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Rapid Prototyping in Maxillofacial Surgery and Traumatology: Case Report

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Review of the literature from 1991 to 2002 on the use of rapid prototyping in the biomedical area emphasizes the applicability of this technique to aid diagnosis and planning in Maxillofacial Surgery and Traumatology. A case report in which a TMJ ankylosis relapse was treated using rapid prototyping (selective laser sintering) for surgery planning is presented. After one year, the patient's buccal opening was 45 mm. Transitory paralysis of the facial nerve disappeared totally in six months.

Key Words: rapid prototyping, stereolithography, maxillofacial surgery.

INTRODUCTION

Traditional presurgical planning is based on the manipulation of 2-dimensional data obtained by means of traditional radiography and photography. This approach limits the full appreciation of various bony structure movements (1,2). With 3-dimensional graphics it is possible to manipulate these components on their three axes and analyze the changes in facial appearance. It is also possible to create a 3-dimensional physical model for planning and simulating surgical procedures. Rapid prototyping is a technique used to produce stereolithographical models based on digital images such as computerized tomography (CT) and magnetic resonance (MR). Thus, surgeons can visualize internal and external anatomy previous to surgery (3-6).

Rapid prototyping has two stages: virtual (modelling and simulating) and physical (fabrication). Before the production of the physical models comes the virtual prototyping, which consists of using imaging processing tools to create a model through dynamic and interactive simulation. The construction of the physical model is the second step, a process in which the 3-dimensional physical model created by computer-aided design (CAD) is constructed layer by layer through deposition of material. This process allows the production of geometrically complex shaped models that otherwise would be impossible to produce (7).

This technology has been widely used as an aid in biomedicine: orthognathic and cranio-maxillofacial surgery (8-10), traumatology (11,12), dental implantology (13), cardiology (14), otorhinolaryngology (15) and archeology (16). The use of rapid prototyping based on stereolithography to construct bony models was initially reported by Mankovich et al. in 1990 (17).

CASE REPORT

In October 2001, a patient was seen at the Maxillofacial Surgery and Traumatology Ambulatory at the Base Hospital in Brasília. A horse had kicked him backwards when he was nine years old. From that time on his buccal opening became gradually limited until he was completely hindered from any mandibular movement. In 1991, an ostectomy of the right TMJ region was performed at the Base Hospital in Brasília, and

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later reconstruction was performed with a costochondral graft.

Eleven years after this first surgery, there was recurrence of right TMJ ankylosis. His maximum buccal opening was of 5 mm (Figures 1 and 2).

Conventional radiographs were taken, mandibular PA, oblique lateral, right and left mandibular, panoramic, Waters' projection and computerized tomography, in order to reconstruct and obtain a model based on rapid prototyping (selective laser sintering). There was a radiopaque area in the region of the right TMJ and a displacement of the costochondral graft anteromedially. The coronoid process presented bilateral vertical hypertrophy (Figure 3).

The patient underwent surgery with general anesthesia. The incision was preauricular to achieve right TMJ and a Risdon incision (submandibular) to access the ipsilateral mandibular angle, preceded by infiltration of marcaine with vasoconstrictor (1:200.000) (Figure 4).

Surgical planning included a virtual planning and a simulation of the surgical procedure with the model, which allowed correct visualization of the skeletal structures (Figure 5).

Careful dissection allowed reaching the bony ankylosis region in the TMJ, mandibular angle and right coronoid process. The coronoid process was removed and a remodeling and insertion of a round silicone implant (3 mm) fixed to the zygomatic process of the temporal bone with three number 1 steel thread in the place of the articular cartilage was carried out (Figure 6).

Through an intrabuccal insertion in the anterior face of the ascending branch of the left side the coronoid process was reached and its subsequent ostectomy. During surgery, a 45 mm buccal opening was obtained (Figure 7).

The patient underwent 30 physiotherapy ses-

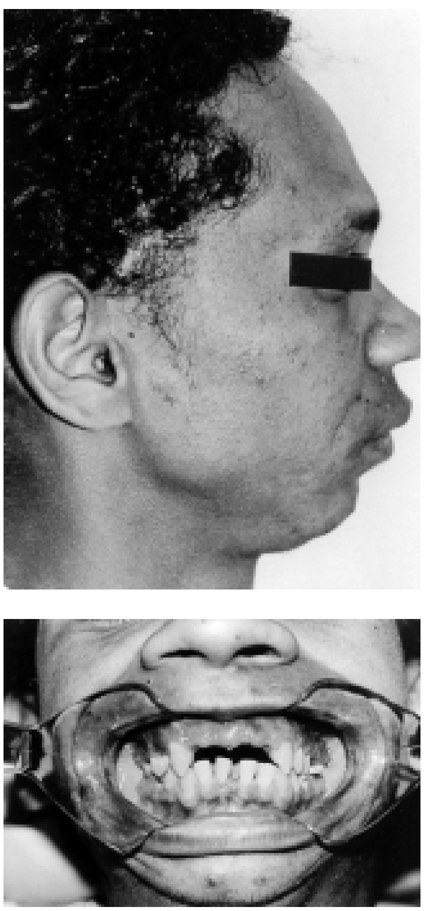

Figure 1. Profile of patient and dental aspect.

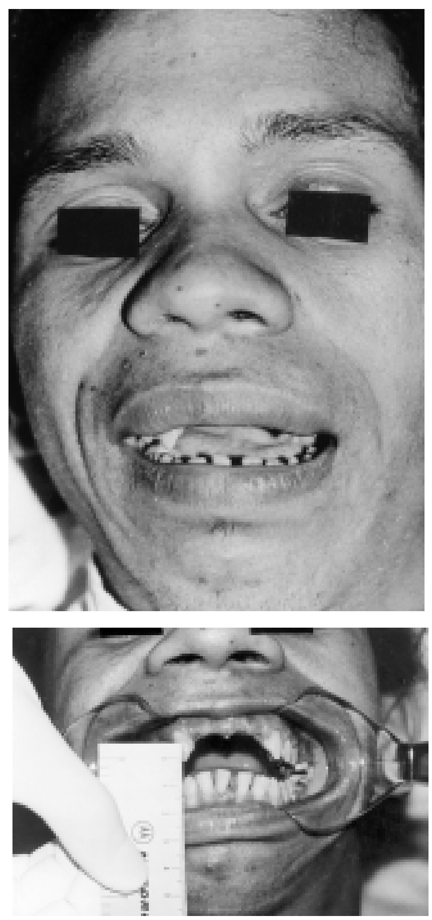

Figure 2. Full open mouth (5 mm).

Figure 3. Panoramic x-ray and prototyped model.

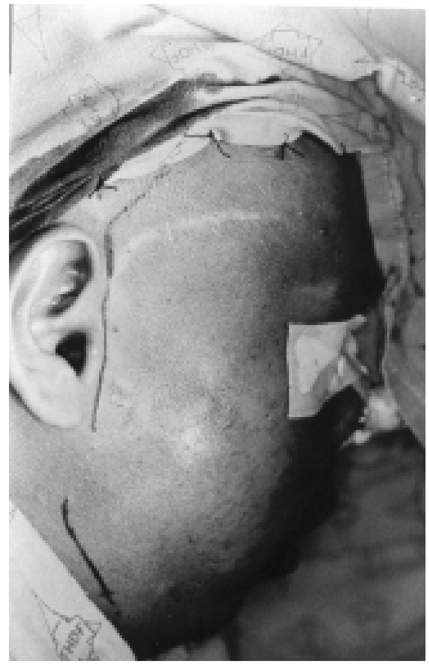

Figure 4. Pre-surgical aspect.

Figure 5. Guidance prototyped appliance and comparison of prototyped model and mandibular region.

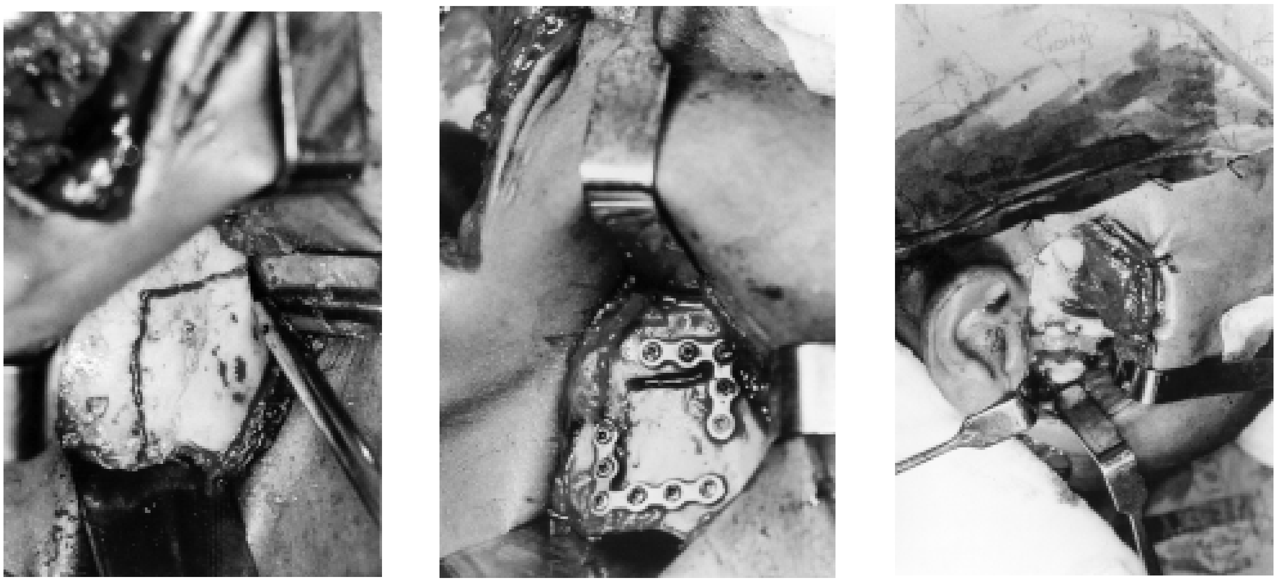

Figure 6. Ascending mandibular ramus (*left panel*), with rigid fixation (*middle panel*) and TMJ silicone implant (*right panel*).

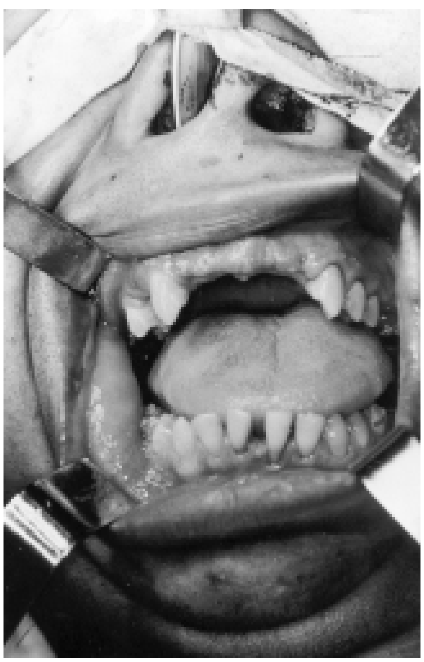

Figure 7. During surgery, a 45 mm buccal opening was obtained.

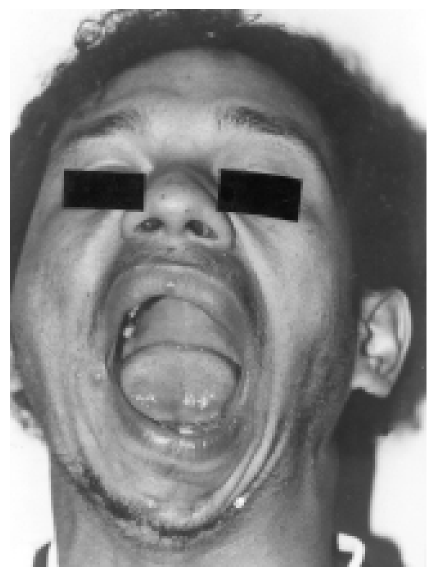

Figure 8. After one year, the patient still had a 45 mm buccal opening.

sions at the Base Hospital of Brasília, and after one year he still had a 45 mm buccal opening (Figure 8). Transitory paralysis of the facial nerve (marginal branch, superior and frontal palpebral) lessened considerably at the third post-surgical month and disappeared totally after six months.

DISCUSSION

Computed tomography and magnetic resonance revolutionized the definition and evaluation of human anatomy. Currently, 3-dimensional computed reconstruction allows elaboration of realistic and spatially accurate images for diagnosis and surgical planning. The manipulation of these images allows the construction of physical models (biomodels) in maxillofacial surgery, microsurgery, orthopedics, etc (2,4,8,10,14,18,19).

Current technologies available in rapid prototyping differ in some aspects: process, materials and accuracy. The first requirement for rapid prototyping is modelling the intended shapes and geometries using the techniques of CAD. For this end, there are several softwares available and the following techniques make it possible to convert a virtual model into a physical model (2-4,7,8,13,17): a) stereolithography (SLA); b) fused deposition modelling; c) laminated object manufacturing process; d) solid ground curing; e) selective laser sintering.

The greatest advantage of rapid prototyping is the full understanding of bony anatomy prior to surgery. This process reproduces the computerized tomography and the magnetic resonance data with fidelity and with a maximum error of 0.1 mm. On the other hand, a great modification takes place during the processing of computerized tomography, in which errors of over 1.0 mm can occur (5). However, many investigations regard the time required for the production of a biomodel and its high cost as disadvantages (1,4,5,7,9-11).

We conclude that rapid prototyping in Maxillofacial Surgery and Traumatology allows the understanding of anatomic details with high quality, simulating surgical procedures, and producing and adapting biomaterials (plates, screws, prosthesis). It also reduces surgical time and morbidity and allows a better training for residents as well as orientation and discussion with patients. The main disadvantage is the availability of equipment and the high cost.

RESUMO

Apresenta-se uma revisão da literatura (1991 a 2002) sobre a utilização da prototipagem rápida em biomedicina enfatizando-se a aplicabilidade da mesma em Cirurgia e Traumatologia Bucomaxilofacial. O planejamento cirúrgico de um caso de recidiva de anquilose da ATM foi realizado com o emprego da prototipagem rápida (sinterelização seletiva a laser). Após um ano da cirurgia a abertura bucal máxima estava em 45 mm. A paralisia transitória do nervo facial desapareceu totalmente em seis meses.

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