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# Single stage treatment of ankylosis of the temporomandibular joint using patient-specific total joint replacement and virtual surgical planning

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**Abstract**

Ankylosis of the temporomandibular joint (TMJ) is a debilitating condition that can result in pain, trismus, and a poor quality of life. It can be caused by injury, infection, and rheumatoid disease. Current management includes gap arthroplasty, interpositional arthroplasty, and reconstruction. Traditionally, joints are reconstructed using stock implants, or the procedure is done in two stages with an additional computed tomography (CT) scan between the resective and reconstructive procedures and use of stereolithographic models to aid the design of the definitive prostheses. We describe a technique for the resection of ankylosis and reconstruction of the joint in a single operation using virtually designed custom-made implants. Five patients with ankylosis of the TMJ had a single stage operation with reconstruction between 2010 and 2012. All had preoperative high-resolution CT with contrast angiography. During an international web-based teleconference between the surgeon and the engineer a virtual resection of the ankylosis was done using the reconstructed CT images. The bespoke cutting guides and implants were designed virtually at the same time and were then manufactured precisely using computer-aided design and manufacture (CAD-CAM) over 6 weeks. After release of the ankylosis and reconstruction, the patients underwent an exercise regimen to improve mouth opening. Follow-up was for a minimum of 6 months. Four patients had one operation, and one patient had two. Median/Mean maximum incisal opening increased from 0.6 mm before operation to 25 mm afterwards (range 23–27), and there was minimal surgical morbidity. This new method effectively treats ankylosis of the TMJ in a single stage procedure. Fewer operations and hospital stays, and the maintenance of overall clinical outcome are obvious advantages.


*Keywords:* TMJ ankylosis; Virtual surgical planning; Total joint replacement; Temporomandibular joint

## Introduction

Ankylosis of the temporomandibular joint (TMJ) is a debilitating condition. It is caused by bony or fibrous adhesion of the anatomical components of the joint and results in loss of function. Complete ankylosis can be defined as interincisal opening of less than 5 mm, and it most commonly occurs in the first and second decades of life.[1] Its causes include injury, infection, or systemic diseases such as the arthritides, but its pathogenesis and the mechanism of its recurrence after operation are not fully understood.[2]

Alloplastic reconstruction has been an option to treat diseases of the joint for around 40 years.[3] Three systems are currently in use: TMJ Concepts (Ventura, California, USA), Biomet Microfixation (Jacksonville, Florida, USA), and TMJ Medical (Golden, Colorado, USA).[4] The systems include both stock and custom-made designs.

The guidelines for total alloplastic joint replacement have been outlined by the National Institute for Health and Care Excellence (NICE) and by UK TMJ replacement surgeons.[5,6] Ankylosis is an indication for replacement when mouth open-

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ing is restricted (less than 35 mm) and a predominantly soft or liquid diet has a detrimental effect on quality of life.

### *Management of ankylosis*

Treatment is unpredictable and is complicated mainly because of the high incidence of recurrence. Various techniques have been reported but no single one gives completely satisfactory results. Operations aim to partly or radically remove the ankylotic mass, prevent recurrence, and restore function and mobility.[7,8] The main methods of treatment are gap arthroplasty, interpositional arthroplasty, and reconstruction. Gap arthroplasty creates a space between the condyle and articulating surface of the glenoid fossa, and interpositional arthroplasty prevents recurrence of ankylosis by placing autogenous or alloplastic material (6–8 mm thick) at the osteotomy site. Reconstruction, which follows resection of the condyle alone or the condyle and fossa, can be done using autogenous bone, a costochondral graft, or alloplastic material, and is necessary when patients have had extensive osteotomy, which reduces the height of the mandibular ramus.

Reconstructive surgery for ankylosis is typically done in two stages: condylar resection and insertion of a spacer followed by secondary reconstruction several weeks or months later. The reconstruction is based on a postoperative CT using a bespoke implant designed to fit the resected condyle and glenoid fossa.

Single stage resection of ankylosis and reconstruction has been described in two ways. First, using stock alloplastic implants,[9] and secondly using model surgery based on three-dimensional stereolithographic models to plan the operation and produce the custom-made implants.[10]

We present five patients who had resection of ankylosis and reconstruction as a single stage procedure using web-based virtual surgical planning and custom-made alloplastic implants.

## Methods

Imaging of the TMJ and the maxillomandibular complex is done by fine slice CT of less than 1.25 mm with a 20–25 cm field of view and no gantry tilt. It is the personal preference of the lead surgeon to do preoperative CT angiography to improve safety during resection because the anatomical position of the maxillary artery can vary (Fig. 1).

The scan is processed to create accurate three-dimensional digital models of the patient's anatomy at a one-to-one scale.[11] These are exported to virtual surgical planning software (Dolphin 3D, Dolphin Imaging and Management Solutions, Chatsworth, USA), which enables digital resection of the ankylosis. Although the surgeon can do the virtual planning, it is typically done through an interactive web meeting with a biomedical engineer from Medical Modeling Inc (Golden, Colorado, USA) (Fig. 2).

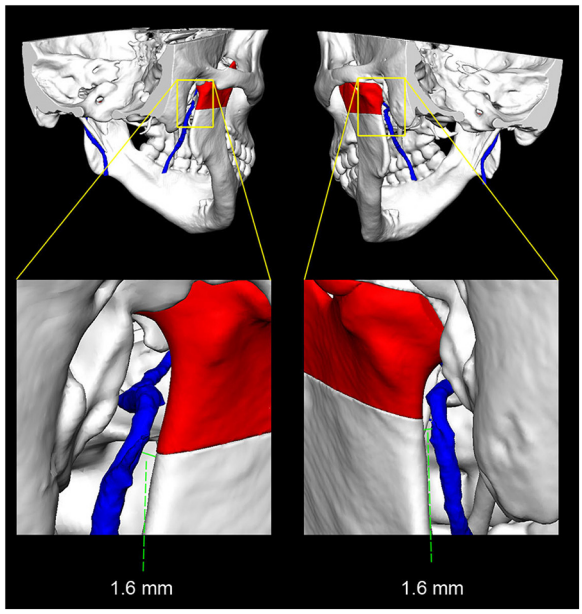


Fig. 1. Computed tomogram showing ankylosis of the temporomandibular joint and position of maxillary arteries (blue).

Design of the joint begins with the fossa component. Any modifications to the bone structure around the fossa such as removal of bony protuberances, is done first. Next, the standard geometry for the articulating surface of the implant is placed three-dimensionally against the base of the skull to accommodate a minimum thickness of 3 mm of UHMWPE

Fig. 2. Virtual surgical planning stage. Proposed condylectomy (red), bone-borne cutting guides (green), design of alloplastic total joint replacement (gold).