# XperGuide: C-arm needle guidance

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MeSH: Paraganglioma [C04.557.580.625.650.700]
Glomus Tumor [C04.557.645.350]
Head and Neck Neoplasms [C04.588.443]
Embolization, Therapeutic [E02.520.360]

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## 1. Purpose

Percutaneous punctures in the head and neck region are traditionally guided using either static CT images, CT fluoroscopy or X-ray fluoroscopy.

All mentioned approaches posses their limitations;
Both CT based procedures are limited by the patient access area within the gantry. Also the needle path, which can be planned and tracked, is restricted to the axial planes that are imaged by the CT modality. Static CT images further lack the real time feedback.
X-ray fluoroscopy generates less X-ray dose, compared to CT fluoroscopy, and offers less restriction in patient access. It does not provide, however, any soft-tissue information.

Here we present a method that integrates soft-tissue information in X-ray fluoroscopy guided cranial needle insertion. The needle paths are pre-operatively planned on a morphological dataset, such as CT or XperCT.

## 2. Methods and Materials

Before the puncture is performed, the optimal needle paths are planned on the morphological data set. This can be a pre-operative CT dataset, or a rotational soft-tissue reconstruction, acquired with the C-arm system (XperCT dataset).
Within the anatomy of interest a target point is selected (mid point of the lesion location, see figures 1-3). Then a 3D view showing unobstructed access to the target, avoiding the impenetrable bones and major vessels, determines the incision entry point, see figure 4. After the target and the entry point have been established, a straight trajectory to the target is planned.
The resulting puncture path can be inspected with respect to the soft-tissue, bones and vessel anatomy, see figure 5. Multiple paths can be stored in this way.

At the beginning of the intervention an XperCT dataset is acquired, and the pre-operative CT dataset is registered to the peri-operative XperCT, which also registers the CT and C-arm coordinate systems, see figure 6.
The fluoroscopy image is overlaid with the planned needle trajectory and an oblique slice of the soft-tissue data, perpendicular to the viewing incidence and passing through the target point. The overlay image is real-time updated for any change in viewing incidence (L-arm, rotation, angulation), field of view, and source-image distance [Söderman et al., Racadio et al.].
The needle path is compensated for parallax distortion.
The C-arm viewing incidence is steered to be tangent to the planned path: the entry view. Since this view is tangent to the needle trajectory, the path is foreshortened to a single point. When the needle is positioned at the entry position and its orientation is tangent to the fluoroscopy image, it can be inserted.
The C-arm viewing incidence is then steered to be perpendicular to the planned path: the progression view. In this orientation, the needle can be navigated along the planned trajectory.

The entry view and progression view steps are repeated for all planned puncture paths. The views can be selected at table side. Optionally, new paths can be planned during the intervention. After the insertion, a new XperCT can be acquired to verify the needle position with regard to the soft-tissue structures and anatomical landmarks.

## 3. Results

The proposed method has been applied to navigate a needle along 8 planned paths to puncture a glomus jugulare tumor for two patients. It has been previously shown that the percutaneous intratumoral injection of cyanoacrylate is an effective approach to embolize head and neck paragangliomas [Giansante Abud et al.].

For both patients two needle trajectories have been planned, using a pre-operative CT. The registration [Maes et al.] with the peri-operative XperCT reconstruction took less than 8 seconds. Using the described XperGuide method, it proved to be possible to guide the needle within 5 mm of the planned path. For the first patient (female, 63 years) one additional path was planned during the intervention in order to maximally embolize the tumor, and for the second patient (female, 64 years) three additional trajectories were planned.

## 4. Conclusions

The fluoroscopy navigation, overlaid with the planned path, has been shown to be an accurate tool for needle guidance. The procedure could be performed in the angio lab, using C-arm fluoroscopy. No additional navigation equipment or special devices were required. The procedure could be performed very efficiently, compared to CT guidance.

The patient orientation differed between the pre-operative CT and the fluoroscopy guided intervention, but this did not form a complicating factor. The needle accessibility of an intracranial location, however, can be limited persé by the topology of the skull.

## 5. Personal Information

We would like to acknowledge the Rothschild foundation in Paris, France, and in particular Dr. Laurent Spelle and Prof. Dr. Jacques Moret, for their support.

## 6. References

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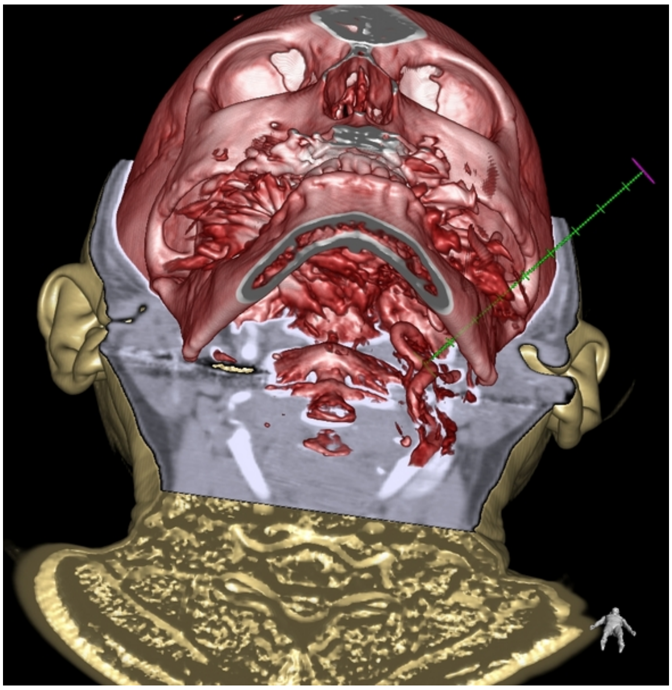
Söderman M., Babic D., Homan R., Andersson T.: 3D roadmap in neuroangiography: technique and clinical interest, Neuroradiology 47(10), pp. 735-740, 2005.

Giansante Abud D., Mounayer C., Benndorf G., Piotin M., Spelle L., Moret J.: Intratumoral Injection of Cyanoacrylate Glue in Head and Neck Paragangliomas, American Journal of Neuroradiology 25, pp. 1457-1462, October 2004.

Maes F., Collignon A., Vandermeulen D., Marchal G., and Suetens P.: Multimodality Image Registration by Maximization of Mutual Information, IEEE Trans. Medical Imaging 16(2), pp. 187-198, 1997.

## 7. Mediafiles:

### CT and XperCT, matched

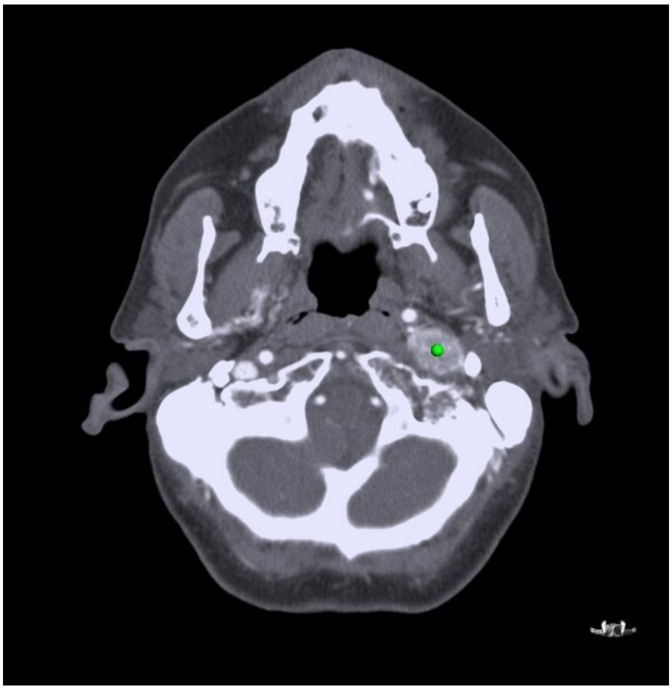


The registered CT (yellow) and XperCT (red) datasets. This view shows that the planned path does not intersect with any major vessel.

### Entry view needle positioning

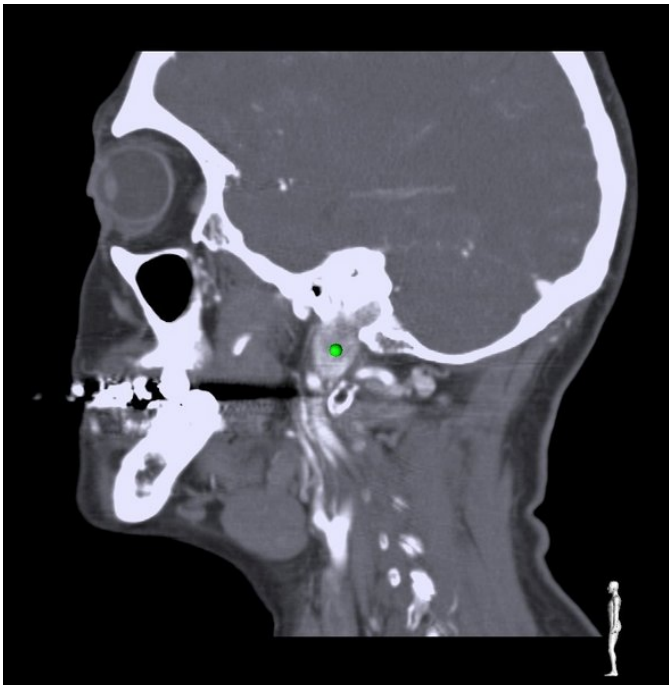

The C-arm gantry is positioned to show the entry view. The needle has to be positioned to be tangent to the view. The real-time X-ray fluoroscopy image stream is overlaid on the 3D CT and XperCT data.

**Fig 1: target, axial**



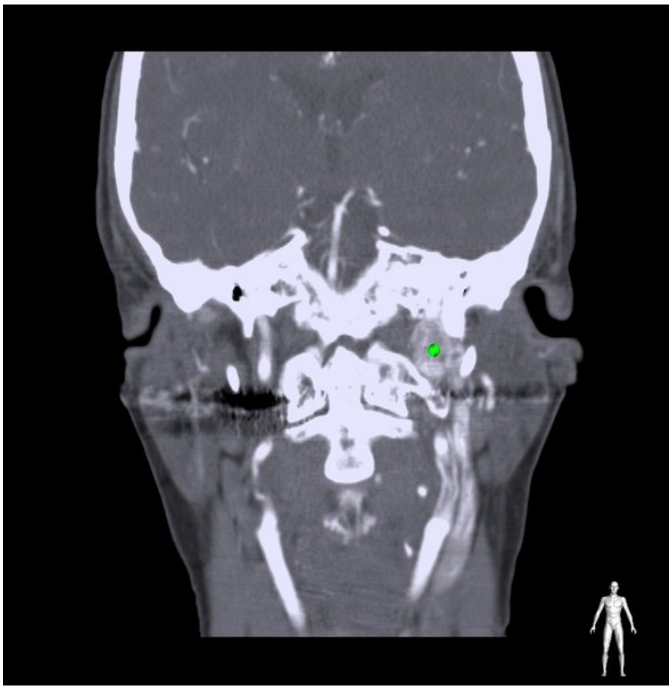
Axial view on the target in the glomus tumor.

**Fig 2: target, sagittal**



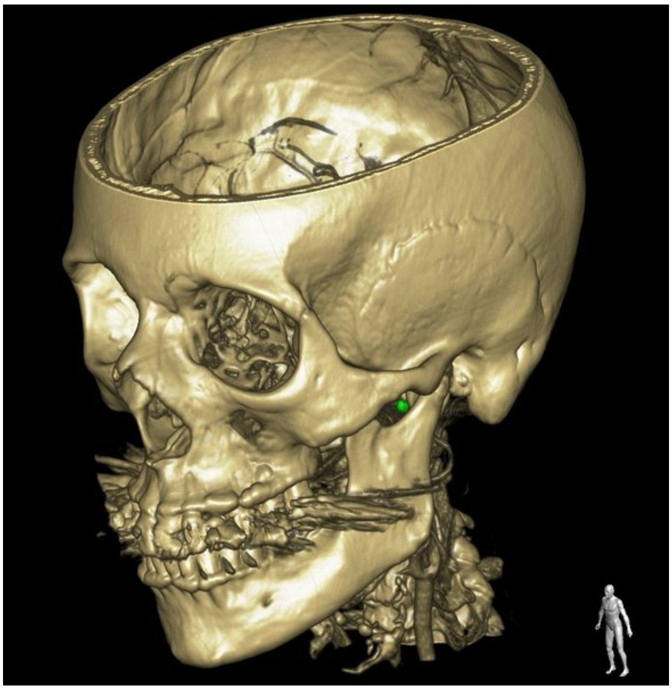
Sagittal view on the target in the glomus tumor.

**Fig 3: target, coronal**



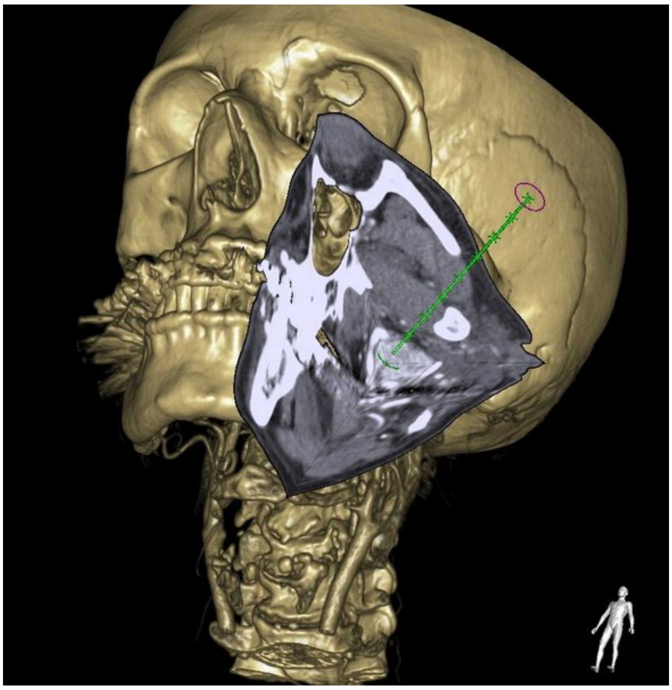
Coronal view on the target in the glomus tumor.

**Fig 4: 3D view on the target**



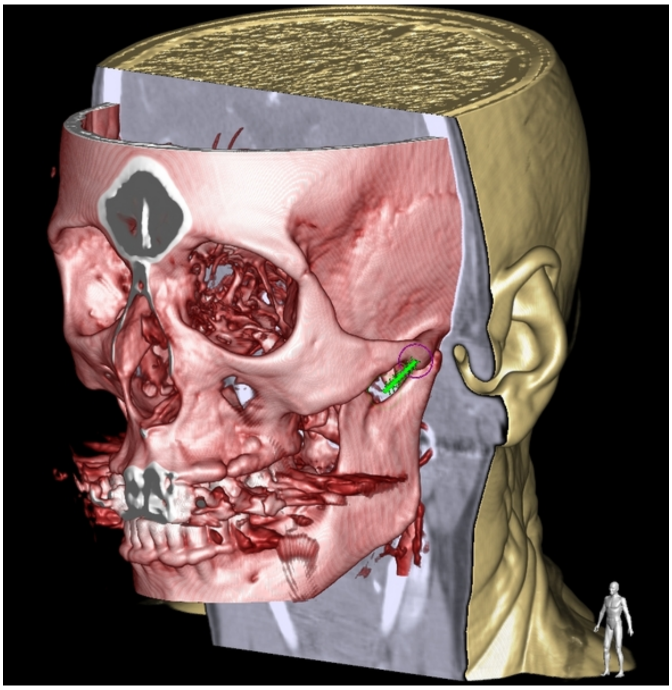
A 3D view on the target, showing the skull and vessels.

**Fig 5: needle path**



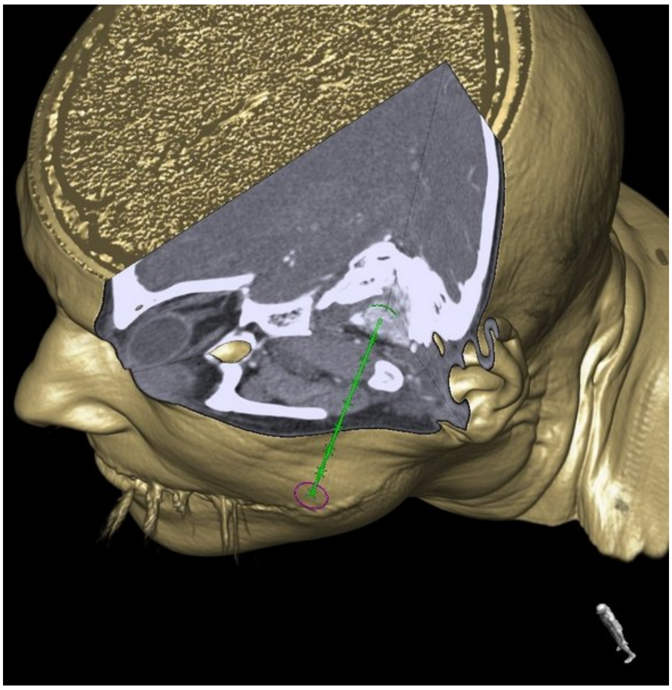
The needle path in 3D view. The octant cut allows evaluation of the soft-tissue, bones and vasculature along the needle path.

**Fig 6: XperCT and CT match**



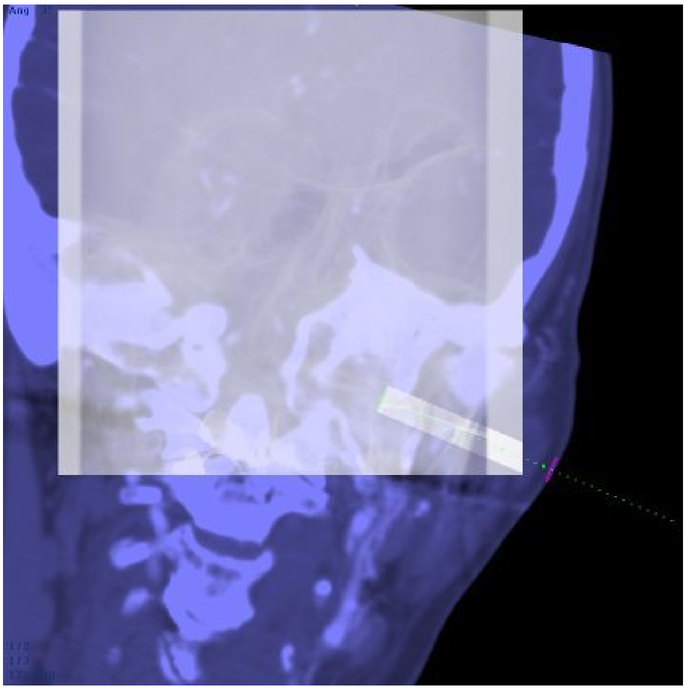
The XperCT volume (red) is peri-interventionally registered to the CT volume (yellow)

## Needle path in 3D



Needle path, with respect to the soft-tissue, bones, vessel and skin.

## Progression view



Real-time X-ray fluoroscopy is overlaid on the oblique slab in the CT data, through which the planned trajectory passes. The fluoroscopy image around the planned path is enhanced to increase the visibility of the needle.