Intraoperative 3D-SPECT of sentinel nodes in combination with navigated lymph node biopsy in early oral squamous cell carcinoma

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Introduction

Occult metastasis of the lymph nodes of the neck occurs in up to 20-40 % of all oral squamos cell carcinoma (OSCC). Levels I—III are involved in most cases; levels IV or V are rarely affected. Therefore, elective neck dissection of levels I - III is still recommended even in a clinically unsuspicious lymph node staging of the neck (cN0), regardless of the size of the primary tumor [AWMF S3 guidelines for OSCC]. Sentinel lymph node biopsy (SLNB), as already routinely used in the therapy of breast cancer, is not a common standard in the therapy of the primary stage of OSCC (cT1-2, cN0). Even if the method is not yet evidence based, several studies have already shown good results that suggest that the SLNB is an alternative procedure for the standard elective neck dissection in these cases. [1-6] However, these studies also showed difficulties in the practical performance of the SLNB. Reasons for this were the close relationship between the sentinel lymph nodes to each other and to the primary tumor. Furthermore, the specific SLNs were difficult to find intraoperatively in a complex soft tissue anatomy of the neck. The possibility of a visualization of the marked sentinel nodes during the operation did not yet exist. The standard γ-probe only gives an acoustic feedback and makes it difficult to locate and separate single nodes that lie close to each other.

A new system for SLNB (declipse®SPECT – SURGICeye®, Munich) now offers the chance for an intraoperative 3D-SPECT of the radioactive SLNs with a 3D visualization of these structures. The marked SLNs are therefore superimposed on a live image of the patient's neck, also known as augmented reality. This method should enable the surgeon to identify the SLNs more accurately. For a secure resection of these nodes, an additional computer navigated γ-probe is used as well. This navigation allows for the determination of direction and distance from the probe tip to the radioactive focus (SLN). At the same time, it is possible to overlay pre-OP PET-CT or SPECT-CT data on the live image of the patient. After tumor and SLNs resection, a detection of the remaining radioactive tissue with a final 3D-SEPCT scan is also possible. Remaining lymph nodes can be visualized and resected before the completion of the operation.

Method

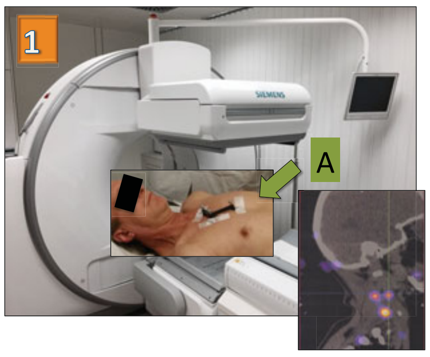

Fig. 1: Injection of Tc-99m around the tumor for SEPCT-CT scan 24 hours pre-OP. For later intra-OP registration, a reference array is picked on the patient's sternum during the SPECT-CT scan (A). At the end of this procedure, SLNs are marked on the patient's skin with a pen (Fig. 3d/D).

1

Importing of the SEPCT-CT data into the SURGICeye declipse®SPECT.

2

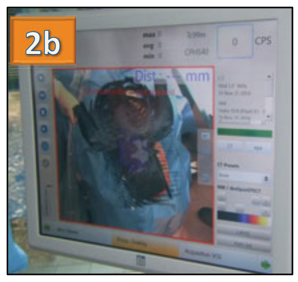

Fig. 2a: Screenshot of the pre-OP SPECT-CT.

Fig. 2b: SPECT-CT data can be superimposed intraoperatively on a live image of the patient on the screen. A reference array is picked on the patient's sternum pre-OP during the SPECT-CT scan (Fig.1: A) and is replaced in the same position during the operation for intra-OP registration.

3

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intraoperative 3D-SPECT

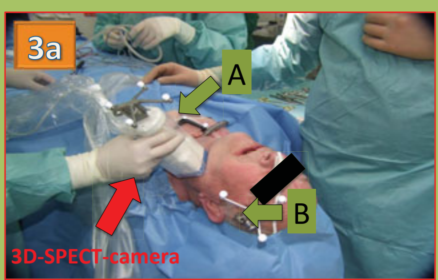
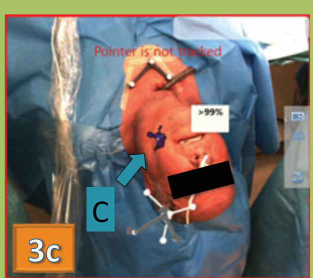


Fig. 3a: Intraoperative 3D-SPECT with a handheld 3D-SPECT Camera. For registration of the patient's position during this procedure, another reference array has to be attached to the skull (B).

Fig. 3b: Live image of the scanned area on the SURGICeye screen during intra-OP 3D-SPECT-Scan.



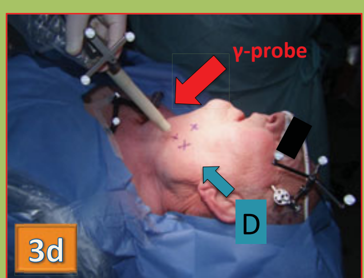


Fig. 3c: After successful SPECT of the tumor and the SLNs, a three-dimensional picture of these structures is superimposed onto the patient's anatomy and visualized on the SURGICeye screen (C). Each radioactive focus can be selected and displayed separately with its quantity of radioactivity (in percentage). SLNs close to the tumor can be separated with this method easier than with a planar projection of the SLNs onto the patient's surface preoperatively.

Fig. 3d: With a navigated γ-probe, the position of the pre-marked lymph nodes (D) can already be verified acoustically and visually before starting the operation.

With the help of 3D-SPECT, a three-dimensional image of all radioactive foci can be superimposed on the patient's anatomy. Pre-OP detected SLNs can be verified and seperated easily intraoperatively.

navigated SLN biopsy

Fig. 4a: After the surgical approach to the patient's neck is finished, SLNs can be detected and separated with the help of a navigated γ-probe. The common acoustic detection of the radioactive structures is thereby still possible.

Fig. 4b: Additionally, locating SLNs is eased by a visual navigation tool on the SURGICeye screen, thereby displaying each radioactive focus measured with the 3D-SPECT (Fig. 3c) onto the live image of the patient again. The navigation mode now shows the distance from the tip of the γ-probe to the preselected SLN in millimeters. The tracking of the γ-probe is also managed with the reference array attached to the skull (Fig. 3a/B).

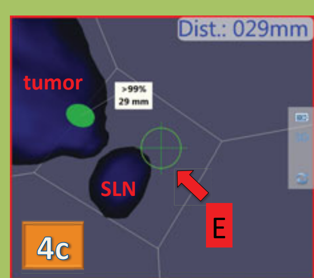


Fig. 4c: Another visual mode navigates the γ-probe to the center of the selected radioactive focus. The crosshairs (E) show the orientation of the probe in the scanned cube. The remaining distance from the tip of the probe to the center of the selected focus is shown in millimeters. This mode allows for the separation of each single SLN from each other. A clear separation from the tumor's radiation should be possible with this method as well.

Finally, a specific SLN biopsy can be performed properly.

With the help of a opticaly navigated γ-probe, SLNs can be detected and separated from the surrounding tissue more easily than with a standard γ-probe. SLNs close to the tumor can be detected and separated more accurately.

Results and Discussion

Even though this method offers promising possibilities in intraoperative visualization and soft tissue navigation, the procedure showed deficits in clinical use. The intra-OP 3D-SEPCT proved itself to be a time-consuming process in practice (10 to 15 minutes). The navigation within the soft tissue of the neck in order to find the SLNs proved itself to be imprecise. Possible reasons for this might be inaccurate registration with the reference array attached to the sternum and the soft tissue shift which has been well-documented in numerous studies. The SLNs could often be detected properly only by the use of the acoustic feedback of the γ-probe. For this reason, this expensive and time-consuming procedure has to be evaluated critically from a clinical point of view. The authors recommend an improvement of accuracy in soft tissue navigation and a more time-efficient workflow. An enlargement of the 3D-SPECT area could reduce the time for intra-OP scanning. This method showed the greatest advantage in intraoperative 3D-SPECT scanning in order to evaluate the complete removal of all radioactive structures (SLNs and tumor) before completing the operation.

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The authors disclose that they have no conflict of interest.