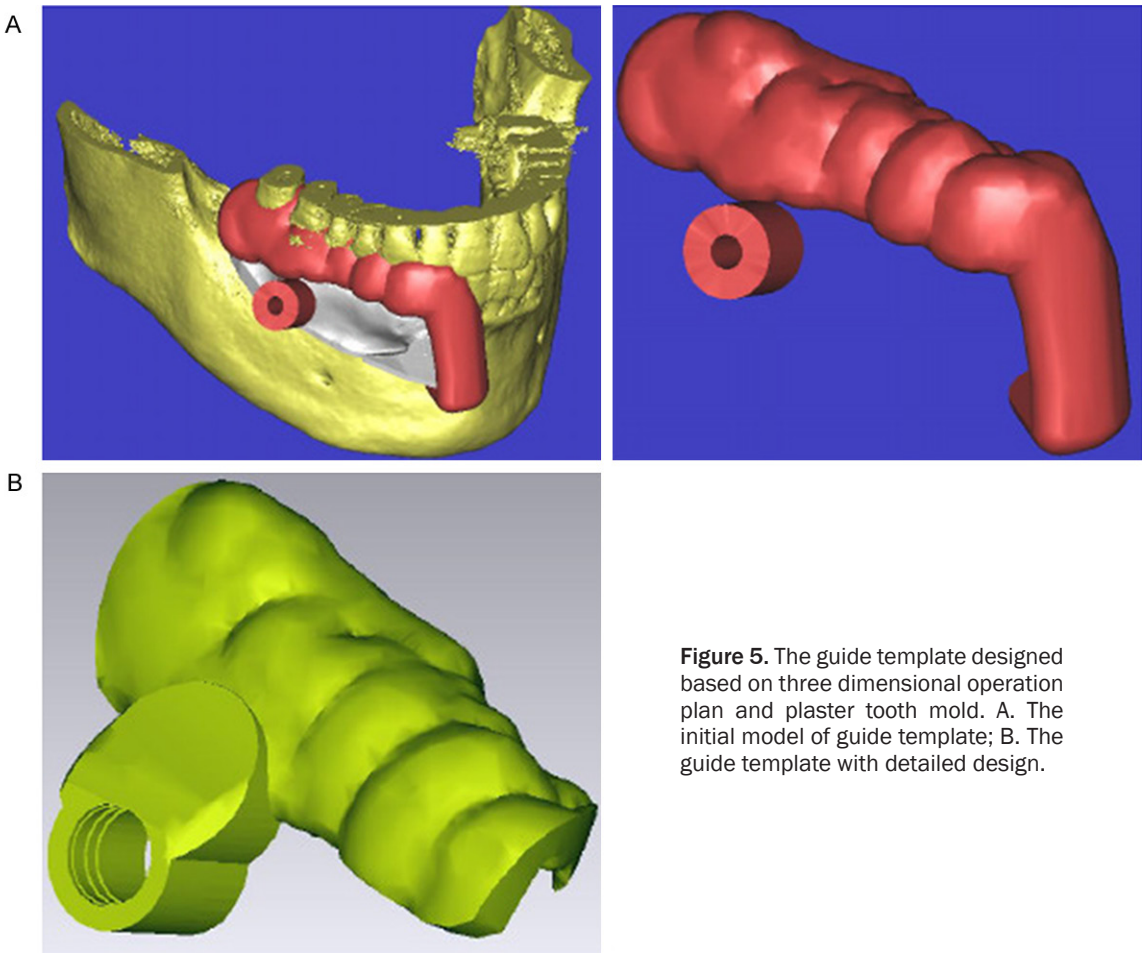

Figure 5. The guide template designed based on three dimensional operation plan and plaster tooth mold. A. The initial model of guide template; B. The guide template with detailed design.

firmed diagnostic rate of dental pulp disease [2]. Recently, Li et al. used CAD/CAM for the design and manufacture of removable partial denture (RPD) and his results showed that this technology had big advantages [3]. Overall, using computer technology for buccal jaw surface surgery has a great future. This work combined the three dimensional imaging techniques and CAD/CAM technology, and applied this for the jaw bone in apex radicis dentis excision for the first time with an excellent effect.

The application of computer made root tip operation guide template has many advantages. First of all, this technology extremely simplifies the whole operation. It is well known that the success of apex radicis dentis excision operation depends on the finding of pathological sites of apex radicis dentis. Unfortunately, for the traditional apex radicis dentis excision operation, the doctors could only know the rough location of apex radicis dentis before they find it. Moreover, in the operation with guide template, doctors could rebuild the three-dimensional oral airway mold by CT film. Base on the three-dimensional mold, the operation plan could be designed, and then the guide template would be designed and. In the operation, when the guide template is fixed in the mouth of patient, the operation plan designed in the computer beforehand could be translated to the patient's oral cavity. By this, the location and the depth of apex radicis dentis could be completely defined. Thus, the time used for operation in this work is much shorter than that of traditional operation.

Besides the above points, there are other advantages. For example, only one small hole would be drilled in this work, the wound is even less than exelcymosis. In contrast, the wound generated in traditional operation is much bigger. Moreover, in this work, the operation guide template is jointed with the tooth surface; and it has certain thickness. The location is correct and stable. The close link of drill and lead hole

Figure 6. The step of operation (A) making the corniform incision, and opening the bone-binding membrane; (B) After setting the operation guide template, putting the drill on the handpiece into the guide template assorted hand grip hole, starting the step tread switch and letting the drill to get into the place with pathological changes slowly; (C) When the handpiece touched the guide template tightly and can no longer go into, it means that the drill is getting to the designed depth, namely, touched the tongue-side border; (D) Cleaning the tissues with pathological changes by curette; (E) Cleaning the wound, and sewing the bone-binding membrane.

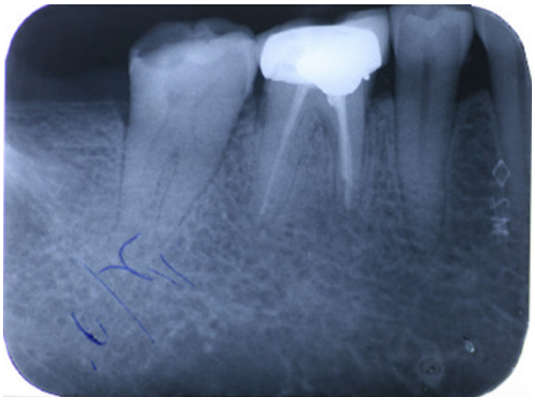

Figure 7. The X-ray film at one year after operation: this picture shows that the density of middle apex radicis dentis is well.

make the drill unable to be deviated. Also, the depth that the drill could get into is just the pathological changes on the border besides tongue. Thus, by the leading of guide template, the operation area and depth for the apex radicis dentis excision could be well controlled. Also, this operation would not hurt the nearby anatomical structure and reduce the risk of operation to be lowest. The traditional operation for apex radicis dentis excision has no risk prevention measures, thus it is easy to hurt nearby organs. Risk control is a hard object of surgeon and this work could make this point.

Conclusion

This work demonstrated the apex radicis dentis excision operation leaded by guide template made by CAD/CAM. Base on the dental CT film and the rebuilding three dimensional buccal models, the operation could be well designed. By this, doctors could know more about the situation of patients. And the time of operation design could change from “in operation” to “before operation”. Thus, the apex radicis dentis excision can be changed from complex to simple, and to be safer. This technology could be applied at any dental clinic.

Disclosure of conflict of interest

None.

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