Patient-Specific Polyetheretherketone Facial Implants in a Computer-Aided Planning Workflow

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Purpose: In the present study, we report an innovative workflow using polyetheretherketone (PEEK) patient-specific implants for esthetic corrections in the facial region through onlay grafting. The planning includes implant design according to virtual osteotomy and generation of a subtraction volume. The implant design was refined by stepwise changing the implant geometry according to soft tissue simulations.

Materials and Methods: One patient was scanned using computed tomography. PEEK implants were interactively designed and manufactured using rapid prototyping techniques. Positioning intraoperatively was assisted by computer-aided navigation. Two months after surgery, a 3-dimensional surface model of the patient's face was generated using photogrammetry. Finally, the Hausdorff distance calculation was used to quantify the overall error, encompassing the failures in soft tissue simulation and implantation.

Results: The implant positioning process during surgery was satisfactory. The simulated soft tissue surface and the photogrammetry scan of the patient showed a high correspondence, especially where the skin covered the implants. The mean total error (Hausdorff distance) was 0.81 $\pm$ 1.00 mm (median 0.48, interquartile range 1.11). The spatial deviation remained less than 0.7 mm for the vast majority of points.

Conclusions: The proposed workflow provides a complete computer-aided design, computer-aided manufacturing, and computer-aided surgery chain for implant design, allowing for soft tissue simulation,

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Guevara-Rojas and Dr Watzinger contributed equally to the present study, with Guevara-Rojas responsible for the technical part and Dr Watzinger for the medical aspects.

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fabrication of patient-specific implants, and image-guided surgery to position the implants. Much of the surgical complexity resulting from osteotomies of the zygoma, chin, or mandibular angle might be transferred into the planning phase of patient-specific implants.

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Medical rapid prototyping is gaining significance in different areas of preoperative planning such as maxillofacial surgery, orthopedics, neurosurgery, and orthognathic surgery. These 3-dimensional (3D) models allow the surgeon to become acquainted with the local anatomy and support the surgeon's intraoperative "3D

FIGURE 1. *A-C,* Preoperative 3-dimensional photograms of the 27-year-old female patient. The midface hypoplasia is clearly visible.

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