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Impact of CAD/CAM technique on operative time in stand-alone genioplasty: A retrospective comparative study

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Abstract

This study investigates the impact of computer-aided design/computer-aided manufacturing (CAD/CAM) techniques on operative time in stand-alone genioplasty compared to conventional methods. CAD/CAM offers advantages like precise virtual planning and the use of patient-specific implants (PSIs), but its effect on surgical time remains uncertain. A retrospective analysis was conducted on patients who underwent genioplasty for chin advancement between 2012 and 2023, divided into two groups: Group I (conventional technique) and Group II (CAD/CAM technique). Each group included 20 patients, with 10 undergoing forward chin advancement and 10 receiving both forward and downward chin movements. Results showed that the mean operative time was significantly shorter in Group II (49.9 ± 3.69 minutes) than in Group I (54.9 ± 7.51 minutes) ($p = 0.012$). No significant time savings were observed for forward movement alone. However, significant time savings were noted for combined forward and downward movements, with Group II showing a mean reduction of approximately seven minutes compared to Group I ($p = 0.033$). While CAD/CAM techniques offer potential time savings, particularly for complex chin movements, these benefits must be weighed against the increased preoperative preparation time. Further research is required to optimize these techniques and fully realize their advantages.

Keywords: Genioplasty; Chin augmentation; CAD/CAM technique; Surgical time; 3D printing

1. Introduction

Chin augmentation, within the scope of genioplasty (also known as mentoplasty), is one of the fastest-growing trends in facial plastic surgery. According to the 2020 Plastic Surgery Statistics Report, there has been a 63% increase in these procedures over the past decade, amounting to 43,900 procedures in 2020. The majority of patients are young to middle-aged, with 78% being female [1]. Genioplasty aims to enhance facial aesthetics by recontouring the lower third of the face, thereby improving facial harmony and balance. Today, augmentation using alloplastic materials such as silicone (Silastic®) or polytetrafluoroethylene (Gore-Tex®), as well as osseous procedures with advancement of the bony chin, are standard techniques [2-4].

In the field of orthognathic surgery, the use of computer-aided design/computer-aided manufacturing (CAD/CAM) techniques with virtual planning and 3D printing of patient-specific implants (PSIs) has been shown to achieve higher accuracy compared to conventional methods [5]. For osseous stand-alone genioplasty, the main advantages of the CAD/CAM technique include virtual planning of the osteotomy planes to protect endangered anatomical structures before surgery, ease of cutting along the provided guides, and the application of a preformed PSI as an osteosynthesis device. This device simultaneously serves as a reposition guide for the chin segment using predrilled screw holes for fixation [6, 7].

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However, the impact of CAD/CAM techniques on surgical time for stand-alone genioplasty remains unclear. Some studies report a reduction in operating time [8, 9], while others observe an increase [10]. This study aims to confirm or reject the null hypothesis that using the CAD/CAM technique in stand-alone genioplasty significantly reduces surgical time compared to conventional techniques.

2. Material and methods

Approval for the study was given by the Ethics Committee of the Medical Association of the state (Study No. 842). All participants were informed about the aims and protocol of the study including data protection and gave written consent.

Medical records of patients who underwent genioplasty for chin advancement alone without other simultaneously performed orthognathic surgery between 2012 and 2023 were enrolled and subjects were assigned to two groups: Group I consisted of patients who received a conventional genioplasty without using cad/cam- technique, group II included patients who underwent genioplasty with the usage of virtual planning and cad/cam- technique (Figure 1).

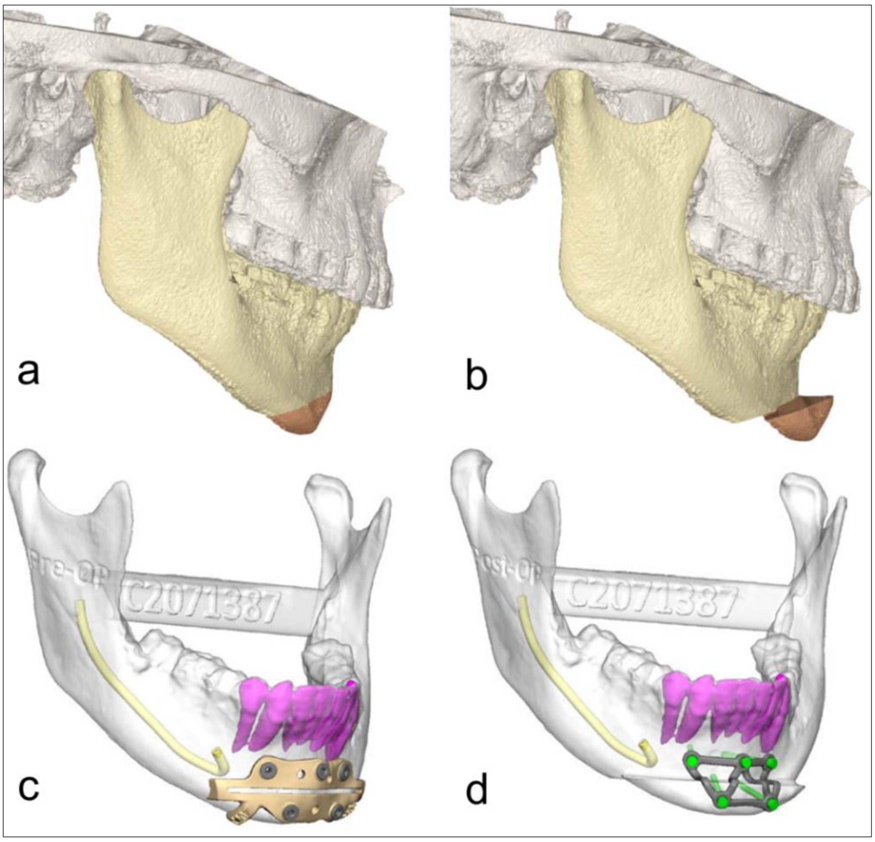

Figure 1 Virtual planning of genioplasty. (a) Initial findings. (b) Chin advancement in the lateral view. (c) Cutting and burring guide. (d) Patient-specific osteosynthesis plate

Surgery was conducted under general anesthesia. An intraoral vestibular incision from premolar to premolar was made to access the chin. Subperiosteal dissection was performed, ensuring the mental nerves were protected, until the caudal border of the mandible was reached. In group I patients, the vertical midline plane of the chin and the osteotomy line were marked with a burr. A horizontal osteotomy was carried out using a piezotome, starting laterally and moving downward from the mental foramina, then proceeding anteriorly at least 5 mm caudally from the roots of the teeth along the mental protuberance. After mobilizing the caudal segment, the chin segment was repositioned "freehand" to the mandibular corpus along the midline, following the preoperative plan. The anterior chin segment was then secured with two L-shaped, hand-bent osteosynthesis miniplates and monocortical screws. In group II patients, after the same dissection procedures as in group I, the cutting and burring guide was fixed in the predefined position. Osteotomy was performed along the slot of the cutting guide, extending inferior and posterior to the mental nerves. Following mobilization of the chin segment, the PSI was inserted and secured with three monocortical screws cranially to the osteotomy plane. The chin segment was then repositioned according to the PSI, ensuring the pre-burred screw holes aligned with the fixation holes of the PSI, and fixed with two monocortical screws. The wound was closed using resorbable sutures (Figure 2).

To minimize bias from a learning curve and address the unequal distribution of genioplasty techniques per group, the last twenty cases of genioplasty using both conventional and CAD/CAM techniques were included in the study. All surgery was performed by one senior surgeon. The total operating time (from incision to suturing) for each group was recorded and compared. The collected data were subjected to statistical analysis using the IBM SPSS statistical software package, version 22 (IBM Corp., Armonk, NY, USA). Differences between pre- and postoperative parameters within groups were evaluated using the paired two-tailed t test and between groups using the unpaired t-test after establishing that the data were normally distributed by the Kolmogorov-Smirnov test. All results were considered significant if the *P*-value was less than 0.05.

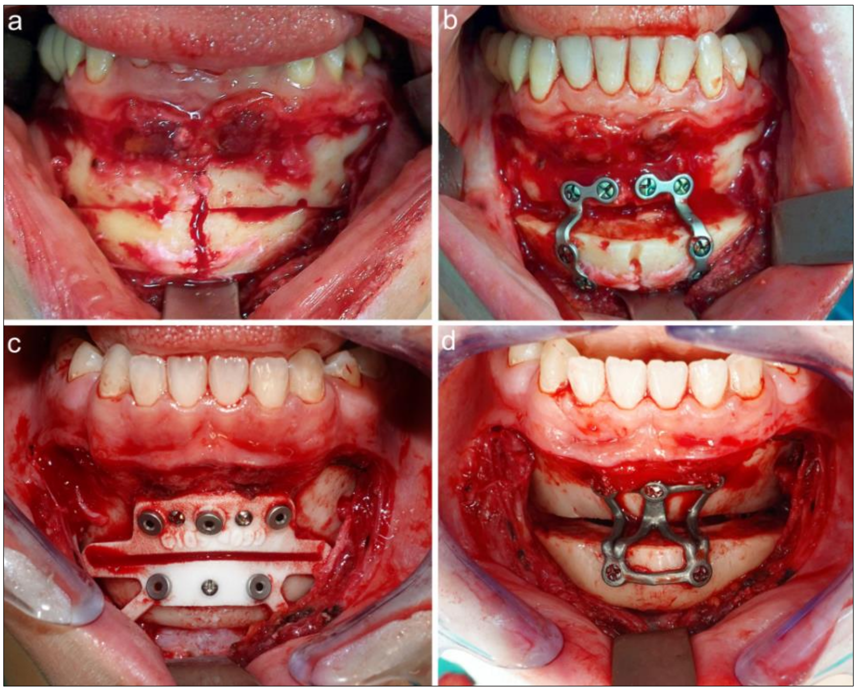

Figure 2 Surgery in Group I subjects: (a) Exposing the mental protuberance and horizontal osteotomy after marking the midline and the osteotomy line. (b) Fixation of the caudal chin segment in the new position. Surgery in Group II subjects: (c) Positioning of the cutting and burring guide. (d) Patient-specific osteosynthesis plate for repositioning and fixing the chin segment in the planned position

3. Results

In each group, 10 patients underwent chin advancement exclusively in the forward direction, while 10 patients received both forward advancement and vertical downward movement of the chin. Group I included 15 females and 5 males, with a mean age of 24.5 ± 6.7 years (range 18 to 40 years). Group II consisted of 16 females and 4 males, with a mean age of 27.5 ± 7.6 years (range 16 to 38 years). The mean ages did not differ significantly between the groups. Additionally, there were no significant differences between the groups in the intended forward movements or the predicted downward movements.

In Group I, operation times for all patients ranged from 44 to 58 minutes, with a mean operative time of 54.9 ± 7.51 minutes. In Group II, operation times ranged between 45 and 52 minutes, with a significantly shorter mean operative time of 49.9 ± 3.69 minutes (p = 0.012). Regarding the directions of chin movement, there was no considerable difference between the groups for forward advancement exclusively (Group I: 51.6 ± 4.43 minutes; Group II: 48.8 ± 3.69 minutes; p = 0.103). However, significant differences were observed between the groups in cases of simultaneous forward and downward movement of the chin (Group I: 58.3 ± 8.63 minutes; Group II: 51 ± 4.47 minutes; p = 0.033) (Figure 3). Differences in operative time between forward advancement exclusively and forward and downward movements within the groups were significant in Group I (p = 0.042) but not significant in Group II (p = 0.191).

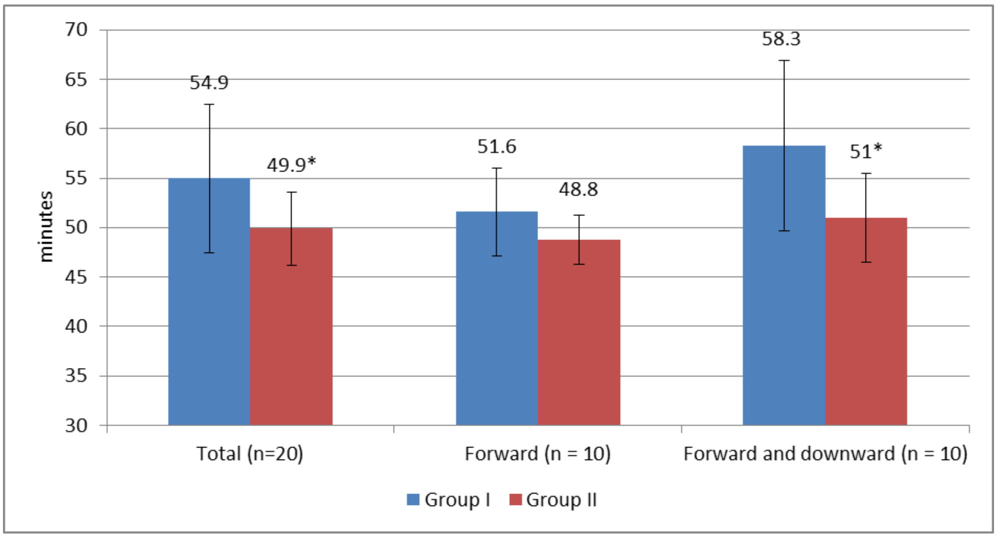

Figure 3 Mean operative time (minutes) in Groups I and II with respect to the direction of chin movement. * indicates significance for $p < 0.05$

4. Discussion

Our results indicate a significant reduction in operative time when using the CAD/CAM technique for genioplasty compared to the conventional method, thus confirming our null hypothesis. However, the time savings achieved must be evaluated with greater nuance, as they depend on the direction of chin movements. For both conventional and CAD/CAM techniques, the average duration from the first incision to the last suture did not exceed 60 minutes. No significant time savings were observed in this study for forward movement exclusively, as the time required to bend two miniplates in the conventional technique did not significantly exceed the time needed to apply and fix the cutting and burring guide using the CAD/CAM technique. The key factor here is that chin positioning is relatively straightforward when movement occurs in only one degree of freedom. In contrast, when the chin is moved in two directions, transferring the preoperative plan to the patient often necessitates repeated intraoperative measurements and longer visual assessments. This is why we observed a significant increase in operative time of approximately seven minutes in Group I patients who underwent combined forward and downward movement compared to those who received forward movement exclusively. In Group II, where the CAD/CAM technique was applied, a time saving of approximately seven minutes was achieved for combined movements, as repetitive measurements and adjustments were not required. However, Hidalgo et al. [11] reported a significant reduction in surgical time of approximately 20 minutes with guided surgery and individualized plates, though these savings did not offset the economic costs. Wang et al. [9] found a reduction in operating time of 30–60 minutes, though the preoperative preparation time increased by 2–3 hours, including three-dimensional planning, design, and template manufacture. When assessing the time-saving benefits of the CAD/CAM technique, it is essential to consider the pre-surgical planning time. This planning can add at least 20 minutes for web-based planning with the provider, or at least 60 minutes for in-house planning, along with additional time required for the surgical team to become proficient with the necessary technology, including software and 3D printer use [6]. Therefore, while the CAD/CAM technique may reduce time spent in the operating theatre, the overall time-saving benefit is not straightforward, as the additional time needed for planning and producing the hardware may offset any reductions in surgical time

5. Conclusion

CAD/CAM techniques offer potential time savings in stand-alone genioplasty, particularly for combined chin movements. However, the benefits should be weighed against the increased preoperative preparation time. Further research is needed to optimize these techniques and fully realize their advantages.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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