Guided biopsy of osseous pathologies in the jaw bone using a 3D-printed, tooth-supported drilling template

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Abstract: Suspicious radiological findings in the jaw bone require histopathological examination for the confirmation of a diagnosis. As pathologies in this region are difficult to reach or are in close proximity to relevant anatomical structures, e.g. tooth roots or nerves, they often represent a challenge. Such factors may adversely affect the predictability of the surgical outcome of a biopsy of the osseous tissues. This technical note introduces a novel method for performing a digitally planned, guided biopsy. For this purpose, a cone beam computed tomography scan and an intraoral scan are superimposed using specific planning software. The resulting three-dimensionally printed, tooth-supported drilling template is designed for a trephine biopsy. It allows a precise, minimally invasive approach, with an exact three-dimensional determination of the biopsy location prior to surgery. The risk of devitalization of the neighbouring teeth or possible damage to the nerve structures can be minimized. Furthermore, a small access flap can be sufficient. In summary, the method of bone biopsy presented here allows high precision and greater predictability for biopsy sampling and is minimally invasive for the patient.

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Guided biopsy of osseous pathologies in the jaw bone using a 3D-printed, tooth-supported, drilling template

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Abstract

Suspicious radiological findings in the bony jaw need a pathohistological examination for the confirmation of a diagnosis. As pathologies in this region are hard to reach or are in close proximity to relevant anatomical structures, e.g. tooth roots or nerves, they often represent a challenge. Such factors may adversely affect the predictability of the surgical outcome of a biopsy of osseous tissues.

This technical note introduces a novel method for performing a digitally-planned, guided biopsy. For this purpose, a superimposition of a CBCT and an intraoral scan was performed using a specific planning software programme. The resulting 3D-printed, tooth-supported drilling template is designed for a trephine biopsy. It allows a precise, minimally invasive approach, with an exact three-dimensional determination of the biopsy location prior to surgery. Risk of devitalisation of neighbouring teeth or possible damage to nerve structures can be minimised. Furthermore, a small access flap can be sufficient.

In summary, the presented method of a bone biopsy allows high precision and more predictability for biopsy sampling and is minimally invasive for the patient.

Introduction

Intraosseous lesions within the upper and lower jaw may appear cystic, lytic, sclerotic, or a mixture of these. For radiological diagnosis, a variety of imaging modalities are used. In oral and maxillofacial surgery, cone-beam computed tomography (CBCT) is commonly applied due to its high spatial resolution, accessibility, and lower radiation dosage compared to computed tomography (CT). For this reason, intraosseous lesions are common findings in CBCTs[1]. In radiographic images, the degree of bone remodelling around lesions will differ as to inflammatory origin, or benign and malignant lesions. These characteristics, along with factors such as location and the dimension of the lesion, allow a differentiation[2]. In clinics, biopsy is relevant prior to treatment. To minimise diagnostic errors, the biopsy specimen needs to include the interface between lesional and normal adjacent tissue[3, 4]. This technical note presents a digitally designed drill guide for biopsy sampling. Using this guide, the sampling location can be reached with increased precision and predictability.

Technique

Digital Planning

A three-dimensional radiography (CBCT) is uploaded into the planning software (smop, Swissmeda AG, Zürich, Switzerland) as a DICOM file. Next, a superimposition with either an intraoral surface scan or a surface scan of a cast model is performed through the upload of the corresponding STL file (Stereolithography or Surface Tessellation File). Tooth crowns are used as landmarks for facilitated matching. This results in an alignment of the 3D image and an intraoral scan. Originally, the planning software was created for guided implant surgery.

However, instead of virtually inserting a dental implant, a cylinder equivalent to the inner dimension of a trephine bur can be placed virtually into the lesion in the desired position.

The next step is the design of the tooth-supported drill guide (Fig. 1). In collaboration with the service center, the new drill guide STL-File can be exported and sent to a 3D printer. The key benefit in the 3D-printing of the drill guide is the freedom of designing a guide according to the individual surgical situation. For this reason there is no need to avoid undercuts in comparison to a milled drilling template. Additionally, enough space can be provided for water cooling and a visual overview for the surgeon can be achieved, using a skeletal design.

Case illustration (Fig. 1)

The teeth serve as retention for the drilling template (Fig. 2a). Surgical access depends on the location of the lesion. Based on appropriate planning, a minimal, semi-lunar mucosal incision is sufficient in most cases (Fig. 2b). Incisal edge distance and vestibular space should be considered during the planning to avoid increased tension on the buccal mucosa, possibly resulting in the elevation of the drilling template during biopsy sampling. Drilling is performed with a standard angled handpiece and a trephine bur under permanent water cooling (Fig. 2c). Subsequently a primary wound closure is performed (Fig. 2d). The biopsy specimen is transferred to the pathologist for histologic evaluation in combination with the preoperative CBCT. Possibly, a postoperative low dose CBCT, as it was performed in this case can also be supplied. A post-operative 3D-image allows the verification of the biopsy location in comparison to the preoperative planning (Fig. 3).

At the follow-up examination after 7 days, the sutures were removed. The mandible showed good wound healing and there was no sensory disturbance.

Discussion

When applied without tension in the proper interlinking with the dentition, the application of this 3D-printed drilling template allows a reliable position for biopsy sampling[5]. The comparison between the virtual planning and the real patient situation was tested for this software for guided implant surgery and showed satisfying results[6]. These findings can be adopted for the guided biopsy technique. Additionally, using a postoperative low dose CBCT Scan, the location of the trephine drill can be radiologically analysed and serves additionally as a valuable source of information for the pathologist. Various fibro-osseous lesions of the facial bone may have a similar histo-pathological presentation and treatment options vary from a wait-and-see procedure to radical surgery[1]. Even with all available diagnostic tools, treatment strategies remain controversial, however. This underlines the importance of a precise biopsy specimen[7].

Another advantage of the described method is the shorter duration of the surgical intervention. Especially for non- or semi-compliant patients, this can be crucial when deciding whether to perform the surgical intervention under local or general anaesthesia. Moreover, the method is also applicable for children and gives improved access to deep-seated locations in complex anatomical regions.

Another advantage is the possibility to plot the drill guide on the day of biopsy, as long as a 3D printer is available in-house. This is due to the fact that all digital steps can be performed either by the planner or the service center[8].

The preoperative planning procedure reduces the time the patient is in surgery, although, compared to conventional techniques, the overall time needed for each patient remains the same. It is also important to point out that experience in planning is essential to minimise application errors [5, 9].

A guided biopsy with a tooth-supported drilling template is a minimally-invasive, time-effective surgical intervention, which allows more preciseness and predictability. This innovative method has its primary indication for a bone biopsy in complex anatomical regions with proximity to sensitive structures.

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