Research Article

Evaluation of Bioabsorbable Plates in Pediatric Maxillofacial Trauma A Comparative Evaluation of Clinical Outcomes, Fracture Stability, Complications, and Advantages Over Titanium Fixation Systems

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ABSTRACT

Background: Management of maxillofacial fractures in children presents unique challenges because of ongoing skeletal growth, developing tooth buds, mixed dentition, and the potential effects of permanent metallic implants on craniofacial development. Conventional titanium plates provide reliable fixation but may require secondary surgery for removal. Bioabsorbable fixation systems have emerged as an alternative that provides temporary mechanical support and gradually degrades within the body.

Aim: To evaluate the clinical efficacy, safety, stability, complications, and advantages of bioabsorbable plates in the management of pediatric maxillofacial trauma.

Materials and Methods: A literature-based review was undertaken using published clinical studies, systematic reviews, and meta-analyses evaluating bioabsorbable fixation systems in patients aged 18 years or younger. Relevant outcome measures included fracture healing, infection, malocclusion, hardware exposure, implant removal, and postoperative complications.

Results: A systematic review of pediatric mandibular fractures involving 232 patients and 269 fractures reported an overall complication rate of 5.2%. Infection occurred in 1.7%, hardware exposure in 1.29%, and malocclusion in 0.43% of cases [1]. A clinical study involving 20 pediatric patients with maxillary fractures reported 100% successful primary fracture healing, with soft-tissue infection in 5% and paresthesia in 10% [2]. A 2026 systematic review and meta-analysis involving 1,584 pediatric patients reported complication rates of 0–11% for resorbable systems and 8–12% for titanium systems [3].

Conclusion: Bioabsorbable plates represent a promising alternative to titanium fixation in selected pediatric maxillofacial fractures, particularly in the upper and middle facial skeleton. Their principal advantage is the elimination of routine implant-removal surgery. However, their lower mechanical strength and higher cost must be considered when selecting an appropriate fixation system.

Keywords: Bioabsorbable plates, pediatric maxillofacial trauma, resorbable fixation, titanium plates, facial fractures, osteosynthesis, craniofacial growth.

INTRODUCTION

Pediatric maxillofacial trauma is an important clinical problem in oral and maxillofacial surgery. Facial fractures in children differ from those in adults because of anatomical, physiological, and developmental characteristics. The pediatric facial skeleton is more elastic, has a relatively higher proportion of cancellous bone, and possesses greater osteogenic potential. Furthermore, the presence of developing tooth buds and active growth centres makes surgical management particularly challenging.

Common causes of pediatric maxillofacial injuries include:

- Road traffic accidents.
- Falls from height.
- Sports-related injuries.
- Accidental household injuries.
- Physical assault.

Conventional titanium miniplates have traditionally been used for open reduction and internal fixation (ORIF). Although titanium provides excellent mechanical strength and stability, it may interfere with subsequent growth, become palpable, or require secondary surgical removal.

Bioabsorbable plates were developed to overcome these limitations. These systems provide temporary stabilization during the initial stages of bone healing and subsequently undergo degradation through hydrolysis and biological resorption.

Their application in pediatric maxillofacial trauma is particularly attractive because they eliminate the need for routine hardware removal and potentially reduce long-term interference with facial growth [4].

AIM AND OBJECTIVES

Aim

To evaluate the clinical effectiveness and safety of bioabsorbable plates in the treatment of pediatric maxillofacial trauma.

Objectives

1. To assess the stability of fractures treated using bioabsorbable plates.
2. To evaluate postoperative complications, including infection, malocclusion, and hardware exposure.
3. To compare bioabsorbable plates with conventional titanium plates.
4. To assess the advantages of bioabsorbable systems in relation to craniofacial growth.
5. To evaluate the need for secondary surgical intervention.
6. To identify the limitations and clinical indications of bioabsorbable fixation.

REVIEW OF LITERATURE

Pediatric maxillofacial trauma

Pediatric facial fractures account for a smaller proportion of facial fractures than adult injuries. The incidence increases with age, particularly during adolescence.

The mandible, maxilla, nasal complex, and zygomatic complex are commonly involved anatomical sites.

Treatment decisions depend on:

- Age of the patient.
- Type and location of fracture.
- Degree of displacement.
- Occlusal disturbance.
- Associated injuries.
- Stage of dental development.

Conservative treatment is preferred whenever adequate functional and anatomical outcomes can be achieved. However, significantly displaced fractures may require surgical fixation.

Bioabsorbable fixation systems

Bioabsorbable plates are manufactured using biodegradable polymer materials.

The commonly used materials include:

Polylactic acid (PLA)

PLA provides relatively prolonged mechanical support and undergoes degradation through hydrolysis.

Polyglycolic acid (PGA)

PGA has a relatively faster degradation profile compared with PLA.

Poly-L-lactic acid (PLLA)

PLLA provides temporary mechanical stability and undergoes gradual degradation.

Poly-DL-lactic acid (PDLLA)

PDLLA is an amorphous polymer used in several resorbable fixation systems.

Composite polymers

Combination systems containing PLLA, PGA, and related polymers are designed to modify mechanical strength and degradation characteristics.

Mechanism of degradation

Bioabsorbable plates undergo degradation primarily through hydrolysis.

The process can be divided into three phases:

Initial phase: The plate provides mechanical stabilization following fracture reduction.

Degradation phase: Water penetrates the polymer structure, causing cleavage of polymer chains and gradual loss of mechanical strength.

Resorption phase: Degradation products are metabolized or eliminated through normal physiological pathways.

The rate of degradation depends on polymer composition, molecular weight, crystallinity, implant dimensions, and local tissue conditions.

Importantly, degradation time and loss of mechanical strength are not identical. Mechanical support may decrease before the material is completely resorbed.

MATERIALS AND METHODS

Study design

This paper is a narrative literature-based review of published clinical evidence. It is not an original prospective clinical trial or a newly conducted meta-analysis.

Literature sources

The following databases and literature sources were considered:

- PubMed/MEDLINE.
- Published clinical studies.
- Systematic reviews and meta-analyses.
- Oral and maxillofacial surgery journals.

Inclusion criteria

- Studies involving patients aged 18 years or younger.
- Studies evaluating bioabsorbable fixation in facial fractures.
- Studies reporting postoperative clinical outcomes.
- Comparative studies involving titanium fixation.
- Systematic reviews and meta-analyses.

Exclusion criteria

- Studies involving only adult patients.
- Experimental studies without clinical outcomes.
- Studies unrelated to maxillofacial trauma.
- Articles without relevant outcome data.

Parameters evaluated

The following clinical parameters were considered:

Parameter	Evaluation
Fracture stability	Clinical and radiographic healing
Infection	Surgical-site infection
Occlusion	Presence of malocclusion
Hardware exposure	Exposure or extrusion of plates
Hardware failure	Breakage or loss of fixation
Nerve injury	Postoperative sensory disturbance
Reoperation	Requirement for secondary surgery
Growth considerations	Potential interference with facial growth

RESULTS

Evidence from published clinical studies

The following studies provide important numerical evidence regarding the clinical performance of bioabsorbable fixation.

Table 1. Summary of published clinical evidence

Study	Sample size	Important findings

Management of pediatric mandibular fractures using resorbable plates [1]	232 patients; 269 fractures	Overall complications: 5.2%
Singh et al. (2023) [2]	20 patients	Primary fracture healing: 100%
Pontell et al. (2021) [4]	736 patients	Complications: 16.7% resorbable vs 27% titanium
Pontell et al. (2022) [5]	1,144 patients	Overall complications: 13%
Rashid et al. (2026) [3]	1,584 patients	Resorbable complications: 0–11%; titanium: 8–12%

Evaluation of postoperative complications

A systematic review involving 232 patients with 269 pediatric mandibular fractures reported the following complications [1]:

Table 2. Complications associated with resorbable plates in pediatric mandibular fractures

Complication	Number of cases	Percentage
Infection	4	1.70%
Hardware exposure	3	1.29%
Wound dehiscence	2	0.86%
Intraoral fistula	2	0.86%
Malocclusion	1	0.43%
Hardware failure	0	0%
Nonunion	0	0%
Revision surgery	0	0%
Total complications	12	5.20%

The findings suggest that resorbable plates provide satisfactory fixation in selected pediatric mandibular fractures, with relatively low complication rates.

An important observation was that patients with multiple fractures had higher complication rates than those with isolated fractures:

- Multiple fractures: 12.5%.
- Isolated fractures: 1.7%.

This suggests that fracture complexity may influence treatment outcomes [1].

Evaluation of bioabsorbable plates in pediatric maxillary fractures

Singh et al. (2023) conducted a clinical study involving 20 pediatric patients with maxillary fractures.

The study used 1.5-mm and 2.0-mm resorbable plates secured using monocortical resorbable screws measuring 6 mm and 7 mm in length.

Patients were followed for six months [2].

Table 3. Clinical findings reported by Singh et al.

Clinical parameter	Reported value

Total patients	20
Male patients	13 (65%)
Female patients	7 (35%)
Falls from height	50%
Road traffic accidents	35%
Maxillary alveolar fractures	40%
Nasal complex fractures	25%
Zygomatic complex fractures	25%
Successful primary fracture healing	100%
Soft-tissue infection	5%
Paresthesia	10%
Follow-up duration	6 months

The authors reported adequate primary fracture healing in all patients.
There was also a significant improvement in postoperative bite force in the incisor and molar regions, accompanied by a reduction in pain and swelling during follow-up [2].
These results indicate that resorbable fixation can be effective in moderately displaced pediatric maxillary fractures.

Comparison between bioabsorbable and titanium plates
Pontell et al. (2021) evaluated upper and midfacial fractures in pediatric patients.
Their analysis included 736 patients:

- Resorbable fixation: 299 patients.
- Titanium fixation: 437 patients.

The overall complication rate was 22.8%.
The titanium group demonstrated a significantly higher complication rate than the resorbable group [4].

Table 4. Comparison of resorbable and titanium fixation

Parameter	Resorbable plates	Titanium plates
Number of patients	299	437
Overall complication rate	16.7%	27.0%
Elective hardware removal	0%	87.3%
Difference in complication rate	-	10.3 percentage points
Statistical significance	P < 0.01	P < 0.01

The difference in complication rates was statistically significant (P less than 0.01). Elective hardware removal was also significantly more frequent in the titanium group (P less than 0.01) [4].
These results support the potential benefits of resorbable plates in pediatric upper and midfacial fractures.

Recent systematic review and meta-analysis (2026)

Rashid et al. published a systematic review and meta-analysis in 2026 involving 1,584 pediatric patients from six retrospective studies [3].

The findings included:

- Resorbable fixation complication rates: 0–11%.
- Titanium fixation complication rates: 8–12%.
- Odds ratio for complications with resorbable fixation: 0.42.
- 95% confidence interval: 0.12–1.48.
- P value: 0.18.
- Heterogeneity: $I^2 = 52\%$.

The difference in overall complications was not statistically significant.

However, titanium fixation was associated with more frequent hardware removal, with reported removal rates of 15–95%, compared with no secondary hardware-removal surgery reported for resorbable systems in the included studies [3].

This is an important distinction: the evidence supports the advantage of avoiding routine implant removal, but does not establish statistically significant superiority in overall complication rates.

DISCUSSION

Fracture stability

Adequate fracture stability is the primary requirement for successful osteosynthesis. Bioabsorbable plates provide temporary fixation during the initial stages of bone healing. They are generally used as load-sharing devices rather than as high-strength load-bearing implants.The 100% primary healing rate reported in the study by Singh et al. demonstrates their potential effectiveness in selected maxillary fractures [2].Similarly, the systematic review of pediatric mandibular fractures reported no hardware failure or nonunion among 232 patients [1].However, the mechanical strength of bioabsorbable plates is lower than that of titanium plates. Therefore, their use should be carefully considered in fractures subjected to significant functional loading.

Effect on craniofacial growth

One of the most important advantages of bioabsorbable fixation is the possibility of reducing long-term interference with skeletal growth.Titanium plates may remain in the facial skeleton for several years. Depending on their anatomical location, they may potentially interfere with developing structures or require removal.Bioabsorbable plates gradually degrade, eliminating the need for permanent metallic implants.However, it is important to recognize that the clinical evidence demonstrating improved long-term facial growth following resorbable fixation remains limited.Therefore, their growth-related benefits should be considered biologically plausible and clinically attractive, rather than conclusively proven.

Complication profile

Common complications associated with bioabsorbable fixation include:

- Surgical-site infection.
- Plate exposure.
- Wound dehiscence.
- Local inflammatory reactions.
- Transient sensory disturbances.
- Foreign-body reactions.
- Loss of fixation in mechanically demanding fractures.

The mandibular systematic review reported an overall complication rate of 5.2% [1].The low incidence of serious complications supports their use in selected pediatric patients. Nevertheless, inflammatory reactions related to polymer degradation and implant palpability should be considered during postoperative follow-up.

Advantages over titanium plates

Table 5. Comparative advantages and disadvantages

Feature	Bioabsorbable plates	Titanium plates
Biodegradability	Yes	No

Permanent implant	No	Yes
Secondary removal	Usually unnecessary	Sometimes required
Mechanical strength	Relatively lower	Higher
Growth considerations	Potential advantage	Potential interference
Radiographic artefact	Generally lower	Can produce artefact
Cost	Generally higher	Variable
Load-bearing capacity	Limited	Excellent
Risk of palpability	Possible	Possible
Long-term implant retention	No	Yes

Limitations of bioabsorbable fixation

Despite their advantages, bioabsorbable systems have several limitations.

1. Lower mechanical strength

They may not provide adequate stability in severely displaced or high-load mandibular fractures.

2. Cost

The cost of bioabsorbable fixation systems can be higher than conventional titanium systems, particularly in resource-limited healthcare settings.

3. Technical sensitivity

Some systems require specific heating, moulding, or adaptation procedures before fixation.

4. Degradation-related reactions

Local inflammatory responses may occur during polymer degradation.

5. Limited long-term evidence

There is insufficient high-quality evidence regarding long-term craniofacial growth, occlusal development, and the effects of polymer degradation in children.

CLINICAL INDICATIONS

Bioabsorbable plates may be considered in the following situations:

- Moderately displaced maxillary fractures.
- Selected zygomatic complex fractures.
- Pediatric upper and midfacial fractures requiring internal fixation.
- Selected non-load-bearing mandibular fractures.
- Fractures in anatomically sensitive areas where permanent hardware is undesirable.

Titanium fixation may remain preferable in:

- Severely displaced mandibular fractures.
- Comminuted fractures requiring stronger fixation.
- Fractures involving significant functional loading.
- Cases where reliable rigid fixation cannot be achieved with resorbable systems.

The final choice should depend on fracture pattern, patient age, bone quality, dental development, and surgeon experience.

LIMITATIONS OF THE AVAILABLE EVIDENCE

The current literature has several limitations:

1. Most available studies are retrospective observational studies.
2. The sample sizes of individual clinical studies are relatively small.
3. Follow-up periods are often insufficient to assess long-term facial growth.
4. Different polymer compositions and fixation systems are used across studies.
5. There is considerable variation in fracture location and severity.

6. Cost-effectiveness data are limited.
7. Randomized controlled trials directly comparing resorbable and titanium plates are lacking.

Consequently, the available findings should be interpreted cautiously.

FUTURE SCOPE

Future research should focus on:

- Prospective comparative clinical trials.
- Long-term assessment of craniofacial growth.
- Standardized evaluation of postoperative complications.
- Comparison of different polymer compositions.
- Evaluation of degradation-related inflammatory reactions.
- Cost-effectiveness analysis in developing countries.
- Assessment of functional outcomes, including bite force and occlusion.

A multicentre prospective study with a minimum follow-up of 2–5 years would provide valuable evidence regarding the long-term safety and effectiveness of bioabsorbable fixation in pediatric patients.

CONCLUSION

Bioabsorbable plates have emerged as a promising alternative to conventional titanium fixation systems in pediatric maxillofacial trauma.The available clinical evidence demonstrates satisfactory fracture stability and healing, with relatively low complication rates in appropriately selected cases.Their most significant advantage is the elimination of routine secondary surgery for implant removal. Additionally, their gradual degradation may reduce the long-term presence of foreign material in the growing facial skeleton.

Published studies have reported complication rates of approximately 5.2% in pediatric mandibular fractures and successful primary healing in 100% of patients in one small pediatric maxillary fracture study [1,2].Recent comparative evidence also suggests that resorbable systems provide clinical outcomes comparable to titanium fixation, although statistically significant superiority in overall complication rates has not been established [3].Therefore, bioabsorbable plates can be considered an effective treatment option for selected pediatric maxillofacial fractures, particularly in the upper and middle facial skeleton. However, titanium fixation continues to have an important role in fractures requiring greater mechanical strength.Further prospective studies with larger sample sizes and longer follow-up are necessary to establish definitive clinical guidelines.

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