INTERNATIONAL JOURNAL OF MEDICAL SCIENCE AND PUBLIC HEALTH RESEARCH (ISSN – 2771-2265)
VOLUME 04 ISSUE 11 Pages: 94-109
SJIF IMPACT FACTOR (2021: 5.456), (2022: 5.681), (2023: 6.591)
OCLC –1242424495

International Journal of Medical Science and Public Health Research

Journal Website: https://ijmsphr.com/index.php/ijmsphr

Research Article

EFFICACY OF EXTRAORAL VERTICAL RAMUS OSTEOTOMY IN COMBINATION WITH INTERNAL FIXATION IN THE TREATMENT OF MANDIBULAR PROGNATHISM

Submission Date: November 09, 2023, Accepted Date: November 14, 2023,
Published Date: November 19, 2023

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ABSTRACT

Extraoral vertical ramus osteotomy (EVRO) is used in orthognathic surgery for the treatment of mandibular deformities. Originally, EVRO required postoperative intermaxillary fixation (IMF). EVRO has been developed using rigid fixation, omitting postoperative IMF. We examined retrospectively the long-term stability and postoperative complications for patients with mandibular prognathism who underwent EVRO with internal rigid fixation. Patients who were treated with EVRO for a mandibular prognathism in the period 2022–2023 at the Department of Plastic Surgery of the multidisciplinary clinic of the Tashkent Medical Academy (N = 12). Overjet and overbite were calculated digitally and cephalometric analyses were performed preoperatively, and at six months, and 18 months postoperatively. There was a general setback of the mandible, decreased gonial angle and reduced degree of skeletal opening. Excellent dental and vertical skeletal stabilities were seen up to 18 months postoperatively, although relapse was seen sagitally up to six months postoperatively. Since the overjet did not show any significant change over time, the sagittal skeletal changes have been attributed to dental compensation. There was no permanent damage to the facial nerve and 8.3% neurosensory damage to the inferior alveolar nerve was observed.

KEYWORDS

Performed preoperatively, and at six months, and 18 months postoperatively. There was a general setback of the mandible.

INTRODUCTION

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Orthognathic surgery involves surgical correction of deformities or malposition of the facial skeleton. The goal of orthognathic surgery is to normalize the relationship between the jaws and the rest of the craniofacial complex (1). Orthognathic surgery can be used to treat a wide range of maxillofacial anomalies, including congenital, developmental, and acquired deformities(2). Correction of maxillofacial deformities requires careful soft tissue analysis with clinical examination and supporting photographs, skeletal assessment using standardized radiographs, and dental evaluation using studied dental casts.

Mandibular prognathism is a common clinical problem; however, its prevalence varies among populations. The highest incidence rate was observed in the Asian population (15%) and the lowest in the Caucasian population (1%) (3). Obwegeiser(4) was the first to demonstrate the possibility of stable and consistent reduction of the maxilla and reported simultaneous reduction of the maxilla and mandible. Most maxillofacial deformities can be corrected using four main osteotomies(5): in the upper jaw - Le Fort type I osteotomy, in the lower jaw - sagittal split ramus osteotomy, vertical ramus osteotomy and horizontal chin osteotomy.

Chin deformities may exist independently of mandibular deformities, and the chin may have abnormal proportions without occlusal involvement. Horizontal symphysis osteotomy (osseous genioplasty) is a much more versatile procedure in which the chin can be moved in multiple planes to correct significant sagittal and vertical deformities of deficiency (microgenia) or excess (macrogenia) and is used to correct facial asymmetry(6).

Currently, sagittal ramus osteotomy is the main method for correcting most cases of retrognathia and prognathism of the mandible. Surgical options for extreme cases of mandibular prognathism are extraoral vertical ramus osteotomy (EVRO), intraoral vertical ramus osteotomy (IVRO), or inverted L osteotomy(6). The extraoral vertical ramus osteotomy technique was the first described and is preferred in most cases.

EVRO is a very simple surgical procedure that takes less time than other mandibular procedures. The advantages of EVRO are simple osteotomy incisions and minimal complications. EVRO is a well-established technique for the correction of mandibular prognathism with documented additional improvements in occlusion and facial aesthetics, as well as facial stability. Calderon et al (7) characterized the extraoral approach as simple, providing excellent visibility, and stated that the intraoral approach should be used only for those who are prone to keloid formation and for those who object to extraoral scarring. Various benefits of orthognathic surgery have been reported, including improved masticatory function, decreased temporomandibular joint pain, and improved facial aesthetics. The purpose of this study is to evaluate the universality of EVRO in mandibular prognathism.

MATERIAL AND METHODS

The study included 12 patients with mandibular prognathism who applied to the plastic surgery department of the multidisciplinary clinic of the Tashkent Medical Academy. The study included patients with mandibular prognathism aged 18-30 years, who had completed active growth and were sufficiently motivated to comply with the treatment regimen. To examine patients with this deformity, we

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use clinical (history taking, subjective and objective research methods), clinical-instrumental (Lateral Cephalogram and MSCT of facial bones) and laboratory (general blood and urine tests, bacteriological) research methods. Due consideration has been given to extreme cases of mandibular macrognathia ((i.e., more than 7 mm of setback). Preoperative orthodontic treatment was performed to decompensate the dental components.

An MSCT analysis of the maxillofacial area was performed. The antilingula on the buccal side and the mandibular foramen on the lingual side were located, and the distance from the top of the sigmoid notch to the lower edge of the body of the mandible and the mandibular foramen was measured (Fig. 1, panels a and bThen the distance from the rear edge to the front edge was also measured. (Fig. 1, panels c and d). Guided by this, an osteotomy of the branch was performed. Predictive tracking was performed for each patient on a preoperative lateral cephalogram, followed by facebow transfer to a semi-adjustable anatomical articulator, and model surgery and splint fabrication were performed (Fig. 2, panels a and b).

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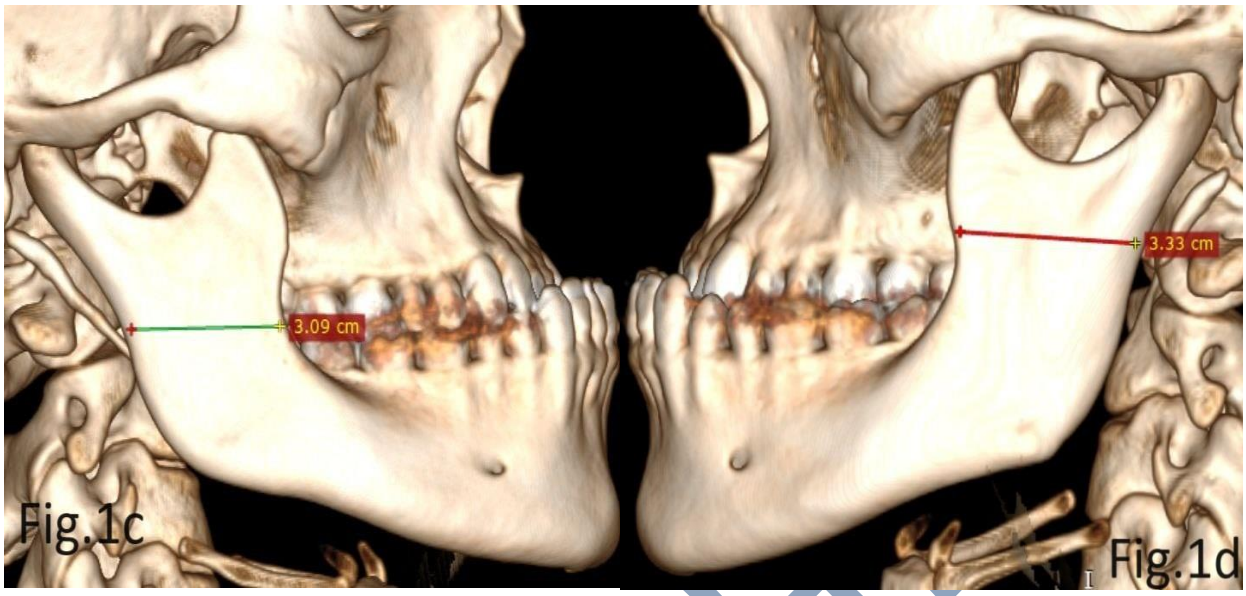

FIGURE 1: (a) sigmoid notch to antilingula, (b) sigmoid notch to antilingula, (c) posterior margin of mandible to antilingula, and (d) posterior margin of mandible to antilingula

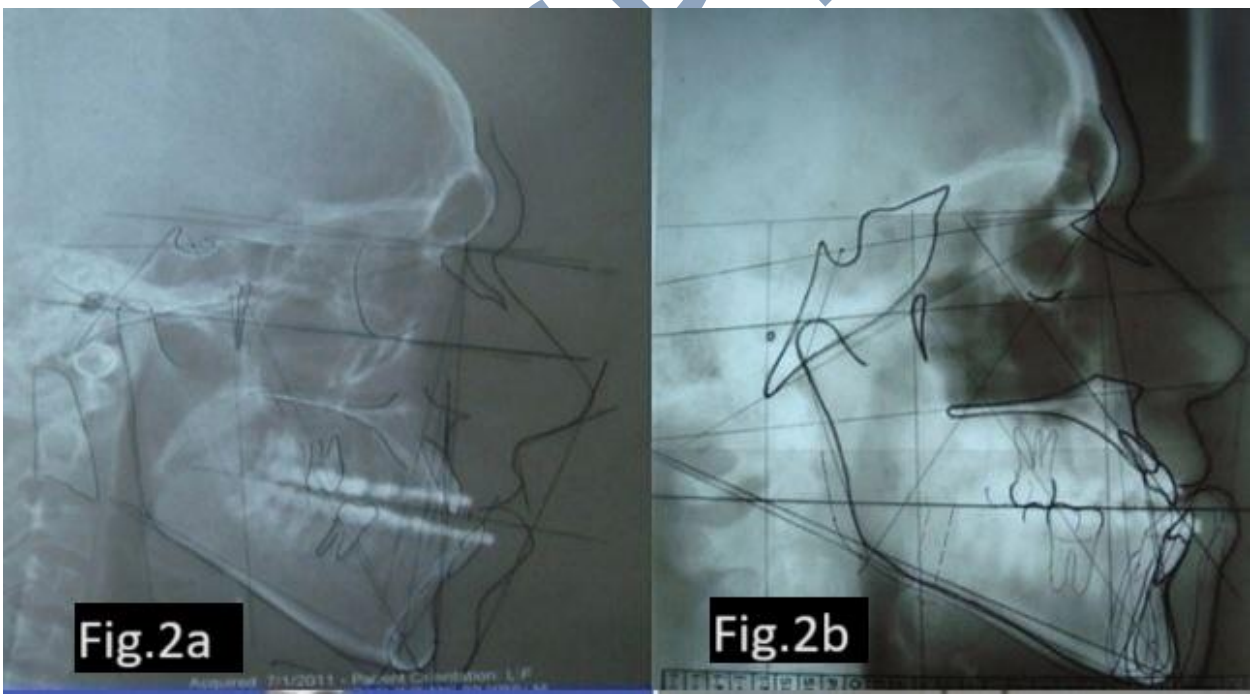

FIGURE 2: (a) Preoperative lateral cephalogram, (b) predicted tracking

Parameters used to evaluate surgical outcome were time spent on surgery, facial harmony in both frontal and profile views, postoperative, intraoperative and postoperative complications, and assessment of

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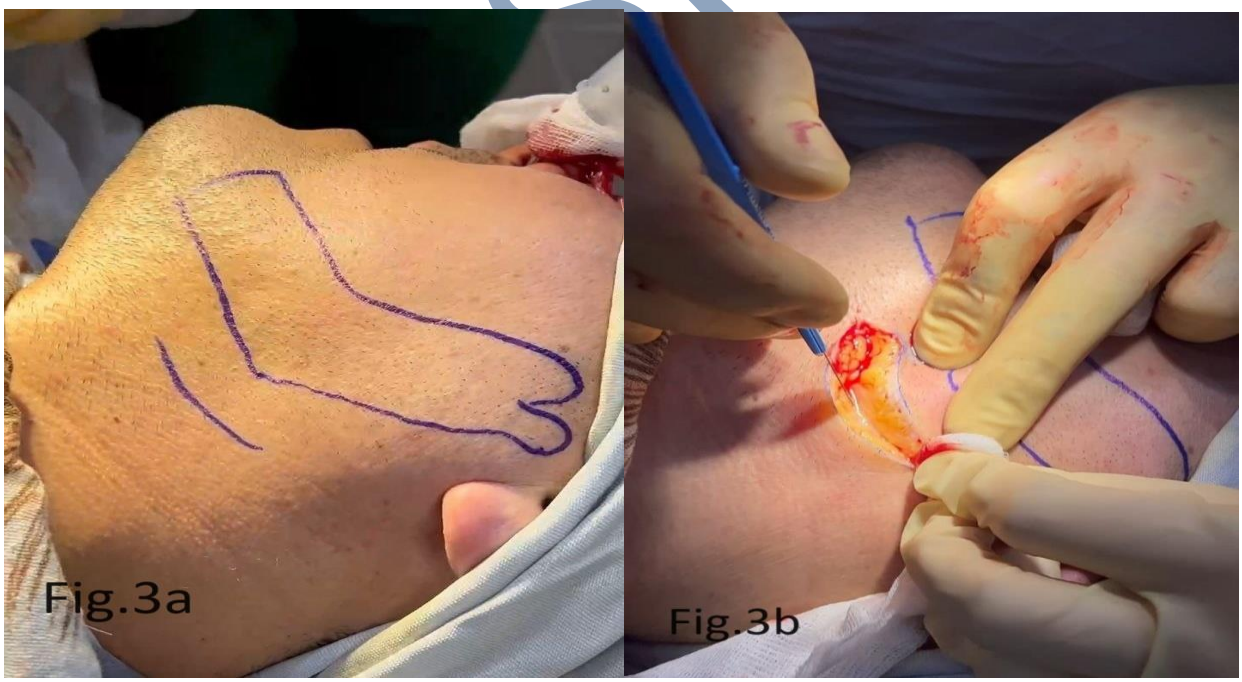
postoperative outcome was performed using lateral cephalograms. Cephalometric measurements were assessed pre- and post-operatively: posterior vertical height was measured perpendicular to the horizontal plane (HP) from the posterior nasal spine to the gonion (PNS-N perpendicular to the HP), anterior nasal spine to the posterior nasal spine (ANS_PNS) and ramus height using articlere to the gonion (Ar-Go). The reference planes used were the Frankfurt horizontal plane (FHP), the Sella-Nacion plane (S-N), the mandibular plane, and the occlusal plane.

Stages of the surgical process

40 minutes before surgery, the patients received premedication. EVRO was performed under general anesthesia via nasoendotracheal intubation by the same surgeon for all patients to avoid bias. Risdon's submandibular incision (8) was located in the submandibular region, 4–5 cm long, (Fig. 3, panels a and b), approximately 2 cm below the angle on the lower edge of the mandible. The incision was made with a No. 15 blade, and dissection was carried out through the skin, subcutaneous tissue, platysma, and superficial layer of the cervical fascia. Precautions were taken to avoid injury to the marginal mandibular nerve. The facial vein and facial artery, if encountered, were clamped and ligated to achieve hemostasis, and the marginal mandibular nerve was identified, retracted posterosuperiorly, and protected. A combination of sharp and blunt dissection was used on the lower edge of the mandible. Along the lower edge of the jaw in the area of the angle, the periosteum was dissected and the outer surface of the lower jaw ramus was skeletonized to the semilunar notch. The posterior edge of the branch and its inner surface in the distal sections were freed from soft tissues. (Figure 3, panel c).



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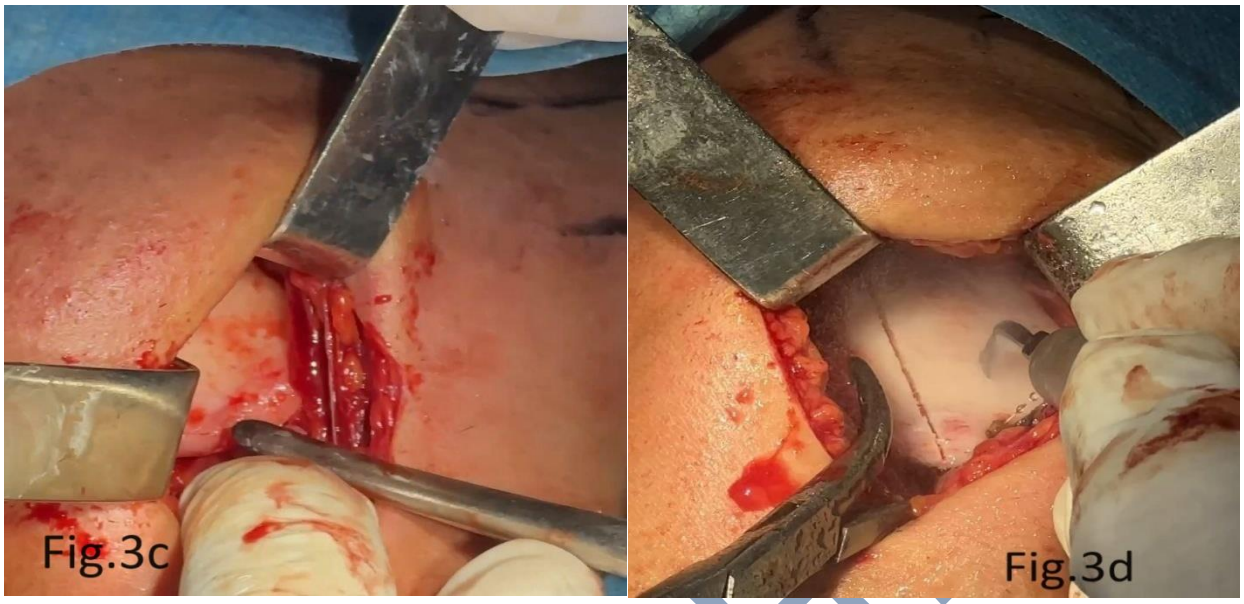

FIGURE 3: (a) Mark the incision line, (b) Submandibular incision, (c) ramus exposure, and (d) osteotomy incision.

After exposure of the lateral surface of the ramus, a protrusion of the antilingula was discovered (Fig. 1, panel a and b). MSCT scan results were used to guide osteotomy incisions in the ramus. A vertical osteotomy incision of the ramus was made from the base of the condylar process to the angle of the mandible (Fig. 3, panel d). A bone incision was made by a physical surgeon to facilitate overlap of the proximal segments with the distal fragment. Parallel to the first cut, a second was made within the outer compact plate. The width of the removed external compact plate corresponded to the planned posterior displacement of the mandible (Fig. 4, panel a). A milling cutter was used to decorticate a small fragment from the inner surface. Appropriate precautions were taken to maintain sufficient proximal segment width when performing a vertical ramus osteotomy to preserve the blood supply to the temporomandibular joint (TMJ) capsule and the superior lateral pterygoid attachment. Precautions were also taken to avoid injury to the inferior alveolar nerve by performing an osteotomy incision posterior to the nerve canal.

The wound was then covered with an aseptic bandage. Similar stages of the operation were carried out on the left side of the lower jaw. After bilateral osteotomy of the lower jaw, the middle fragment of the jaw was installed in the correct position - orthognathic (Fig. 4, panel b), the upper and lower jaws were fixed together with rubber rods (Fig. 4, panel d), installed on the bracket system. The central fragment was displaced posteriorly and the bone fragments were fixed in the correct position using miniplates at the edge of the angle of the mandible (Fig. 4, panel c).

The surgical wound was sutured in layers with 5/0 Vicryl synthetic sutures after achieving sufficient hemostasis. Intradermal 5/0 Vicryl sutures were placed on the skin. The patient was under intermaxillary fixation (IMF) for 7–10 days after surgery (Fig. 4, panel d). Light elastic traction was used to correct the occlusion over the next four to five weeks until initial bone healing occurred. All patients received nasal feeding via a Ryle tube for 10 days followed by oral liquid feeding until IMF was released.

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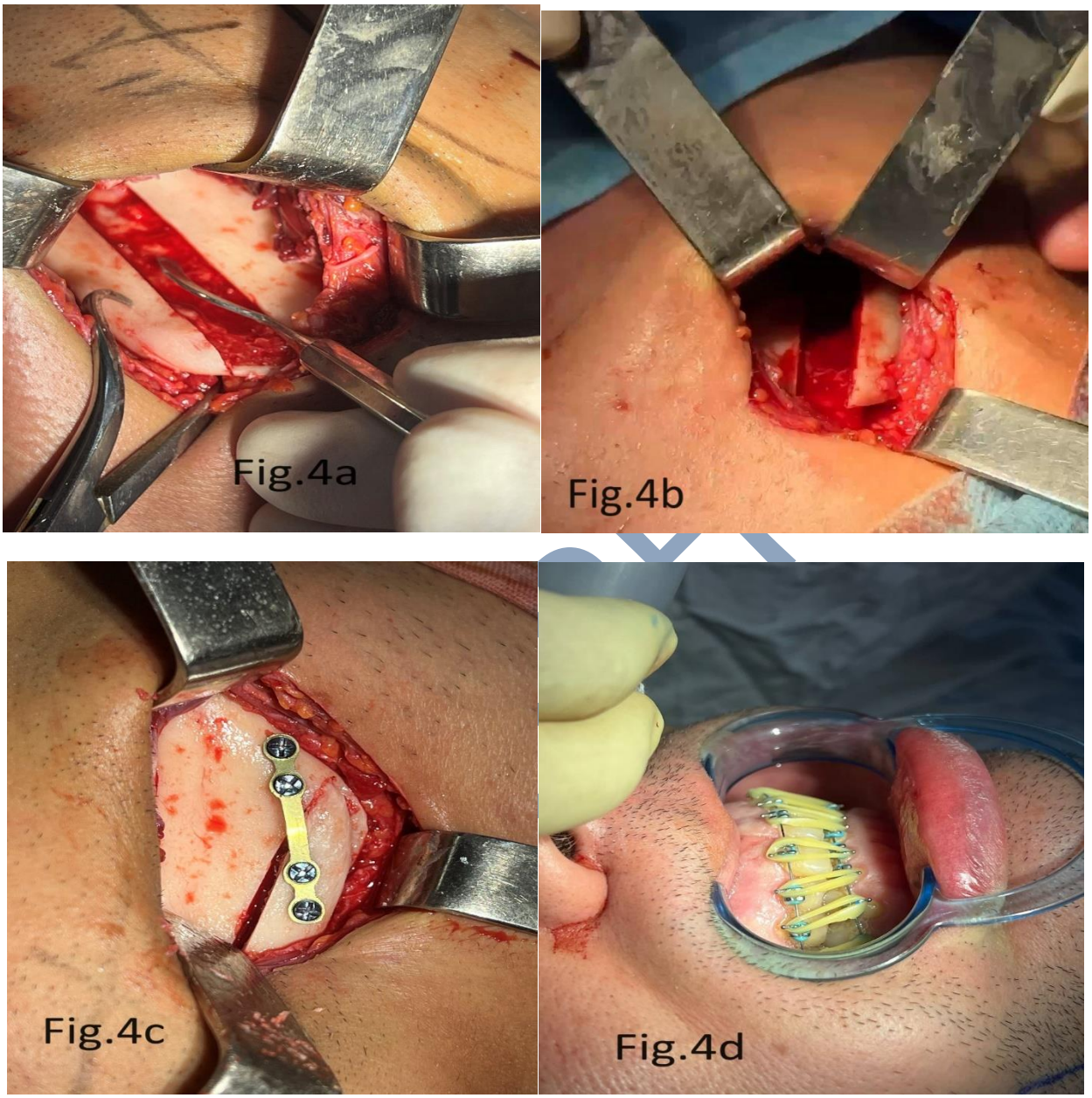

FIGURE 4: (a) Overlapping segments, (b) overlapping segments, (c) fixed bone fragments (d) IMF with rubber bands

RESULTS

Twelve patients (seven men and five women) with chief complaints of mandibular macrognathia were included in the study. The average age of study participants (N = 12) was 22 ± 2.263 years. The reverse overlap was 7 mm in nine patients and 8 mm in three patients. The average mandibular setback achieved was 10 mm (Table 1).

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S. No	Age/Sex	Diagnosis	Reverse Overjet	Total Time Taken for Surgery in Minutes	Surgical Access	Visibility
1.	21/M	Mandibular prognathism	-7 mm	**95**	Excellent	Excellent
2.	23/F	Mandibular prognathism	-7 mm	**93**	Excellent	Excellent
3.	18/M	Mandibular prognathism	-7 mm	**97**	Excellent	Excellent
4.	19/F	Mandibular prognathism	-7 mm	**97**	Excellent	Excellent
5.	22/M	Mandibular prognathism	-8 mm	**90**	Excellent	Excellent
6.	25/M	Mandibular prognathism	-7 mm	**87**	Excellent	Excellent
7.	24/M	Mandibular prognathism	-7 mm	**95**	Excellent	Excellent
8.	27/M	Mandibular prognathism	-8 mm	**95**	Excellent	Excellent
9.	30/M	Mandibular prognathism	-7 mm	**98**	Excellent	Excellent
10.	19/F	Mandibular prognathism	-7 mm	**85**	Excellent	Excellent
11.	20/F	Mandibular prognathism	-7 mm	**92**	Excellent	Excellent
12.	23/F	Mandibular prognathism	-8 mm	**90**	Excellent	Excellent

TABLE 1: Preoperative and intraoperative assessment

The time required for the entire surgical procedure, from incision to closure, ranged from 85 to 98 minutes, with the average time required per operation being about 94 ± 8.80 minutes. In subsequent cases, a gradual reduction in operating time was observed. We had excellent visibility and access to the surgical site for all patients. Immediate postoperative results showed a clinically satisfactory frontal and profile appearance (Figure 5, panels a-d).

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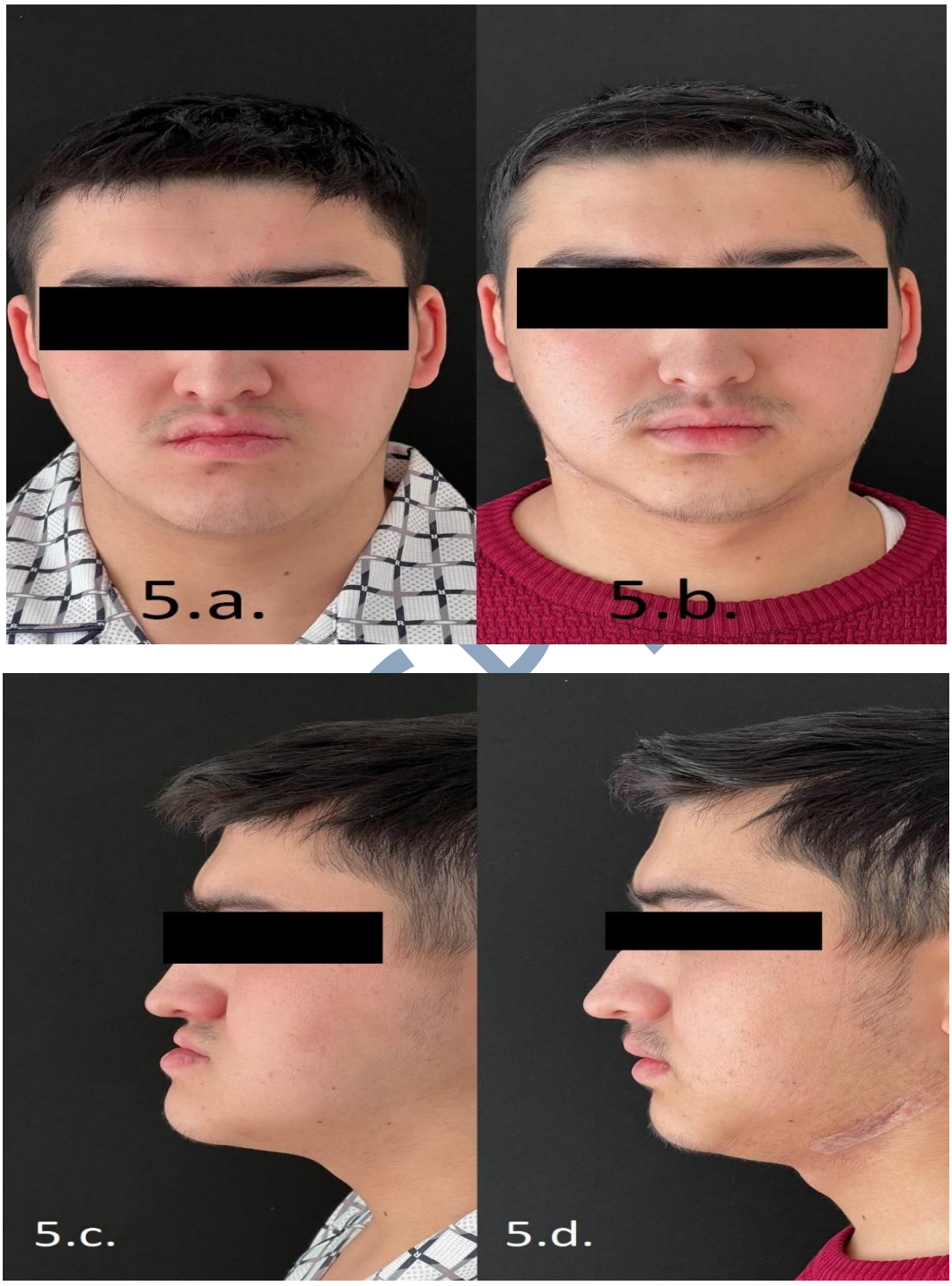

FIGURE 5: (a) Anterior view before surgery, (b) Anterior view after surgery, (c) Profile view before surgery, and (d) Profile view after surgery

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All patients achieved class I molar occlusion (Fig. 6, panels a and b). There was found to be a statistically significant difference between the preoperative (mean = 53.4, SD = 5.854) and postoperative (mean = 47.5, SD = 5.039) PNS-N N perpendicular HP (mm) score with p <0.001. Similarly, there was a statistically significant difference between the preoperative (mean = 81.4, SD = 2.716) and postoperative assessment (mean = 74.4, SD = 3.627) of mandibular body length (mm) with p < 0.001.

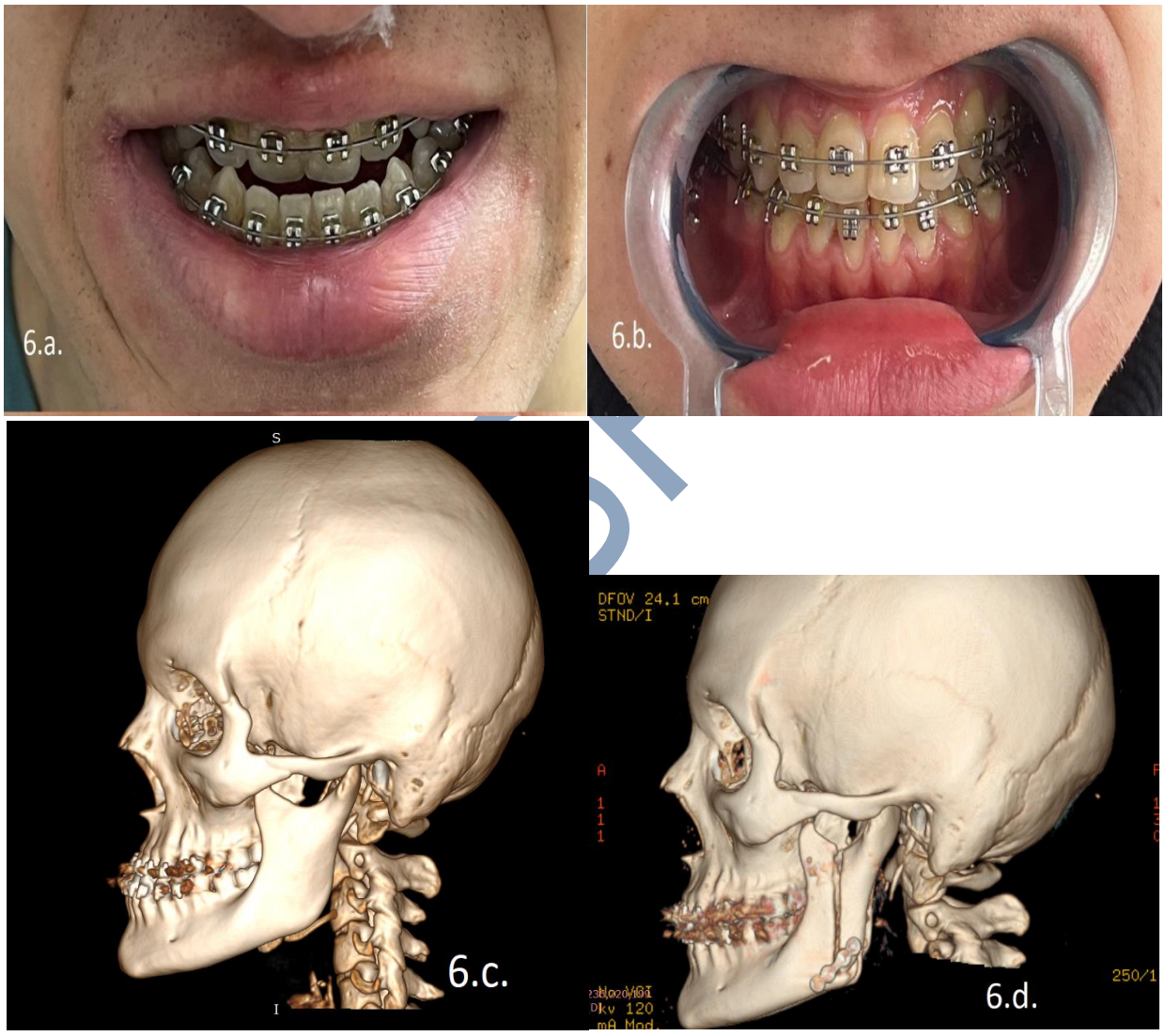

Figure 6: (a) preoperative occlusion, (b) postoperative occlusion, (c) preoperative MSCT, and (d) postoperative MSCT.

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However, there is no statistically significant difference between preoperative and postoperative ANS_PNS score (mm) and Ar-Go branch height (mm) (Table 2). Aesthetically satisfactory results were observed in all patients during the follow-up period, both clinically and radiographically (Fig. 6, panels c and d). The concave profile was transformed into a straight one in the preoperative period.

S. No	PNS-N 1 HP in mm		ANS_PNS in mm		Ramus Height Ar-Go in mm		Mandible Body Length in mm	
	Preop.	Postop.	Preop.	Postop.	Preop.	Postop.	Preop.	Postop.
1.	58	52	60	60	49	49	87	81
2.	43	41	51	51	49	49	78	71
3.	54	50	54	54	59	59	83	77
4.	53	46	53	53	57	56	64	78
5.	48	41	53	53	67	67	80	72
6.	57	51	54	54	56	56	82	74
7.	59	52	58	58	58	58	81	72
8.	46	40	60	60	49	49	79	72
9.	56	50	52	52	48	48	78	70
10.	60	52	55	55	57	57	84	77
11.	58	51	53	53	55	55	80	73
12.	56	50	52	52	54	53	79	72

TABLE 2: Cephalometric analysis: before and after surgery

PNS-N: posterior nasal spine to nasion; HP: Horizontal plane; ANS_PNS: from anterior nasal spine to posterior nasal spine; Ar-Go: Articular to the gonion.

The length of stay of our patients in the hospital ranged from seven to ten days, including the preoperative period. One patient in the postoperative period had a slight deviation of the lower lip to the left side, probably due to retraction, as well as weakness of the marginal mandibular nerve on the right side. The lower lip deviation resolved after two to three weeks and the

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patient appeared normal. The average follow-up period for all patients was three years.

DISCUSSION

Dentofacial deformity is evident in the majority of the population, with mandibular prognathism making the greatest contribution, and a significant proportion of the population is found to suffer from this skeletal deformity. The incidence of mandibular macrognathia is significantly higher than other craniofacial deformities (9). However, its prevalence varies from place to place and by race. The highest incidence (15%) was observed in the Asian population, and the lowest incidence (1%) was observed in the Caucasian population [10].

Bilateral sagittal split ramus osteotomy has been the most widely used surgical procedure for the correction of mandibular retrognathia and macrognathia. In most extreme cases of mandibular macrognathia, the treatment of choice is "extraoral vertical ramus osteotomy" or "intraoral vertical ramus osteotomy" [11]. EVRO was first proposed by Caldwell and Letterman in 1954 [11]. This was first reported by Robinson in 1956 and Hinds in 1957 [12].

Vertical subcondylar osteotomies of the mandibular rami to correct mandibular prognathism can be performed via extraoral or intraoral access. The simplicity of the approach, access and surgical visibility have forced many surgeons to prefer "EVRO" for the correction of mandibular prognathism [13]. Due to the external scar and the possibility of damage to the facial nerve, many authors have preferred the intraoral approach [14]. In this study, we did not encounter such an incidence of noticeable scarring or damage to the facial nerve, with the exception of one case in which weakness of the marginal mandibular nerve was observed, which resolved after three weeks. Ornell et al reported transient hypersensitization of the inferior alveolar nerve in 19.2% of patients and no complaints of scarring in their study of EVRO with internal fixation [15]. Hogensley et al [16] reported neurosensory impairment in one of 65 patients undergoing extraoral vertical subcondylar osteotomy with rigid fixation for macrognathic mandibles. This result was associated with a different osteotomy design and the use of monocortical osteosynthesis plates, which avoided intervention into the mandibular foramen. Peleg et al [17] reported neurosensory impairment of the inferior alveolar nerve in 11.54% of patients who underwent sagittal osteotomy and in 5.08% of patients who underwent intraoral vertical osteotomy of the mandibular ramus. The results of the current study and other studies indicate that ramus osteotomy has a lower risk of nerve injury.

The operative time of "EVRO" in this study ranged from 5 minutes to 98 minutes, with a mean of 94 ± 8.80 minutes, compared to the study conducted by Thornes and Gilhuus-Moe [13], in which the time of operation "EVRO" ranged from 50 to 180 minutes, average 88 minutes. In contrast, Ornell et al reported that the duration of the surgical procedure was two hours and 26 minutes, whereas Peleg et al. reported that the duration of intraoral vertical ramus osteotomy was two hours and seven minutes, indicating that extraoral ramus osteotomy is performed faster than intraoral ramus osteotomy. All patients received prophylactic antibiotic therapy to avoid contamination of the extraoral wound during intraoral manipulation of the segments. None of our patients received a blood transfusion either during surgery or in the postoperative period, since in all cases the recorded blood loss was less than 400 ml. Wang and Waite [18] estimated blood loss using the "EVRO" method to range from 50 to 650 mL with a mean of 180 mL, and Ornell et al estimated blood loss to be 76 mL [15].

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Cephalometric changes observed on lateral cephalograms showed a significant difference in mandibular setback, and long-term stability of the mandible was satisfactory both clinically and functionally, similar to the study of long-term stability of the EVRO and IVRO groups by Nordin et al. [19]. They concluded that the final choice of surgical approach should be made primarily based on clinical aspects. Li et al [20] compared the postoperative stability of sagittal split ramus osteotomy and IVRO and concluded that horizontal stability at point B was higher in the IVRO group. Nihara et al. [21] studied immediate and long-term postoperative skeletal changes after intravenous ovarian cancer using lateral cephalograms. In the short term, they observed clockwise rotation of the distal segment of the mandible, which could be associated with adaptation of the masticatory system. At long-term follow-up, the menton (Me) moved anteriorly by only 0.9 mm and the recurrence rate was only 15.3%, confirming the excellent long-term stability of muscle branch osteotomies. In our study, among 12 patients with mandibular prognathism, ten patients underwent preoperative orthodontics and two patients (90%) did not undergo preoperative orthodontics, similar to the study conducted by Thornes and Gilhuus-Moe [13] in which 86% of patients underwent preoperative orthodontics. However, the stability of the procedure depends on the degree of retrusion, the rigidity of the fixation and the continuous growth of the mandible [17].

In one case, supra-eruption of the lower incisor was observed during the IMF period, and the pressure on this tooth was relieved to avoid further complications. A review of the literature shows that many authors preferred IMF over existing orthodontic appliances [22]. Mobarak et al [23] compared the stability of the EVRO using two methods of fixation: plate versus maxillary fixation and skeletal suspension. They reported that in the maxillary fixation group, there was posterior movement of the mandible with increasing mandibular plane angle, shortening of the ramus, and dental compensation, which resulted in a slight anterior relapse after release of the maxillary fixation and skeletal suspension, whereas this was not observed with plate fixation, as only a 10% tendency for anterior recurrence was reported, suggesting that plate fixation in the EVRO provides superior long-term stability. This tendency toward anterior recurrence was not observed in our patients because rigid fixation was performed. All of our patients had difficulty speaking and feeding due to maxillofacial fixation, which appears to be the main disadvantage of extraoral ramus osteotomy [24].

Although all patients in our study received antiemetic treatment, out of 12 patients, only one experienced nausea (20%) compared to the study by Malekzadeh et al [15], in which 21.2% of patients experienced nausea . Mild to moderate swelling was observed in all of our patients until the fifth postoperative day. During treatment with corticosteroids for five days, gradual disappearance of edema was observed. Infection was not observed in any of our cases during the follow-up period, as observed by Tornes [13] in his study in EVRO.

The total period of hospitalization ranged from seven to 10 days, with an average of 5.2 days, compared to a study conducted by Thornes and Gilhuus-Moe [13], in which he found that the EVRO procedure required a shorter period of hospitalization, i.e. from three to 10 days. an average of 4.8 days compared with IVRO, in which the hospitalization period ranged from 3 to 11 days. No incidence of parotid fistula was observed in our cases because extreme precautions were taken during surgery to minimize postoperative complications.

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Hines et al. [25] showed that the EVRO is simple, providing excellent visibility and access, and the intraoral vertical ramus osteotomy is intended for patients with keloids and patients who objected to extraoral scars. The EVRO carried out in all our cases provided excellent exposure and good access. Although the surgical procedure left a scar, it was not noticeable, and none of our patients developed a keloid. No patient complained of scarring problems.

Thornes and Gilhuus-Moe [13] stated in their study that patients with very high branches are considered technically challenging in IVRO. These patients were operated on using extraoral vertical ramus osteotomy. All of our cases were of a very high branch and were exposed to EVRO. Based on the observations made in our study, EVRO is a well-established method for correcting mandibular prognathism with documented additional improvements in occlusion and facial aesthetics, as well as the stability of established skeletal relationships.

This study has several limitations. In our study, virtual surgical planning was not performed. In a recent meta-analysis comparing the effectiveness of traditional (TSP) and virtual surgical planning (VSP) in orthognathic surgery, VSP and customized osteosynthesis were found to be significantly better in predicting certain reference areas, in addition to the benefit of reducing surgical time, even for inexperienced surgeons.

Conclusions

Extraoral vertical ramus osteotomy is an acceptable surgical procedure due to its ease of execution, lack of complications, and positive results. Due to its lack of recurrence and almost undetectable scar, this surgical procedure has been observed to offer the best chance of long-term results, provided extreme care is taken in case selection (mandibular macrognathia > 7 mm). In the future, this technique will be valuable in the hands of oral and maxillofacial surgeons if it is preceded by careful examination and careful patient selection.

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