A NOVEL TRAINING ALTERNATIVE IN ORTHOGNATHIC MANDIBULAR OSTEOTOMY: AIR DRIED CLAY MODEL

ORTOGNATİK MANDİBULA OSTEOTOMİSİNDE YENİ BİR EğİTİM SEÇENEĞİ: HAVA KURUTMALI KİL MODELİ

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ABSTRACT

Objective: Patient safety and low complication rates are indispensable in surgical training and models are among the main educational tools. The aim of this study is to assess the efficiency of a novel model for orthognathic mandibular osteotomy.

Material and Methods: A template and seventeen partial mandibular models (MM-17) were manufactured with air dried clay. The dimensions of the models were feasible for sagittal split ramus osteotomy (SSRO). Model surgery was performed by surgeons with a minimum of three years’ experience in orthognathic surgery. Each surgeon operated four separate models and the following data were recorded: corticotomy and SSRO completion time, MM-17 fracture type, similarity value of MM-17 with native mandible, representation value of MM-17, and the training compatibility value of MM-17.

Results: The cost was 0.6 American Dollars. The mean corticotomy time was 126.75 seconds (110-150). Mean cortical resistance similarity value was 8.75 (8-10). The mean SSRO time was 288 seconds (205-401). Sixty percent of the fractures were seen in the outer cortex. The mean medullary resistance similarity value was 5 (4-6) and mean mandibular representation value was 5.25 (4-7). The training compatibility value was 8.25 (7-10).

Conclusion: Air dried clay demonstrated mechanical similarities with bone cortex and it was used for mandibular modelling.

ÖZET

Amaç: Hasta güvenliği ve düşük complikasyon oranları cerrahî eğitimde olmazsa olmazdır ve modeller temel eğitim yöntemleri arasındadır. Bu çalışmanın amacı, ortognatik mandibula osteotomisinde yeni bir modelin etkinliğini değerlendirmektir.

Gereç ve Yöntemler: Hava kurutmalı kilden kribilen bir şablon ve 17 kısmi mandibula modeli (MM-17) üretilmiştir. Model cerrahisi ortognatik cerrahide en az üç yıllık deneyimi olan dört cerrah tarafından yapıldı. Her cerrah dört ayrı modelde çalıştırıldı ve şu değerler kaydedildi: corticotomi ve SSRO tamamlanma süresi, MM-17 kırığı ve türü, MM-17’in mandibula ile benzerlik değeri, temsil değeri ve eğitim uygunluk değeri.

Bulgular: Maliyet 0,6 Amerikan Doları’ydı. Ortalama corticotomi süresi 126,75 saniyediydi (110-150). Ortalama kortikotomi benzerlik değeri 8,75 (8-10). Ortalama SSRO süresi 288 saniyediydi (205-401). Kırıkların yüzde altmışı dış korteksteydi. Ortalama medulla direnç benzerlik değeri 5 (4-6) ve ortalama mandibula temsil değeri 5.25 (4-7). Eğitim uygunluk değeri 8,25’ti (7-10).

Sonuç: Hava kurutmalı kıl, kemik kırıkları ile mekanik benzerlik göstermektedir ve mandibula modeli üretiminde ilk kez kullanılmıştır. Aynca, MM-17 diğer modellerden daha ucuzdur. Kortikotomi ve SSRO tamamlama süreleri kısaştır. Çünkü dissek-
for the first time. MM-17 cost less than other devices. Corticotomy and SSRO completion times were short due to the lack of dissection and bleeding. Despite its drawbacks in SSRO, MM-17 is a versatile and low cost alternative in orthognathic mandibular corticotomy training. High power drill utilization skills may be gained with MM-17 before clinical practice.

Keywords: Air-dried clay, mandible, model surgery, orthognathic surgery, training

INTRODUCTION

Orthognathic surgery is one of the main aspects of plastic reconstructive and aesthetic surgery. The management of dentofacial deformities that may be present in dental and facial contours is planned and performed by collaboration between orthodontists and plastic reconstructive and aesthetic surgeons. After appropriate orthodontic treatment, patients may be referred for orthognathic surgery (1). Double jaw surgery may be performed in order to address the deformities in both the maxilla and mandible whereas single jaw surgery is indicated for deformities involving only the mandible (2).

Sagittal split ramus osteotomy, first defined by Obwegeser and Trauner in 1955 is currently the most popular mandibular osteotomy (2, 3). Various authors including Hunsuck and Epker modified this osteotomy in order to adapt it to modern practice (4, 5).

Due to its anatomical structure, the mandible is suitable to be split through the sagittal plane from both rami. However, such splitting is technically demanding and it requires a level of expertise (1). Orthognathic surgery is not performed equally in quantity throughout the training facilities of Turkey and the number of orthognathic operations is insufficient in some centers (6). All surgical training begins in a clinical manner and novice and inexperienced surgeons, as they go through a learning curve, may perform procedures that result in complications. In order to overcome such shortcomings and to gain expertise, surgical residents must be trained on surgical models. Today, highly technological computer-based planning and simulation is utilized in orthognathic surgery and the training is supported by virtual reality and touch sensitive (haptic) devices (7, 8). However, such techniques require both expensive hardware and software and such an infrastructure is lacking in most training facilities.

With the help of a novel, low cost, air-dried clay model, the inexperienced surgeons may improve their skills using high-power surgical devices and progress to a level where they can perform actual surgical procedures.

The aim of this study is to assess the efficiency of this model in basic orthognathic mandibular osteotomy training.

MATERIAL AND METHODS

The study was presented to the local Ethic Committee in April 2019 and approval was not deemed necessary. In fact, the study was performed neither on humans nor other live subjects.

After the molding process, the air-dried clay (Hardpas, Argiles Bisbal, Spain) can harden without any extra treatment in 24 to 48 hours (9). In order to maintain standardization, an air-dried clay template was manufactured out of an artificial human mandibular model (1020159 [A20], 3B Scientific, USA) (Figure 1). The template was prepared to enable the production of partial mandible models that allowed sagittal split ramus osteotomy.

Figure 1: In order to maintain standardization of the model, an air dried clay template was manufactured out of an artificial human mandibular model (1020159 [A20], 3B Scientific, USA)

The template was filled with 75 grams of air-dried-clay for each model and partial mandibles were produced. Each model was dried at room temperature for two days and they were weighed at the end of the second day. The mean mass of the models was 68 grams (65–70 grams). A total of 17 models were produced and they were named “Mandibular Model–17” (MM-17) (Figure 2).
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Four plastic reconstructive and aesthetic surgeons with at least three years’ experience in orthognathic surgery were invited to participate in the study by post. In order to demonstrate the surgical procedure, the first author performed the model surgery while the four surgeons observed. Demonstrative corticotomy and sagittal split ramus osteotomy were performed and the instructions were given to the surgeons. Each participant was given four MM-17’s, a high-power drill and a cutting handpiece and they performed model surgeries individually. The participants were asked to operate on four models in order to increase the reliability of the study. The following data were recorded for each model: Corticotomy and SSRO completion time, MM-17 fracture type and time during corticotomy and SSRO, resistance similarity value of MM-17 cortex and medulla with native mandible, mandibular representation value of MM-17, and training compatibility value of MM-17. Resistance similarity and representation values were subjective measurements. A score of “0” represented no similarity and “10” total similarity and representation between MM-17 and native human mandible. Training compatibility value was another subjective measurement with a similar scale. Zero was total incompatibility whereas ten was total compatibility with orthognathic mandibular osteotomy training. The mean values were calculated and the results were compared. Corticotomies of the entire cortex without fractures were accepted as successful and complete bipartite sagittal split ramus osteotomies without fractures were accepted as successful.

RESULTS

The human mandibular anatomic model (1020159 [A20], 3B Scientific, USA), the high-power drill and the cutting handpiece belong to our institution and they were not included in the study costs. The only expense of the study was the air-dried clay (Hardpas, Argiles Bisbal, Spain) that was used for the production of both the template and the model. After the production of two templates and seventeen MM-17’s, the cost of a single MM-17 was calculated as 0.6 American Dollars.

The results are listed in Table 1. All corticotomies were completed successfully (16/16) and no fractures were observed during the corticotomies (Figure 3). Mean corticotomy completion time was 127.75 seconds (110–150 seconds). Mean cortical resistance similarity value was 8.75 (8–10). Only three sagittal split ramus osteotomies were completed successfully (3/16) (19%) (Figure 4). The

Table 1: The mean values and results obtained from each surgeon after the model surgeries

| Surgeon  | CCT (seconds) | CSV | SSROCT (seconds) | SSROSV | SSRO failure | RV | TCV |
|----------|---------------|-----|------------------|--------|--------------|----|-----|
| Surgeon 1 | 110           | 8   | 401              | 5      | 3            | 5  | 9   |
| Surgeon 2 | 150           | 10  | 0                | 5      | 4            | 4  | 7   |
| Surgeon 3 | 116           | 8   | 259              | 6      | 3            | 7  | 10  |
| Surgeon 4 | 131           | 9   | 205              | 4      | 3            | 5  | 7   |
| Mean     | 126,75        | 8,75| 288              | 5      | 13 failures (81%) | 5,25 | 8,25 |

CCT: Corticotomy completion time; CSV: Corticotomy similarity value; SSROCT: Sagittal split ramus osteotomy completion time; SSROSV: Sagittal split ramus osteotomy similarity value; SSRO failure: Sagittal split ramus osteotomy failure; RV: Representation value of MM-17; TCV: Training compatibility value of MM-17.

Figure 2: “Mandibular Model-17” (MM-17). The osteotomy lines were marked on the medial, lateral and upper marginal cortices on each model with a surgical marking pen.

Figure 3: A successful MM-17 corticotomy.
outer cortex was affected in sixty percent of the fractures and the inner cortex was affected in forty percent of the fractures. Three successful SSRO’s were completed in a mean time of 288 seconds (205-401 seconds). Mean medullary resistance similarity value was 5 (4–6). Mean mandibular representation value of MM-17 was 5.25 (4–7). Mean value of compatibility with orthognathic mandibular osteotomy training was 8.25 (7–10).

No technical problems were observed in either the high-power drills or the handpieces (Figure 5).

DISCUSSION

Structural deformities of the maxilla and the mandible may cause dental misalignment, malocclusion and alterations in facial appearance. Such deformities may be corrected with orthognathic surgery, ameliorating both form and function (2).

In sagittal split ramus osteotomy, the osteotomy of the medial cortex of the ramus is performed above the lingula and the lateral corticotomy is performed between the first and the second molar teeth. Finally, the upper margin of the ramus is corticotomized in order to connect the medial and the lateral corticotomy lines. After the corticotomies, a full-thickness osteotomy is performed in order to split the ramus into condylar and alveolar fragments. At the end of bilateral sagittal split ramus osteotomies, two condylar and one alveolar fragments are formed and the alveolar fragment may be positioned in three planes according to the orthodontic plan (1-5).

Sagittal split ramus osteotomy (SSRO) is prone to complications including unfavorable fractures, unfavorable splits, inferior alveolar and facial nerve injuries and internal maxillary artery injuries (10). The avoidance and management of these complications require technical experience in SSRO.

Although there are numerous plastic reconstructive and aesthetic surgery training institutions in Turkey, orthognathic surgery training is still limited and there are vast differences between centers (6). The main reasons for this limitation are requirements of coordination with orthodontics clinics and of specialized surgical instruments (2). In modern surgical training of the residents, maximal patient safety and minimal complication rates are basic principles (11). However, due to the aforementioned limitations, most residents can not have sufficient orthognathic surgical training in line with these principles (6). In order to maintain patient safety with minimal complications, orthognathic surgical models may be utilized.

Residents of all surgical fields may gain relevant skills with surgical models and they may support their theoretical knowledge before clinical practice. Palter et al. compared training results with low cost artificial models for fascial repair and the residents who had practiced with the models had a better surgical ability and understanding of the surgical procedure in the operating room (11). Easily reproducible and low cost models such as MM-17 may yield similar results in orthognathic surgery training. Plastic Reconstructive and Aesthetic surgery residents may gain relevant skills with MM-17 and continue clinical practice with more safety and fewer complications.

Cadavers and various artificial materials are regarded as the gold standard in all surgical training models (8). However, they may not be feasible for every training institution due to cost and availability. Three-dimensional virtual and solid models can be manufactured using thin sliced maxillofacial computed tomographs and model surgery can be practiced on such models (7). Currently, virtual reality is a popular alternative in orthodontic planning and orthognathic surgery training and it may be supported by touch-sensitive haptic simulators (12). With such simulators, the resident may visualize the relevant anatomic area with three-dimensional, real time detail through virtual reality and hand-held or wearable haptic devices may reflect the alterations in the target tissue (8, 13, 14). All such surgical models require specialized computer software, three-dimensional printers...
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