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Interactive MR-guided biopsies before maxillofacial surgery

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1. INTRODUCTION

Computertomography (CT) and Magnetic Resonance Imaging (MRI) of the head and neck are of great importance to the maxillofacial surgeon in staging tumors of this region (1, 2). Multiplanar image acquisition and superior soft tissue resolution make MRI an important tool in preoperative tumor evaluation (3, 4). However, for the specific tumor diagnosis histological work up has to be undertaken. For this to date an open biopsy technique was required: Under sterile conditions local anesthesia is applied and an incision of the oral mucosa is made. Elevation of a muco-periosteal flap will then give access to the underlying structures, e.g. the maxilla. After the biopsy is taken, the incision has to be closed with sutures. Most often the suture material is non-resorbable and therefore has to be removed after ten days. Only if the tumor perforates the skin or mucosa a direct biopsy of the tumor can be carried out obviating the necessity to elevate a muco-periosteal flap.

To date CT- and MRI-guided cytological biopsy techniques were lacking an interactive tool in positioning the biopsy needle accurately. With the introduction of open MR-systems it became possible to biopsy with non-ferromagnetic needles soft tissue structures under real time conditions (5-9).

If it would be possible to accurately biopsy structures in the head and neck region which are suspicious for e.g. tumors an additional tool for the preoperative work up for maxillofacial surgery would be at hand. And if needle biopsies would acquire sufficient tissue for representative cytological diagnosis this new tool would also obviate the necessity of incisions of the mucosa or skin and the subsequent suturing and suture removal.

Deep areas of the midface can at times only be biopsied under general anesthesia - an MRI-guided biopsy with a small needle could possibly still be performed under local anesthesia.

2. MATERIAL AND METHODS

Seven patients were examined and biopsied in the second half of 1996. A superconducting 0.5-Tesslar open magnet system (General Electric Medical Systems, Milwaukee, WI, USA) with an interactive MR-guided biopsy system (Flashpoint 5000 position encoder, Pixsys, Boulder, CO, USA) was used. Permission of the hospital human ethic research Commitee was obtained.

All patients had a solid or cystic tumorous lesion in the maxilla extending to the floor of the orbit, into the ethmoid sinus and towards the skull base. There were two female and five male patients with a mean age of 44.6 years (range 31-60 years). After clinical examination a CT scan (SR 7000, Philips Medical Systems, Eindhoven, The Netherlands) was carried out.
Before biopsy local anesthesia with 0.5 mg % Scandicaine was applied to the enoral mucosa and the periosteum of the alveolar process. Then a flexible surface transmission and emission ENT coil (GE Medical Systems, Milwaukee, WI, USA) was wrapped around the patient's face leaving the oral cavity uncovered. We used 5 cm and 10 cm 22 and 18 gauge needles (E-Z-EM, Westbury Inc., N.Y., USA) in the specially designed "Flashpoint" hand held probe of the stereotactic guiding system. One radiologist and one maxillofacial surgeon followed the positioning of the needle on a video screen inside the open system. To localize the needle three-dimensionally 0° (horizontal), 90° (sagittal) and perpendicular planes were calculated using the coordinates of the hand-held probe (Figs 1,2).
Communication with the technologist outside the scanner room was performed via a two way audio system. Imaging before intervention was carried out using standard T2-weighted fat suppressed Spin Echo-Sequences. Imaging using the interactive stereotaxic system was conducted using T1 weighted fast gradient recalled echos (GRE) TR 19, TE 7.1, flip angel 30°, slice thickness 1 cm, FOV 24x24 cm, matrix of 256x128, 1-8 NEX.

After localization of the needle tip within the lesion the hand held probe was disconnected and a 20 ml aspiration syringe brought in place. Cytology specimens were immediately fixed by a cytology technician asked into the MR-scanner room. Cytology result were available within four hours after the biopsy to allow a repetition of the biopsy during the same day if needed.

3. RESULTS

All patients were biopsied without complications in a time less than 30 minutes. All biopsies demonstrated representative cytological material. This was confirmed during histological investigation of material acquired during subsequent surgical procedures. Two patients had ameloblastomas of the maxilla and paranasal sinus reaching the skull base, one patient had a Non Hodgkin Lymphoma penetrating the orbit and the skullbase, two patients had large odontogenic cysts of the maxilla penetrating the ethmoids and two patients had longstanding inflammatory sinus desease with retention of mucous and erosion of sinus walls, e.g. the medial orbital wall.

The interactive monitoring in near real time (1 images every 1.5 sec) served as a "third eye" to locate the needle tip. The sagittally and perpendicularly computed planes proved to be helpful in determination of the needle tip to spare delicate structures, e.g. intraorbital contents. Due to osseous parts and air filled cavities the needle tip showed a deviation to the computed track of 5 to 15 degrees.

4. DISCUSSION

Staging of tumors in the maxilla and the skull base can be undertaken by CT and MRI. Although MRI is less suited to evaluate bone and air filled cavities in the spanchnocranium, it is able to delineate soft tissue infiltration and vessels even better than computed tomography (1). Due to its multiplanar image acquisition and dynamic contrast enhanced sequences MRI increases the preoperative safety to delineate benign and malignant tumors in the vicinity of vital organs like vessels and the orbit. Furthermore artefacts due to dental amalgam filling are less pronounced than in CT.

In our study the interventional potential of open MRI was used to retrieve cytological specimens of tumors, cysts and inflammatory desease staged by CT and MRI. This combines the imaging and interventional potential of the new generation of open magnet systems. After comparing the CT images and the MR-scans always an enoral approach was chosen in supine position of the patient. Using a 22 or 18 Gauge non-ferromagnetic needle after local anaesthesia the small osseous lamella could be perforated and the access to the maxillary sinus was created. This allowed fluid aspiration of benign radicular cysts as well as cytological material from the rostral and dorsal wall of the cyst. All these procedures were accomplished under interactive guidance of the needle which served as a third eye to the interventional team consisting of a radiologist and the referring maxillofacial surgeon.

Malignancy in cystic tumors of the maxillary region cannot be excluded by CT and MRI (10) and therefore representative biopsy material has to be harvested. In the two patients with the rare ameloblastomas of the maxilla enough cytological material could be retrieved to allow proper histological diagnosis. Ameloblastomas are benign, locally infiltrative odontogenic tumors that are characterized by a variety of histologic appearances and a persistent growth pattern (11-13). Only 10 % occur in the maxilla and show a more aggressive pattern than their counterpart in the mandible. Ameloblastomas of the upper jaw tend to recur, therefore an initial proper preoperative surgical staging by CT and MRI is mandatory. There is a association of ameloblastomas and dentigerous cysts and therefore every cystic tumor in the maxilla has to undergo at least cytological examination if not complete resection (13). Our two patients with benign radicular cysts underwent complete surgical resection of the maxillary cysts. Further workup was not necessary. The patients with inflammatory mucus retention were also biopsied without problems (14).

Another patient with a soft tissue tumor in the upper jaw infiltrating the skull base and the orbit underwent an open biopsy and a fine needle biopsy of the tumor. Typical non Hodgkin lymphoma cells could be retrieved from both specimens, although a specific lymphoma grading could only be accomplished with the open (larger) biopsy specimen. Non Hodgkin Lymphoma of the sinus are rare extranodal manifestations counting only 8 % of all neoplasias in this location. To define the extent of skull base infiltration, MRI is better suited than CT (15). To do proper Lymphoma classification, an open biopsy is often necessary. But the open biopsy technique needs sometime general anaesthesia, whereas fine needle biopsy in the maxillary sinus can always be performed with local anaesthesia alone.Open surgical biopsies also needs suturing and suture removal, whereas this was not necessary in these seven patients.

All patients reported the interventions in the open MR as bearable and did not suffer pain or any other complication like bleeding or infection.

5. CONCLUSION

Interactive MR-guided biopsies in an open system of the head and neck are technically feasible and safe.

The positioning of the needle can be monitored in multiple planes assuring to spare vital structures. Interactive MR-guided biopsies can replace some open surgical procedures in the maxillary region. The positioning device could be used for application of laser energy.

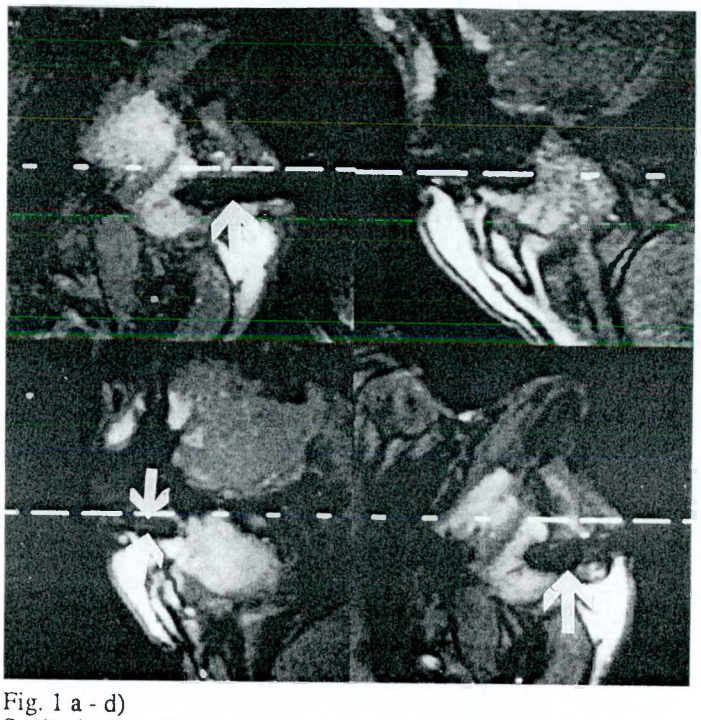


Fig. 1 a - d)
Sagittal view: interactively guided biopsy of an ameloblastoma originating from the tooth bearing part of the maxilla. White marks indicate the virtual biopsy path. Low intensity susceptibility artefacts demonstrate the non-ferromagnetic needle in the maxillary sinus (aarows).

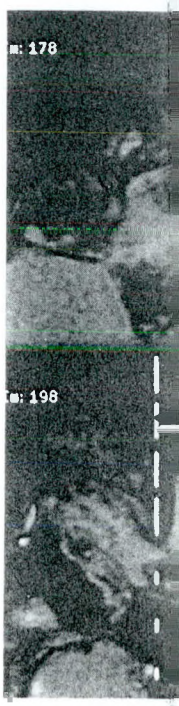
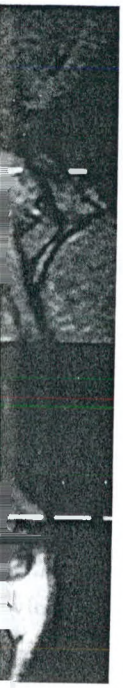


Fig. 2 a - d)
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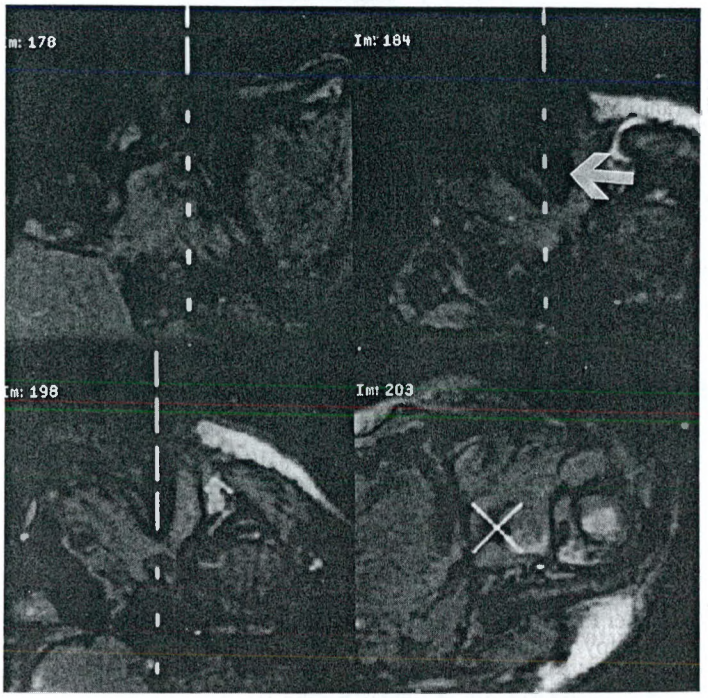


Fig. 2 a - d)
Same patient with ameloblastoma: after enoral anaesthesia sagittal, axial and perpendicular planes counted according to the coordinates of the interactive guidance system. Note slight deviation of the non-ferromagnetic needle to the virtual biopsy path due to perforation of bone (arrow).

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