Accuracy of maxillary advancement during bimaxillary operations using a CAD/CAM generated splint

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Method:
10 mandibulo-maxillary operations were virtually planned by using the software ProPlan CMF © (Materialise, Belgium).

First the primary CT-scan was segmented followed by performing a virtual Le-Fort-I-osteotomy and digital maxillary advancement. (Fig. 1a,b and 2a,b).

For the transfer of the planned position into the operation site stereolithographic splints were generated and used during the surgical procedure to reposition the maxilla (Fig. 3).

The dental casts of the upper and lower jaw were digitally scanned and overlaid with the CT scan. (Fig. 4, 5) As a result a precise intraoral fitting of the CAD/CAM generated splint on the patient dentition could be achieved (Fig. 6).

The primary position of the mandible in relation to the maxilla was fixed during the 3D-imaging (Fig. 7, 8) where the patient carried a blue conventional primary splint in habitual occlusion (Fig. 9). During the operation the position was maintained using this splint and fixed to the maxilla with osteosynthesis plates from the ramus mandibularis to the zygoma region on each side (Fig. 10 a,b). After removing the ramus fixation plates and the primary splint the Le-Fort-I-osteotomy and the mobilization of the maxilla was done. This was followed by mandibulomaxillary fixation with the positioned CAD/CAM generated splint (Fig. 11, 12). Consequently the planned transversal and sagittal movement was transferred to the operational site.

To transfer the vertical positioning, the ramus fixation plates were placed at both sides of the ramus of the mandible. Then the mandibulomaxillary complex (positioned by the CAD/CAM generated splint) was moved cranial, until both fixation plates could be aligned and re-fixed in the original holes cranial of the Le-Fort-I-osteotomy line (Fig. 13). The definitive osteosynthesis followed with miniplates paranasal and after removing the ramus fixation plates in the zygoma region (Fig. 14).

After bilateral sagittal split osteotomy of the mandible the final occlusion was defined by a conventional dental lab produced splint and osteosynthesis with semi rigid splitfix plates (Fig 15-17).

Maxillary Positioning
To evaluate the accuracy of the transfer into the operational site image fusion of the 3 dimensional planned position (green) and the post-operative result CT-scan (blue) was performed.

The post-operative dataset (blue) was segmented and overlaid with the primary (red) and the planning data set (green) using a semi-automatic registration method in the unchanged zygoma/arc region (Fig. 18). All three datasets were positioned in the same coordinate system.

Five occlusal landmarks were defined on the scanned digital dental impressions and marked in the virtual model (Fig. 1b: incisor point, tip of the canine teeth and mesio-buccal cusp of the first molars). The marked digital impression models were overlaid on each of the 3 data-set. Afterwards the deviation between the points was measured followed by the evaluation of the variance of the results in x, y and z-axis in mm. (Fig. 20 - 24b).

Results:
The median deviation over all points and teeth was 0.76mm. Across the three defined axes, there was a median deviation of 0.97mm in the transversal, 0.62mm in the sagittal and 1.05mm in the vertical plane. It appears that there is a more precise transfer of the planned sagittal position into reality being possible by using our method, than in the other planes (without significance) (Fig. 25 and Tab. 1). During our analysis there was no significant difference between the defined groups incisor point, tip of the canine and mesiobuccal tip of the first molar by relative high precision.

The maximal deviation between planning and the operation results was 2.03mm in the transversal, 2.23mm in the sagittal and 2.58mm in the vertical plane.

Discussion and Conclusion:
The method used in our hospital is shown to be very precise overall with a good clinical applicability. However, by using the mandibular fixation for the vertical reference the operation time is prolonged by approximately 30-45 minutes.

Alternatively, waferless positioning of the maxilla can be achieved by patient specific CAD/CAM guides and CAD/CAM plates. First results of this method seem to be very promising by noticeable reduction of the operation time and increased precision.

Tab. 1

<table>
<thead>
<tr>
<th>Deviation of all teeth in the three axes</th>
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<tbody>
<tr>
<td>transversal</td>
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<td>Q25</td>
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The authors disclose that they have no conflict of interest.