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Technical note

Virtual planning of a composite model of bone and teeth to facilitate the adjustment of a hybrid distractor for the transport of alveolar bone

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In recent years 3-dimensional computer planning in maxillofacial surgery has been widely used.[1] Hammoudeh et al described stereolithographic modelling for the orientation of vectors when using a bone-to-bone distractor,[2] but the method is not accurate enough for use with a hybrid distractor.

The current technique of using hybrid distractors, such as a VEGAX device (modified hyrax device), requires adaptation to the individual anatomy of the patient.[3] To achieve this, the bone and dental attachments of the distractor are usually bent on a plaster model (obtained from dental impressions) and sculpted around the piriform and zygomatic buttresses on model casts. Such plaster models are more reliable in the reproduction of teeth than bones.

We propose a method of virtual construction of a composite model of bone, teeth, and soft tissues. Once printed 3-dimensionally it can create a better fit of hybrid devices and help to position them more accurately during operation. This updated technical approach requires preoperative cone-beam computed tomography (CT) to acquire DICOM data files, and a standard upper dental cast.

The dental model can be scanned with any optical dental scanner - for example, 3Shape (Copenhagen, Denmark), and a stereolithography (STL) file of the model is generated.

Skeletal maxillary reconstruction data from cone-beam CT and the STL dental model are superimposed in any 3-dimensional virtual planning software for orthognathic surgery - for example, Dolphin 3D software (Patterson Supply, St Paul, MN, USA), or Mimics (Materialise Dental NV, Leuven, Belgium). Once the optically scanned teeth have been superimposed on to the teeth on the cone-beam CT, we have a composite model, which shows the position of the teeth, gums, and cortical bone (Figs. 1 and 2). A cutting plane is then designed 1–2 mm above the mucogingival junction and parallel to the occlusal plane, and both models are cut along the same plane.

The composite model is printed 3-dimensionally and used to simulate the anatomy of the patient to position the hybrid device. It helps to prebend the arms and loops to better fit the device to bone (Fig. 3). The margin between the two parts of the composite model (at the site of the cutting plane of the virtual composite model) is where the arms of the distraction device must make a step and stay close to the bone to improve closure of the soft tissues once the device is fixed in place. Prebending the arms may have the potential to reduce operating time because no further adaptation is needed and we can make a smaller incision.

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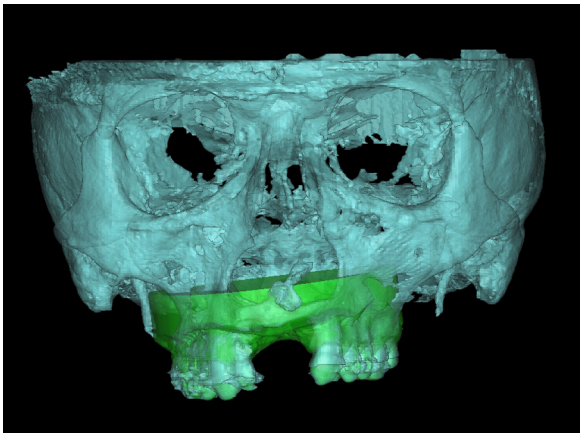

Fig. 1. Transparent view of 3-dimensional object rendered from the cone-beam computed tomogram (in blue) and an optical model scan superimposed on the upper teeth (in green). The upper part of the cone-beam computed tomographic 3-dimensional object and the lower part of the optically scanned model will complete the composite bone, teeth, and gingival part of the plaster model, and the lower part of the cone-beam computed tomographic 3-dimensional object and the upper part of the optically scanned model are discarded.

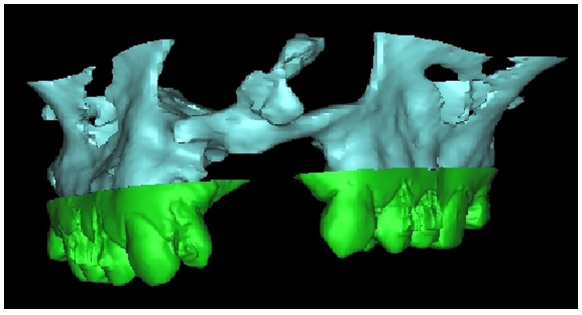

Fig. 2. Composite upper jaw model made by superimposing the cone-beam computed tomogram and the optical scan. Cone-beam computed tomographic 3-dimensionally-rendered bone is shown in blue and the optically-scanned teeth and gums are green.

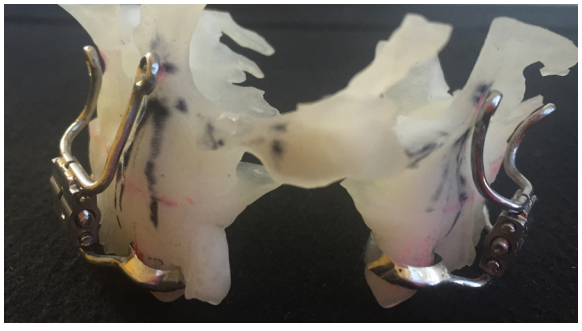

Fig. 3. Three-dimensional printed composite upper jaw model with custom-made devices in place. The arms and loops had been bent directly on the model, which shows the advantage of having accurate bony anatomy.

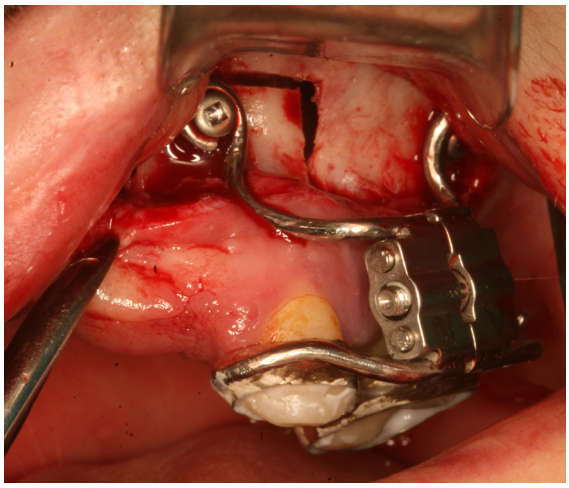

Fig. 4. The custom-made devices with prebent arms and loops are inserted during operation and show a good fit to the surface of the bone.

It is important to know the individual anatomy of the patient, because this helps us to place the distractor accurately and achieve the desired movement precisely (Fig. 4). The additional costs associated with this technique cover the medical engineering and 3-dimensional printing, but we have found that shorter operating times and more precision compensate for these in our practice.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patients' permission

Not applicable.

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