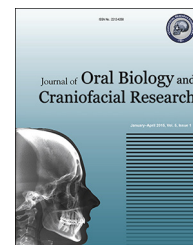


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Original Article

Management of pediatric mandibular fractures using bioresorbable plating system – Efficacy, stability, and clinical outcomes: Our experiences and literature review



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ABSTRACT

Aims: The purpose of this study was to determine the efficacy and stability of the biodegradable fixation system for treatment of mandible fractures in pediatric patients by measuring the bite force.

Methods: Sixty pediatric patients with mandibular fractures (36 males, 24 females) were included in this study. The 2.5-mm resorbable plates were adapted along Champy's line of ideal osteosynthesis and secured with four 2.5 mm diameter monocortical resorbable screws, 8 mm in length. All patients were followed for 10 months. Clinical parameters, such as soft tissue infection, nonunion, malunion, implant exposure, malocclusion, nerve injury, and bite force for stability, were prospectively assessed.

Results: Adequate fixation and primary bone healing was achieved in 100% of the cases. Six minor complications (10%) were observed: 2 soft tissue infections (3%), 1 plate dehiscence (2%), 1 malocclusion (2%), and 2 paresthesia (3%).

Conclusion: 2.5-mm resorbable plating system along Champy's line of ideal osteosynthesis is a good treatment modality for mandible fractures in pediatric patients.

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1. Introduction

Successful treatment of mandible fractures signifies an anatomic bony union with restoration of normal occlusion and function. Mandibular fractures may be either treated conservatively or with open reduction and internal fixation. The principles of management of mandibular fractures differ in children. While in adults, absolute reduction and fixation of fractures is indicated, minimal manipulation of facial skeleton is mandated in children. The goal of fracture management is to restore the underlying bony architecture to preinjury position, in a stable fashion, as noninvasively as possible, with minimal residual esthetic and functional impairment.

Most fractures are treated conservatively by splints with circummandibular wires and maxillomandibular fixation; but in unstable fractures, internal fixation using miniplates is required. Titanium plates have been the gold standard for internal fixation of mandible fractures.¹ Resorbable plating systems have been used for midface, craniofacial, and pediatric fracture cases. The purpose of this study was to determine the efficacy and stability of the biodegradable fixation system in the treatment of pediatric mandible fractures by measuring the bite force.

2. Methodology

Sixty children with mandible fractures, who reported to our outpatient department over a period of one and half years, were included in the study, irrespective of age, sex, caste, religion, socioeconomic status, and nature of injury. Inclusion criteria include normal healthy individuals with no debilitating systemic and bony diseases, and single, noncomminuted mandibular fractures (symphysis, parasymphysis, body, angle) where open reduction was indicated (Fig. 1). An informed consent was obtained from their parents prior to their enrollment in the study. Exclusion criteria include infected fracture site, undergoing steroid therapy, pathological fracture, and concomitant condylar, coronoid fractures, and midface fractures.

Pediatric patients having mixed and permanent dentition in the age range of 8–15 years were included in the study. Preoperative detailed history was recorded. Careful examination of the soft tissues and underlying facial skeleton excluded



Fig. 1 – Intraoral view of fracture and deranged occlusion.



Fig. 2 – Preoperative O.P.G.

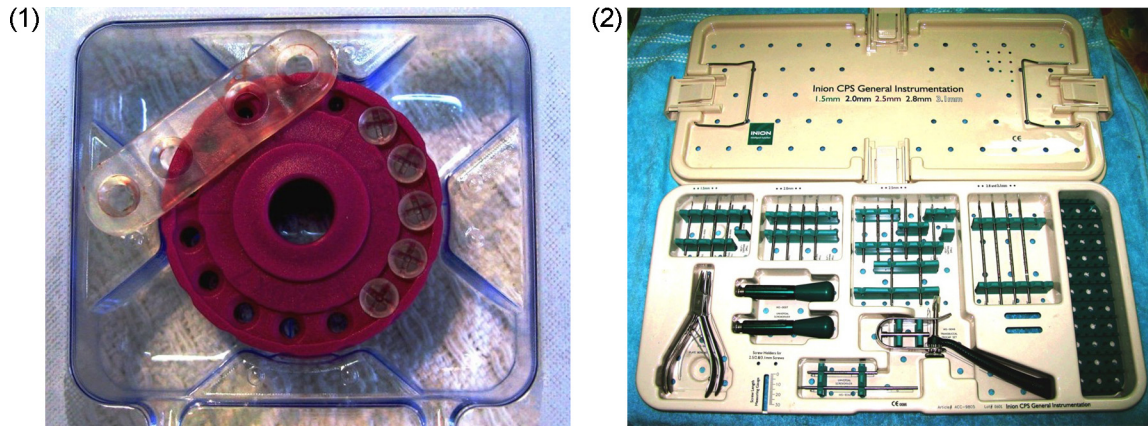
any other associated injuries. Radiographs (Fig. 2) and routine blood investigations were advised and parents were informed of the treatment plan. Prophylactic antibiotic coverage and analgesics were prescribed. Mean duration between injury and surgery was 2 days.

Nasotracheal intubation was done and all fractures were treated under general anesthesia. Fractures were treated either intraorally with vestibular/mucosal incision or extraorally through existing traumatic scar. Extraction of teeth in the line of fracture was performed if the tooth was fractured, periodontally involved, nonrestorable, grossly carious, or interfering with reduction of fracture, or occlusion. Either a splint was made after impression or interdental eyelet wiring was done prior to surgery.

Ideal occlusion was achieved using maxillomandibular fixation, and fractures were reduced. 2.5-mm INION – CPS plating kit was used for plating (Fig. 3 and 4). A four-hole resorbable plate was adapted along Champy's line of ideal osteosynthesis after being immersed in a sterile water bath at 55 °C for 15 s, and was secured with four 8 mm length, 2.5 mm diameter monocortical screws, using a drill-tap-screw sequence (Fig. 5). Care was taken to place the screws lateral to roots and superior to neurovascular bundle, with a minimum of two screws in the proximal and distal segments of the fracture. Interforaminal fracture involving symphysis and parasymphysis was fixed with 2 four-hole resorbable plates. The area was irrigated and closed with resorbable sutures. All patients received a postoperative course of intravenous antibiotics and chlorhexidine oral rinse upon discharge. A short-term postoperative IMF for 2 weeks was done. Patients were followed for bite force, temporo-mandibular joint function, esthetics, and complications if any.

2.1. Bite force recording

Bite force recordings were made using indigenous Bite Force Recorder, designed at Research Design and Standard Organization, Lucknow. The recorder consists of four strain gauges mounted on steel bar forming a wheatstone bridge. Load changes in steel bar produces measurable voltage changes across the strain gauges, which were converted into the kilogram force (kp). Bite forces were recorded at the bilateral molar region and incisor region.



Figs. 3 and 4 – INION – CPS plating kit containing plates and screws.

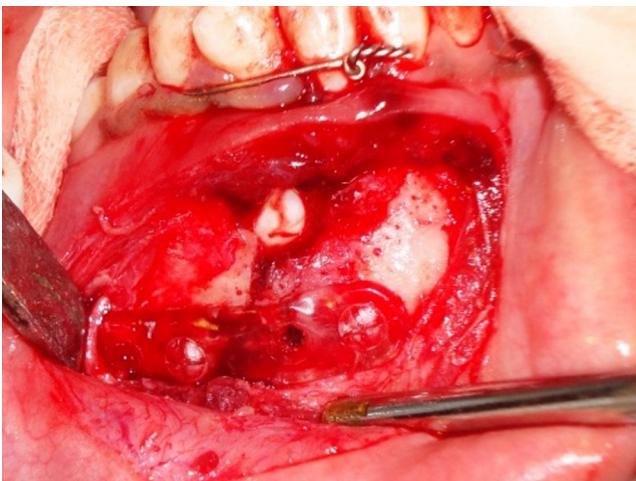


Fig. 5 – Intraoperative view of reduction and plate fixation.



Fig. 7 – Postoperative Occlusion.

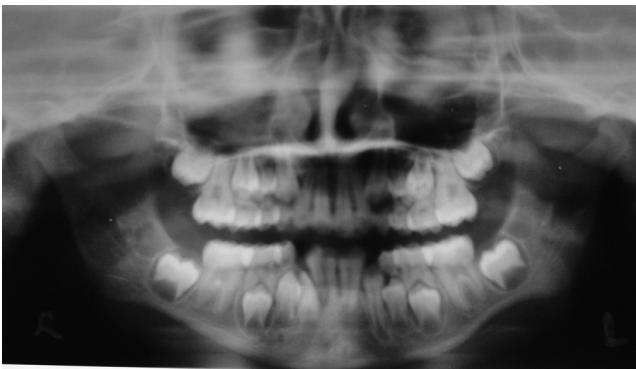


Fig. 6 – Postoperative OPG showing healing of fracture.

3. Results

In the present study, 60% were male and 40% were females. 55% of the mandibular fractures were in body, 25% at angle, and 20% in the parasymphiseal region. Biodegradable fixation system provided satisfactory stability to enable bone healing during the initial phase, as bone healing was achieved in all fractures (100%) with satisfactory alignment of fracture segments, reproducible preinjury occlusion, normal temporomandibular joint function, and satisfactory esthetics, as determined clinically and radiographically (Figs 6 and 7).

Bite force analysis showed an increased stability and masticatory function at incisor and molar regions at all monthly follow-ups. (Tables 1-2). Table 3 demonstrates the complications observed.

Table 1 – Bite force assessment in incisor region.

	Bite force (mean ± SD)	Change in bite force (mean ± SD)	't' value	'p' value
2 weeks	3.58 ± 1.281	–	–	–
3 months	5.25 ± 1.624	1.670 ± 0.786	8.886	<0.0001
6 months	6.71 ± 1.795	3.13 ± 1.144	11.449	<0.0001

Significant increase in bite force at 3 months and 6 months, from 2nd week onwards.

Table 2 – Analysis of bite force in molar region.

	Bite force (mean ± SD)	Change in bite force (mean ± SD)	't' value	'p' value
2 weeks	6.11 ± 1.846	–	–	–
3 months	11.385 ± 1.934	7.245 ± 2.038	14.880	<0.0001
6 months	17.14 ± 2.443	12.030 ± 3.076	18.373	<0.0001

Table 3 – Complications.

Complications	Numbers (%)
Soft tissue infection	2 (3%)
Nerve injury (paresthesia)	2 (3%) with body fracture for 4 weeks, resolved at further follow-up
Implant exposure	1 (2%) at 3rd week follow-up
Malunion, nonunion	0
Malocclusion	1 (2%)
Total	6 (10%)

4. Discussion

Pediatric fractures are rare and estimated to occur in 5% of all maxillofacial trauma.² Approximately 40% of all pediatric fractures involve mandible.³ The basic treatment principles differ from the adult population because of the mixed dentition, unerupted teeth, and the ongoing growth.⁴ Hence, these patients present with their own unique treatment requirements. Treatment of mandible fractures with titanium plates⁵ and lag screws⁶ has been applied to improve osteosynthesis at mandibular fracture sites for decades. There are reported disadvantages, such as osteoporosis,⁷ implant migration,⁸ release of metal ions,⁹ extrusion,¹⁰ stress shielding,¹¹ artifacts on radiographic examinations,¹² restrictions on growth in children,^{13,14} and thermal sensitivity.¹⁵ Other disadvantages of titanium plating include palpability, thermal sensitivity, image interference, transcranial migration in pediatric cases,¹⁶ growth inhibition when placed across growth sutures, and the need for secondary hardware removal surgery.¹⁷ The reported removal rates of nonresorbable plates are as 12–18%, with infection as the major cause in 50–60% of cases.^{18,19}

In 1966, Kullkarni first applied bioresorbable materials for the fixation of maxillofacial bones.²⁰ These plates were made of polymers consisting of varying compositions of polylactic acid (PLA) and polyglycolic acid (PGA). Many problems had been encountered,²¹ such as foreign body reactions and persistence of the material in the body for periods longer than desired. Development of polymer technology and regulation of PLA/PGA ratios make it completely biocompatible, with adequate biomechanical resistance and elimination from body without causing any foreign body reaction. The INION resorbable plates and screws consist of an amorphous injection-molded copolymer of L-lactide/D-lactide/trimethylene carbonate. These plates resorb slowly, maintaining 70% of their strength at 9–14 weeks, and losing their strength steadily thereafter. There is a 42% bulk resorption at 40 weeks and then complete resorption by 2–4 years. The mechanism of plate and screw resorption is hydrolysis of the long polymer chains into

shorter water-soluble fragments and then metabolism via Krebs cycle and excretion as CO₂ and water. This product retains more than 100 MPa of its strength after 6 months and converts into carbon dioxide and water by the process of bulk hydrolysis and absorbs completely in approximately 36–60 months.²² The absorption happens in two phases: hydrolysis and fragmental metabolization.²³ Hydrolysis occurs when body fluids enter the implant and chemically react with the polymer and break the polymer chains. Fragmental metabolization occurs as the polymer continues to fragment until single lactic acid molecules are finally metabolized in the liver into carbon dioxide and water.²⁴

The mechanical strength of bioresorbable plates is weaker than that of metal plates. Through advances in bioengineering and technology, contemporary resorbable plate systems have almost achieved similar strength levels compared to metal plates.

Kallela observed good stability after mandibular advancement and fixation with polylactide biodegradable screws.²⁵ Enislidis successfully used new biodegradable copolymer osteosynthesis system for fixation of zygomatic fractures^{26,27} as absorbable mesh plates for orbital floor²⁸ and craniosynostosis²⁹ due to its easy shaping and application. Turvey used self-reinforced biodegradable bone plates and screws in orthognathic surgery.^{30,31} Self-reinforced poly(L-/DL-)lactic acid copolymer does not require heating before adaptation to bony contours. Even high load-bearing areas, such as the human mandible, can be treated with biodegradable devices under certain circumstances due to their new biomechanical properties. Ylikontiola successfully used them for fixation of anterior mandibular fractures.³²

Ricalde studied the effect of heating on bioresorbable plates.³³ Ferretti³⁴ conducted a prospective trial of poly-L-lactic/PGA copolymer plates and screws for internal fixation of mandibular fractures in 29 patients and observed a 22.5% complication rate, range 13.7–43%. He concluded that PLLA/PGA copolymer plate and screw fixation of mandibular fractures, although technically more challenging and costly, is a viable alternative to traditional metal devices. Yang et al.³⁵ treated 10 patients (6 men, 4 women) with isolated displaced mandibular angle fracture using single or dual resorbable plates. They found resorbable plates suitable for the fixation of isolated mandibular angle fractures. Recently, An et al.³⁶ fixed pediatric mandibular 42 fractures and concluded that the biodegradable fixation devices were safe and efficient. Although osteolysis follows biodegradable fixation of pediatric mandibular fractures, it has no adverse effect on fracture healing.

At present, the most important problem with resorbable plating systems is their high cost. However, their advantages, such as low infection rates and minimization of the need for secondary operations, make them an attractive option. With

newer and cost-effective systems, we believe that they will be preferred more frequently among other options.

5. Conclusion

Based on our study, we conclude that the bioresorbable plate system provides reliable stability for osteosynthesis of mandibular fractures without major complications. Case selection is the key and it should only be used as a load-sharing plate in a semirigid technique after anatomic reduction. However, a long-term follow-up and more cases are needed to confirm these results.

Conflicts of interest

The authors have none to declare.

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