CUSTOM TEMPOROMANDIBULAR JOINT REPLACEMENT SURGERY USING A VIRTUAL SURGICAL PLANNING PROTOCOL: SURGICAL ACCURACY AND PATTERN OF ERROR

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INTRODUCTION

Temporomandibular dysfunction refers to a wide spectrum of disease, from mild discomfort to debilitating pain and limited jaw opening. In end-stage temporomandibular dysfunction, where few or no joint structures are salvageable, total alloplastic TMJ replacement is an established treatment.

TMJ implant malposition increases stress on system components, increasing the risk of mechanical failure through early screw loosening, screw failure, implant loosening and implant displacement. These problems account for approximately 16% of postoperative complications in TMJ replacement surgery [1]. In this context, accurate placement of system components is an important surgical goal.

TMJ replacement surgery has been revolutionised by the uptake of virtual treatment planning (VSP) technologies. VSP allows clinicians to preoperatively plan and simulate surgery based on preoperative three-dimensional imaging. VSP technologies can also be integrated with computer-aided design and manufacturing (CAD-CAM) processes to design and manufacture patient specific implants and medical devices [2].

VSP is thought to facilitate more accurate and precise surgery, however, evidence in the context of TMJ replacement surgery is limited by small sample sizes and little information about the direction of surgical error [3].

OBJECTIVE

This study aimed to assess the accuracy and pattern of surgical error associated with a typical VSP protocol which used fully customised 3D printed TMJ implant components and surgical cutting guides.

METHODS

A retrospective analysis was undertaken on 40 adult patients who were implanted with a fully customised, 3D printed TMJ prosthesis due to end-stage TMJ disease. Planned TMJ implant position based on preoperative CBCT images was compared with final position on postoperative OPGs using a previously validated linear rescaling method [4] (Figure 1). Translational discrepancy was described in the anterior-posterior direction and superior-inferior direction. Rotational discrepancy was described as anterior or posterior. Ethical approval was granted by the Medicine and Dentistry Human Ethics Sub-Committee, The University of Melbourne (HREC Approval No. 1852732).

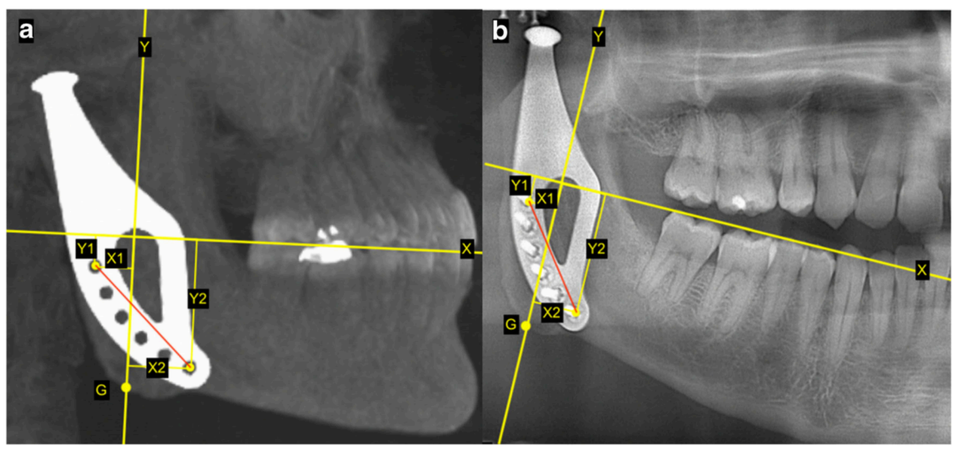

Figure 1: Planned and final mandibular implant screw positions based on preoperative CBCT imaging (a) and postoperative OPGs (b), respectively. (X) and (Y) coordinates were mapped on a linearly rescaled cartesian plane based on the occlusal line and mandibular gonion (G). Coordinates of the most superior screw (X1, Y1) and inferior screw (X2, Y2) were used to geometrically map implant position as a line segment (red). Preoperative and postoperative line segments were compared, and the translational and rotational discrepancy calculated.

RESULTS

Lin's concordance between preoperative (planned) measurements and postoperative (final) measurements was 0.97 (95% confidence interval 0.96–0.98), and these differences were not statistically significant ($p > 0.05$). Bland-Altman analysis showed a 95% limit of agreement of − 5.9 to 5.4 mm. Overall, final implant position was more anterior (0.4 mm), superior (0.4 mm) and posteriorly rotated (2.4°) compared with planned position (Figure 2).

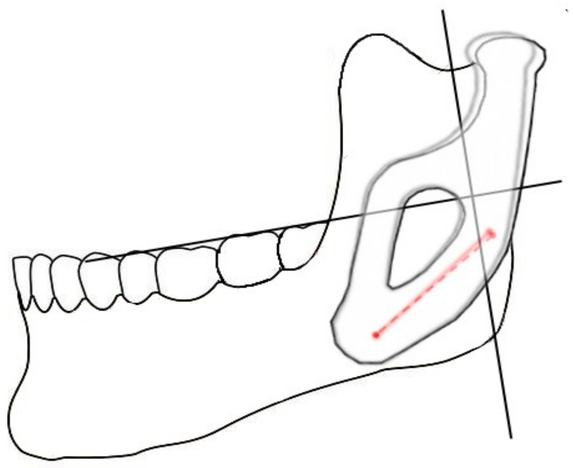

Figure 2: Figure 3: Overall final implant position (solid) was more anterior (0.4mm), superior (0.4mm) and rotated posteriorly (2.4°) compared to planned position (dashed).

Implants were placed anteriorly in 62.5% and posteriorly in 37.5% of cases. Mean anterior discrepancy was 1.8 mm (1.3 mm), and posterior discrepancy was 2.0 mm (2.1 mm). Implants were placed superiorly in 40.0% of cases and inferiorly in 60.0%. Mean superior discrepancy was 2.4 mm (1.6 mm), and inferior discrepancy was 2.2 mm (2.1 mm). Implants were rotated posteriorly in 75.0% of cases and anteriorly in 25.0% of cases. Mean posterior rotational discrepancy was 4.4° (3.1°), and anterior rotational discrepancy was 4.7° (4.6°) (Table 1).

		Cases	Mean Discrepancy
Horizontal			
	Anterior	25 (62.5%)	1.8mm (1.3mm)
	Posterior	15 (37.5%)	2.0mm (2.1mm)
Vertical			
	Superior	24 (60.0%)	2.4mm (1.6mm)
	Inferior	16 (40.0%)	2.2mm (2.1mm)
Rotation			
	Posterior	30 (75.0%)	4.4° (3.1°)
	Anterior	10 (25.0%)	3.7° (4.6°)

Table 1: Observed translational and rotational discrepancy between planned and final TMJ implant position.

CONCLUSIONS

This study found that the use of a typical VSP protocol, which included patient-specific TMJ implant components and surgical cutting guides, resulted in a high agreement between planned and final implant position. Discrepancies in planned and final implant position tended to result in the mandibular component of the implant being translated anterior-superiorly and rotated posteriorly, with potential implications for the biomechanical performance of the implant and overall device longevity. These results should be used to assist TMJ surgeons pre- and intraoperatively to facilitating accurate implant positioning and optimal surgical rehabilitation.

These findings are based on the study:
Mian M, Ackland D, Fink S, Wang N, Dimitroulis G, 2020. Accuracy of custom temporomandibular joint replacement surgery using a virtual surgical planning protocol. Oral Maxillofac Surg. http://doi/10.1007/s10006- 020-00928-6

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