Standardized Protocol for Visual Surgical Plan and Three Dimensional Surgical Template-Assisted Single-Stage Mandible Contour Surgery

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ABSTRACT

Background: Mandible contour surgery, such as reduction gonioplasty and genioplasty, has become increasingly popular in East Asia. However, it is technically challenging, and hence, leads to a long learning curve, high complication rates, and often needs secondary revisions. The increasing use of three-dimensional (3D) technology makes accurate single stage mandible contour surgery with minimum complication rates possible with a virtual surgical plan (VSP) and 3D surgical templates. This study is to establish a standardized protocol for VSP and 3D surgical templates-assisted mandible contour surgery and evaluate the accuracy of the protocol.

Methods: In this study, we enrolled 20 patients for mandible contour surgery. Our protocol is to perform VSP based on 3D CT data. Then design and 3D print surgical templates based on preoperative VSP. The accuracy of the method was analyzed by 3D comparison of VSP and post-op results utilizing detailed computer analysis.

Result: All patients had symmetric, natural osteotomy lines, and satisfactory facial ratios in a single-stage operation. The average relative error of VSP and post-op result on the entire skull was 0.41±0.13 mm. The average new left gonial error(Go'-L Error) was 0.43±0.77mm. The average new right gonial error(Go'-R Error) was 0.45±0.69mm. The Average pognion error(Pg error) was 0.79±1.21mm. Patients were very satisfied with the aesthetic results. Surgeons were also very satisfied with the performance of surgical templates to facilitate the operation.

Conclusion: Our standardized protocol of VSP and 3D printed surgical templates assisted single-stage mandible contour surgery result in accurate, safe, and predictable outcome in a single-stage.

Key words: Virtual Surgical Plan; 3D surgical guide; mandible contour surgery; standardized protocol

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Figure Legends

Figure. 1. The pre-op profile simulation for genioplasty was performed using the Dolphin imaging software to communicate about the expected results with patients.

Figure. 2. The midplane of the skull was automatically identified by Geomagic Studio 12.0 (Geomagic, Morrisville, USA).

Figure. 3. A, The inferior alveolar nerve canal was draw on both sides. B, The VSP for mandibular angle bicorticle curved osteotomy were done on one side. C, The osteotomy was mirrored onto the opposite side. D, The VSP for mandibular cortex thining or splitting were done on one side. Then mirrored onto the opposite side. E, The osteotomy line for Genioplasty was designed to shape a natural contour with reduction gonioplasty. F, The cutting template for geniolasty was designed accordingly. G, The movements of

genioplasty were done according to the design on Dolphin. H, The fixation template for geniolasty was designed accordingly.

Figure. 4. A, B, Surgical templates were 3D printed out and disinfected for surgery. C, mandibular angle bi-cortical curved osteotomy template was rigid fixed with a screw. D, mandibular cortex thinning or splitting template was attached. E, genioplasty was guided by cutting templates F, genioplasty was guided by fixation templates. G, rigid fixation with titanium plates and screws for genioplasty.

Figure.5. Postoperative outcomes were evaluated by 3D comparison between the preoperative VSP and postoperative result. Four parameters were adopted to evaluate the accuracy of the method: Average Relative Error, the mean value of discrepancy between postoperative result and preoperative VSP on the skull; Left new gonial point error (Go'-L Error): discrepancy between postoperative result and preoperative VSP at left new gonial point; Right new gonial point error(Go'-R Error): discrepancy between postoperative result and preoperative VSP at right new gonial point; Pg Error: discrepancy between postoperative result and preoperative VSP at Pg. They were all calculated by Geomagic automatically.

Figure.6. Typical case 1: the photograph before(left) and 1 years after(right)

reduction gonioplasty.

A, Preoperative frontal view

B, Postoperative frontal view

Figure.7. Typical case 2: the photograph before (left) and 1 year after (right) reduction gonioplasty and genioplasty.

A, Preoperative frontal view

B, Postoperative frontal view

C, Preoperative left lateral view

D, Postoperative left lateral view

Figure.8. Typical case of VSP, surgical template design and accuracy analysis for reduction gonioplasty.

A, Preoperative 3D skull

B, surgical templates design for reduction gonioplasty. Red: mandibular angle bicorticle curved osteotomy template. Yellow: mandible outer cortex splitting template.

C, Preoperative VSP result

D, Postoperative 3D skull

E, 3D comparison between preoperative VSP result and postoperative result on the skull

Figure. 9. Typical case of VSP, surgical template design and accuracy analysis for reduction gonioplasty and genioplasty

Typical case 2

A, Preoperative 3D skull

B, Surgical templates design for reduction gonioplasty and genioplasty. Red: mandibular angle bicorticle curved osteotomy template. Yellow: mandible outer cortex thinning template. Blue: cutting template for genioplasty

C, Fixation template design for genioplasty after reduction gonioplasty.

D, Preoperative VSP result

E, Postoperative 3D skull

F, 3D comparison between preoperative VSP result and 1 year

postoperative result on the skull