

## Evaluation of the Use of Biomodels in Sequelae of Maxillofacial Trauma

Evaluación de la Utilización de Biomodelo de Secuelas de Traumatismo Maxilofacial

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**ABSTRACT:** The use of rapid prototyping technology in Oral and Maxillofacial Surgery has been increasing in the last decade, allowing the management of biomodels from medical image processing as computed tomography in order to obtain a three dimensional model with the same geometric characteristics as the virtual one. The aim of this study is to present the use of biomodels for treatment of maxillofacial trauma sequelae with evaluation of clinical records in a period that varies from January 2000 to December 2010. For diagnosis and surgical planning of maxillofacial sequelae in this period, some 15 prototypes were used, allowing us to determine the treatment planning with more accuracy and to save operating room time.

**KEY WORDS:** trauma centers, diagnostic techniques, surgical, preoperative care.

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### INTRODUCTION

The first application of stereolithography in Maxillofacial Surgery was performed by Brix & Lambrecht in 1985 for craniofacial surgery planning, and, after the technological advances in hardware and software of this method, stereolithography has been refined and incorporated in craniofacial surgery in recent years (Sinn *et al.*, 2006). After computed tomography (CT) image acquisition, the model can be performed by stereolithography technique, resulting in a translucent biomodel with great accuracy (Mankovich *et al.*, 1990), or by the selective laser sintering technique, resulting in an opaque biomodel with more simplicity and lower cost (Silva *et al.*, 2003).

Biomodels are considered an interesting appliance for diagnosis in congenital malformations, craniomaxillofacial defects, pathologies, reconstruction, maxillofacial trauma, orthognathic surgery, facial asymmetry, surgical planning, custom prosthesis design and even professional-patient communication (Silva *et al.*; Li *et al.*, 2009). In cases of facial fractures sequelae, the prototype ensures a contribution to the

surgical planning and the intraoperative determination of the osteotomies and also the adaptation of osteosynthesis plates prior to surgery, thus providing a decrease in surgical time, improving the security, decreasing blood loss and enriching the treatment outcome (D'Urso *et al.*, 1998; Mazzonetto *et al.*, 2002).

The aim of this study is to report a 10-year experience at the Oral and Maxillofacial Surgery department of the School of Dentistry of Piracicaba at University of Campinas (FOP-UNICAMP) with the use of biomodels for maxillofacial trauma sequelae treatment.

### MATERIAL AND METHOD

This research was approved by Ethics Committees of School of Dentistry of Piracicaba / University of Campinas. A retrospective analysis was performed from patients clinical records that had

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maxillofacial trauma sequelae and that used a biomodel in diagnosis and surgical planning at the Oral and Maxillofacial Surgery department of FOP-UNICAMP, in a period that varies from January 2000 to December 2010. CT images were used to manufacture the biomodels at Renato Archer Information Technology Center (CTI), using the selective laser sintering technique.

## RESULTS

From January 2000 to December 2010, some 63 patients have been treated using biomodels for different conditions such as pathologies, facial trauma, dentofacial deformities and extra-oral implants. From these patients, 15 prototypes were used for diagnosis and surgical planning of maxillofacial trauma sequelae: 5 cases of mandibular fractures, 2 cases of maxilla fractures and 8 cases of zygomatic-orbital complex fractures (some of them associated with other facial bones fractures: 1 case with nasal fracture, 2 cases with mandibular fractures and 3 cases with naso-orbito-ethmoidal fractures).

## DISCUSSION

Rapid prototyping uses computer technology and image processing techniques to enable the construction of a complex model in three dimensions (3D), usually from computed tomography data (D'Urso *et al.*, 1999; Herlin *et al.*, 2011). The selective laser sintering – SLS, as its name suggests, is a localized sintering of powder by the action of a CO<sub>2</sub> laser system, contained in a specific machine. In this retrospective study, the model that was produced by CTI is made of resin through the technology 3D Printer of ZCorp (ZP 510 machine), where layers in the Z axis of 0.1 mm are added together by a printhead with an accuracy of 0.4 mm in X and Y axes using a specific baider. We noted that this material provides a great cost-benefit, but its surface is more porous, with fewer details when compared to stereolithography method and with no reproduction of internal structures of the skull.

Clinical experience has found many advantages in the use of 3D models. These models enhance the ability to visualize patient's unique structures before surgery and surgeons also can rehearse proposed surgery on critical structures before committing to the

procedure (Erickson *et al.*, 1999). Another great advantage observed for our department is the possibility of planning the surgery on a real model and also simulate it, with dimensional and anatomical measurements of the alterations presented by the patient. Furthermore, Meuer *et al.* (2007) complement with the possibility to elaborate the surgical technique, refine the procedure and to anticipate difficulties and especially the solution for them. The limitations of its use are: emergencies cases, as there is a need for a certain amount of time to manufacture the prototyping model; the excellence of biomodels are related to the computed tomography quality; and also the presence of artifacts (metallic restorations, prostheses and orthodontic appliances), which can produce distortions and impair the biomodel quality (Arvier *et al.*, 1994). We can also mention the high cost of biomodels manufacture. In our cases, a partnership with CTI has enabled the fabrication of biomodels for our patients from the Health Public System with no charge.

Templates made of acrylic can be used to minimize errors and facilitate the surgical procedure. Other possibility of prototype usage is to shape prefabricate bone plates before surgery (Fig. 1). For Wagner *et al.* (2004), 3D provides the opportunity to plan fracture reduction and to contour plates under ideal conditions before surgery. Therefore, the contoured plates not only serve to reconstruct the fracture but also to act as a template to establish the final phase of alignment with precision. We noticed that the difficulty of bending a reconstruction plate could be avoided in the trans-operative with the biomodels, thus reducing the overall time of surgery.

Frequently, facial trauma is combined with other severe injuries. Depending on the general condition of polytraumatized patients, the primary reduction of facial fractures may be delayed in favor of intensive care therapy. In the event of delayed primary treatment, the time interval can be used for the production of an anatomical model and simulation of surgery (Kermer *et al.*, 1998). Its use, according to our reality, is impracticable in acute trauma because it is necessary a period of 2 or 3 weeks for fabrication and transport of biomodels, which avoids its use in the primary treatment of fractures. To decrease the data reformatting and model construction time, new 3D printing techniques can construct a model in as little as 4 hours (Chow & Cheung, 2007) and the speed that these models are made turns them useful for planning acute maxillofacial trauma (Bill *et al.*, 1995). Currently, for trauma sequelae with maxillofacial defects, an innovative 3D



Fig. 1. The biomodels allow the shaping of prefabricate bone plates, reducing the time of surgery and also the confection of templates guides, facilitating the surgical procedure.

photographic image capture is available for fabricating extraoral maxillofacial prosthesis. The advantages of this technique include less discomfort for the patient and soft tissue details in the model to fabricate prosthesis, providing shading, contours and an open-eye position, which are not available with conventional hard tissue impression biomodels (Sabot *et al.*, 2011).

Kermer *et al.* used prototypes in 16 patients with maxillofacial trauma. All intra-operative conditions corresponded to the stereolithographic model, making it possible to adjust prefabricated plates as in the preoperative planning. The authors also report that configuration and bending of the plates also acted as a device for the anatomical reduction of the fragments, providing a satisfactory functional and aesthetic result in all patients.

D'Urso *et al.*, (1998) mention a 16% reduction in surgical time and a decrease in the number of surgical interventions, making it clear that investment in building biomodels is justified when compared to the costs of a new surgery in hospitals (Herlin *et al.*). A reduction in the number of revision surgeries coupled with decreased surgical time would offset the initial investment in technology for rapid 3D prototyping (Wagner *et al.*).

## CONCLUSION

The use of biomodels in Oral and Maxillofacial Surgery is a valuable adjunct for patient care, admitting diagnosis and surgical planning accuracy, and also for visualization of the approach and saving of operating room time. Currently, the long processing period to manufacture the

prototype makes its use unviable in acute maxillofacial trauma, remaining only for sequelae cases. Our department, in partnership with the Renato Archer Information Technology Center (CTI), allowed that 15 patients with facial trauma sequelae from the Public Health System could be benefited with the use of biomodels, with no additional cost to them.

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**RESUMEN:** El uso de tecnología de prototipado rápido en Cirugía Oral y Maxilofacial se ha incrementado en la última década, lo que permite la gestión de los biomodelos de procesamiento de imágenes médicas, como tomografía computarizada para obtener un modelo tridimensional con las mismas características geométricas del virtual. El objetivo de este estudio es presentar el uso de biomodelos para el tratamiento de las secuelas de un traumatismo maxilofacial con la evaluación de las historias clínicas en un período que varía entre enero de 2000 a diciembre de 2010. Para el diagnóstico y la planificación de la cirugía maxilofacial de las secuelas en este período, 15 prototipos fueron utilizados, lo que permite determinar la planificación del tratamiento con más precisión y para ahorrar tiempo de quirófano.

**PALABRAS CLAVE:** centros de traumas, técnicas de diagnóstico, quirúrgico, cuidado preoperatorio.

## REFERENCES

- Arvier, J. F.; Barker, T. M.; Yau, Y. Y.; D'Urso, P. S.; Atkinson, R. L. & McDermant, G. R. Maxillofacial biomodelling. *Br. J. Oral Maxillofac. Surg.*, 32(5):276-83, 1994.
- Bill, J. S.; Reuther, J. F.; Dittmann, W.; Kübler, N.; Meier, J. L.; Pistner, H.; et al. Stereolithography in oral and maxillofacial operation planning. *Int. J. Oral Maxillofac. Surg.*, 24(1 Pt2):98-103, 1995.
- Chow, L. K. & Cheung, L. K. The usefulness of stereomodels in maxillofacial surgical management. *J. Oral Maxillofac. Surg.*, 65(11):2260-8, 2007.
- D'Urso, P. S.; Atkinson, R. L.; Lanigan, M. W.; Earwaker, W. J.; Bruce, I. J.; Holmes, A.; et al. Stereolithographic (SL) biomodelling in craniofacial surgery. *Br. J. Plast. Surg.*, 51(7):522-30, 1998.
- D'Urso, P. S.; Barker, T. M.; Earwaker, W. J.; Bruce, L. J.; Atkinson, R. L.; Lanigan, M. W.; et al. Stereolithographic biomodelling in cranio-maxillofacial surgery: A prospective trial. *J. Craniomaxillofac Surg.*, 27(1):30-7, 1999.
- Erickson, D. M.; Chance, D.; Schmitt, S. & Mathis, J.. An opinion survey of reported benefits from the use of stereolithographic models. *J. Oral Maxillofac. Surg.*, 57(9):1040-3, 1999.
- Herlin, C.; Koppe, M.; Béziat, J. L. & Gleizal, A.. Rapid prototyping in craniofacial surgery: Using a positioning guide after zygomatic osteotomy: A case report. *J. Craniomaxillofac. Surg.*, 39(5):376-9, 2011.
- Kermer, C.; Lindner, A.; Friede, I.; Wagner, A. & Millesi, W. Preoperative stereolithographic model planning for primary reconstruction in craniomaxillofacial trauma surgery. *J. Craniomaxillofac. Surg.*, 26(3):136-9, 1998.
- Li, W. Z.; Zhang, M. C.; Li, S. P.; Zhang, L. T. & Huang, Y. Application of computer-aided three dimensional skull model with rapid prototyping technique in repair of zygomatico-orbito-maxillary complex fracture. *Int. J. Med. Robot.*, 5(2):158-63, 2009.
- Mankovich, N. J.; Cheeseman, A. M. & Stoker, N. G. The display of 3-D anatomy with stereolithographic models. *J. Dig. Imaging*, 3(3):200-3, 1990.
- Mazzonetto, R.; Moreira, R. W. F.; de Moraes, M.; Albergaria Barbosa, J. R.; Passeri, L. A. & Spagnoli, D. B. Uso de modelos estereolitográficos em cirurgia buco-maxilo-facial. *Rev. Assoc. Paul. Cir. Dent.*, 56(2):115-8, 2002.
- Meurer, E.; Oliveira, M. G.; Meurer, M. I.; Silva, J. V. L.; Santa Bárbara, A.; Heitz, C. Os biomodelos de prototipagem rápida em cirurgia e traumatologia bucomaxilofacial. *Rev. Odontol. ATO*, 5(2):349-73, 2007.
- Sabol, J. V.; Grant, G. T.; Liacouras, P. & Rouse, S. Digital image capture and rapid prototyping of the maxillofacial defect. *J. Prosthodont.*, 20(4):310-4, 2011.
- Silva, J. V. L.; Gouveia, M. F.; Santa Barbara, A.; Meurer, E. & Zavaglia, C. A. C. Rapid prototyping applications in the treatment of craniomaxillofacial deformities – Utilization of Bioceramics. *Key Eng. Mater.*, 254-256:687-90, 2003.
- Sinn, D. P.; Cillo, J. E. Jr. & Miles, B. A. Stereolithography for craniofacial surgery. *J. Craniofac. Surg.*, 17(5):869-75, 2006.
- Wagner, J. D.; Baack, B.; Brown, G. A. & Kelly, J. Rapid 3-Dimensional prototyping for surgical repair of maxillofacial fractures: A technical note. *J. Oral Maxillofac. Surg.*, 62(7):898-901, 2004.

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