

Intra-operative Transfer of Planned Zygomatic Fixtures by Personalized Templates: A Cadaver Validation Study

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1 Background

Our previously developed 3D CT-based oral implant planning system [1,2] has been extended recently towards zygoma fixtures [3]. Zygomatic implant surgery requires a meticulous pre-operative planning (Figure 1) due to factors such as the length of the implant's trajectory (> 40 mm), the complicated and curved anatomy of the sinus, the relative small size of the zygomatic target area, and a limited intra-operative visibility.

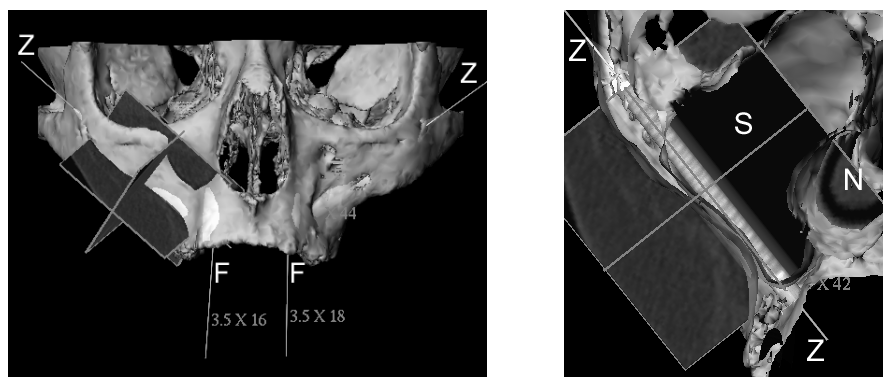


Fig. 1. *Left:* Two zygoma fixtures are shown at Z, and two frontal alveolar implants at F. *Right:* a CT reslice along a planned implant's axis is co-visualized with extracted bone structures. Note the nearby nasal cavity (N) and the course of the implant along the cortex of the sinus (S).

For conventional alveolar implants, personalized drilling templates have proven their efficiency and effectiveness, see [4]. However for zygomatic fixtures, where the problem of intra-operative transfer is even more important, it was up till now unknown whether personalized drilling templates could yield the necessary accuracy. Therefore a validation study was set-up with three cadavers (six zygoma fixtures).

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2 Materials and Methods

Based on pre-op CT images, fixture planning was done in the environment [3]. For each cadaver a personalized template was designed and manufactured in stereolithography, see Figure 2. Actual drilling did occur without opening the usual small 'window' in the outer cortex of the sinus. The latter procedure is typical for zygoma fixtures as it allows to adjust the drilling direction intra-operatively. In our study however, it was the intention to assess a complete dependency on the template. The template was only employed to guide drilling. Afterwards fixtures were inserted.



Fig. 2. *Left:* CAD design of the zygoma drill template visualized in the planning environment. *Right:* actual stereolithographic template generated from the design and applied intra-operatively. The template contains tubes, in which metal drill guides can be inserted (arrows).

Post-op CT images were acquired and matched to the pre-op CT images (and the planning) using the fusion approach of [5], which is unaffected by local image deformations. After resampling post-op over pre-op, the zygoma implants were easily segmented, which allowed to visualize and inspect them in the pre-op space.

3 Results and Conclusions

One out of the six fixtures installed showed a deviation of 7° from the planned axis direction, of 6 mm. from the planned maxillary entry and of 8 mm. from the planned zygomatic exit. Considering the other five fixtures, the worst(best) case values were $3.1(0.6)^\circ$, 2.1(0.7) mm. and 2.7(0.8) mm. respectively. These results indicate that acceptable accuracy is to be expected from zygoma fixture drilling templates.

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