RESEARCH PAPER

Biodegradable Osteosynthetic Systems in Maxillofacial Surgery: A Review of Materials, Clinical Applications, and Future Directions

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ABSTRACT

Maxillofacial fractures and orthognathic surgical procedures necessitate internal fixation that is sufficiently rigid to ensure stable reduction and healing of the bony segments. Titanium has historically been regarded as the gold standard material for osteosynthetic fixation owing to its superior mechanical strength, biocompatibility, and corrosion resistance. However, the inherent limitations of titanium—including the necessity for a second surgical procedure for plate removal, thermal sensitivity, interference with radiographic imaging, growth restriction in paediatric patients, and the risk of stress-shielding-related bone resorption—have prompted sustained research interest in biodegradable alternatives. Bioresorbable osteosynthetic systems, fabricated predominantly from polymer families including polyglycolic acid (PGA), poly-L-lactic acid (PLLA), poly-DL-lactic acid (PDLA), and their co-polymers (PLGA), offer the compelling advantage of gradual degradation and absorption within the body, thereby eliminating the need for a second operation. Third-generation materials, such as uncalcined/unsintered hydroxyapatite/poly-L-lactide (uHA/PLLA) composites, further augment these properties by incorporating osteoconductivity and bioactivity alongside resorbability. A Cochrane systematic review and multiple prospective clinical studies have demonstrated comparable outcomes between bioresorbable and titanium fixation systems in terms of complication rates, infection, temporomandibular joint dysfunction, paraesthesia, and relapse. Biodegradable systems are particularly advantageous in paediatric maxillofacial surgery, where metallic implants risk impeding mandibular growth and necessitate mandatory removal. Although current biodegradable systems exhibit limitations including reduced mechanical strength, higher susceptibility to screw breakage, and occasional foreign body inflammatory reactions, ongoing material science advancements are progressively addressing these shortcomings. This review comprehensively examines the historical development, polymer composition, mechanical properties, clinical applications, complications, and future perspectives of biodegradable osteosynthetic armamentarium in oral and maxillofacial surgery, with emphasis on its potential to replace conventional titanium and steel systems.

Keywords: biodegradable plates and screws, titanium osteosynthesis, bioresorbable fixation, maxillofacial fractures, orthognathic surgery, PLLA, PLGA, uHA/PLLA, paediatric management, internal fixation.

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INTRODUCTION

Oral and maxillofacial surgery encompasses a wide spectrum of interventions ranging from the management of traumatic facial fractures to elective orthognathic osteotomies for the correction of dentofacial deformities. In all such procedures, internal fixation of bony segments is fundamental to achieving stable anatomical reduction, optimal osseous healing, and satisfactory functional and aesthetic outcomes.[1] Historically, the introduction of metal plates and screws represented a paradigm shift in the surgical management of maxillofacial injuries, transforming outcomes that were previously achievable only through prolonged maxillomandibular fixation. The advent of titanium as the preferred metallic fixation material further consolidated this transformation, owing to its combination of high tensile strength, excellent biocompatibility, osseointegration potential, and resistance to corrosion.[1]

Despite these merits, titanium implants present clinically significant limitations. Chief among these is the frequent requirement for a secondary surgical procedure to remove the hardware following complete osseous consolidation—a step that imposes additional anaesthetic risk, surgical morbidity, prolonged recovery, and economic burden upon the patient.[2] Furthermore, titanium plates in the craniofacial region are susceptible to palpability and occasional visibility beneath thin soft tissue coverage, thermal sensitivity to temperature extremes, interference with radiographic modalities such as computed tomography (CT) and magnetic resonance imaging (MRI), and the well-documented phenomenon of stress shielding, whereby the mechanical load borne by the implant reduces the mechanical stimulation of the healing bone, potentially leading to bone atrophy.[3] In the paediatric population, these limitations are compounded further: metallic fixation may physically impede the natural growth trajectory of the developing facial skeleton, making implant removal not merely optional but often mandatory.[4]

The development and clinical adoption of bioresorbable osteosynthetic systems has emerged directly in response to these limitations. Bioresorbable materials, utilised in surgery for decades in the form of suture materials and guided tissue regeneration membranes, have progressively been engineered into structurally competent plate-and-screw fixation systems capable of providing the stability required for facial fracture management and orthognathic surgery.[1] The defining characteristic of these materials is their capacity for gradual, predictable degradation through hydrolysis and subsequent metabolic absorption, such that they are ultimately eliminated from the body without residual implant burden.[5] As the implant resorbs, the mechanical load is incrementally transferred back to the regenerating bone a process considered physiologically advantageous for promoting bone remodelling and long-term skeletal stability.[6]

Comparative studies and systematic reviews have now accumulated sufficient evidence to indicate that bioresorbable fixation produces clinical outcomes broadly comparable to those of titanium in a range of maxillofacial applications.[7] A landmark Cochrane review demonstrated no statistically significant difference between resorbable and titanium plates in orthognathic surgery with respect to overall complication rates, relapse, infection, and neurosensory disturbances.[7] While biodegradable systems are not yet universally applicable across all fixation scenarios, they represent a rapidly evolving and clinically viable alternative for selected indications. The purpose of this review is to provide a comprehensive, updated synthesis of the properties, applications, limitations, and future directions of biodegradable osteosynthetic armamentarium in oral and maxillofacial surgery.

HISTORICAL DEVELOPMENT OF BIODEGRADABLE FIXATION

The concept of biodegradable internal fixation in surgery dates to the early 1960s, when the first clinical use of polyglycolic acid (PGA) sutures was reported. However, the application of bioresorbable materials as rigid fixation devices in craniomaxillofacial surgery was pioneered by Bos et al. in 1987, who first demonstrated the feasibility of poly-L-lactide (PLLA) plates and screws for the fixation of zygomatic fractures.[8] This landmark work validated the concept that polymer-based devices could provide sufficient mechanical stability for facial fracture repair and laid the foundation for subsequent material development and broader clinical application. Following this, the technique was rapidly extended to other regions of the craniomaxillofacial skeleton, including the orbit, cranial vault, midface, and eventually the mandible.[9]

The first generation of bioresorbable fixation devices was primarily composed of pure homopolymers—predominantly high-molecular-weight PLLA—which, while mechanically competent, degraded slowly (over several years) and were associated with delayed foreign body inflammatory reactions triggered by the crystalline degradation particles.[10] Recognition of these limitations stimulated the development of second-generation copolymers, including poly(L/DL-lactide) and poly(glycolide-co-lactide) (PLGA), which offered faster and more

controlled resorption profiles. By altering the monomer ratio, manufacturers could engineer degradation timelines suited to specific clinical requirements.[9] The third generation of bioresorbable devices, exemplified by uncalcined/unsintered hydroxyapatite reinforced with poly-L-lactide-co-glycolide (uHA/PLLA-co-GA), represents the current frontier, combining mechanical reinforcement with osteoconductive bioactivity to further optimise outcomes in maxillofacial reconstructive surgery.[11]

COMPOSITION OF BIODEGRADABLE PLATES AND SCREWS

Bioresorbable osteosynthetic systems are fabricated from a class of aliphatic polyester polymers that undergo hydrolytic degradation within the physiological environment. The principal polymer families employed in craniomaxillofacial fixation devices include polyglycolic acid (PGA), poly-L-lactic acid (PLLA), poly-DL-lactic acid (PDLA), and their various co-polymers. Each polymer and co-polymer exhibits a distinct combination of mechanical strength, degradation rate, crystallinity, and biocompatibility, rendering their selection application-specific.[6,10]

Polyglycolic acid (PGA) is the simplest aliphatic polyester and was among the earliest biodegradable polymers adopted for surgical use. It possesses a high degree of crystallinity, contributing to its initial mechanical strength. However, this same crystallinity renders PGA highly susceptible to rapid hydrolytic degradation in vivo, with significant strength loss occurring within two to four weeks. This accelerated degradation profile, coupled with the production of acidic byproducts (glycolic acid), limits its standalone utility in maxillofacial fixation, where biomechanical support must be sustained for a minimum of six to twelve weeks.[10] Consequently, PGA is most frequently employed as a copolymer constituent rather than as a pure homopolymer implant material.

Poly-L-lactic acid (PLLA) is the most widely studied and clinically utilised polymer for rigid bioresorbable fixation. Its semicrystalline structure confers higher initial mechanical strength compared to PGA, and its degradation profile is substantially slower—occurring over a period of two to five years which ensures prolonged mechanical support during the osseous healing phase.[10] The major limitation of pure PLLA is the generation of crystalline degradation particles during the later stages of resorption, which may elicit a delayed sterile foreign body inflammatory response characterised by localised swelling and osteolysis.[12] Poly-DL-lactic acid (PDLA), the racemic form of polylactic acid, is amorphous in structure and therefore degrades more predictably and uniformly than PLLA. PDLA demonstrates excellent biocompatibility across all regions of the facial skeleton, including the mid-face and mandible, and its amorphous nature reduces the risk of crystalline particle-mediated inflammatory reactions.[2] Despite these advantages, its more rapid degradation profile compared to PLLA means that adequate mechanical strength must be achieved through appropriate implant thickness and design geometry.

The resultant co-polymer of PGA and PLA poly(lactic-co-glycolic acid) (PLGA) spans a broad spectrum of mechanical and degradation properties depending on the molar ratio of its constituent monomers. PLGA polymers are highly resorbable, with degradation timelines tunable from weeks to years, and are produced in a full formulation range suited to various clinical demands.[10] The second-generation copolymers, including poly(L/DL-lactide) blends (e.g., 70:30 PLLA/PDLA), represent the current clinical standard for most bioresorbable craniofacial fixation systems, offering a balance between mechanical performance and resorption kinetics.[9]

Most recently, the infusion of uncalcined/unsintered hydroxyapatite (uHA) nanoparticles into PLLA or PLLA-co-GA matrices has produced composite implants with enhanced mechanical properties and intrinsic osteoconductive bioactivity, representing the third generation of bioresorbable maxillofacial fixation devices.[9,11]

PROPERTIES OF THE CONSTITUENT POLYMERS

Polyglycolic Acid (PGA)

Polyglycolic acid is characterised by its high degree of molecular crystallinity and elevated molecular weight, which confer notable initial rigidity. However, its rapid hydrolytic degradation in the physiological environment results in a precipitous loss of mechanical strength within two to four weeks, far shorter than the six to twelve weeks typically required for consolidation of maxillofacial fractures.[10] The acidic metabolic byproduct (glycolic acid) may accumulate at the implant site during rapid degradation, lowering local pH and potentially triggering an inflammatory tissue response. These characteristics restrict PGA to applications requiring only short-term fixation, such as suture materials and membrane applications, or as a constituent of PLGA co-polymers where its degradation rate can be modulated.

Poly-DL-Lactic Acid (PDLA)

PDLA is an amorphous, highly biocompatible polymer suitable for fixation across the entire facial region, including the peri-orbital, midface,

and mandibular zones. Its amorphous microstructure facilitates uniform, predictable hydrolytic degradation without the generation of crystalline particles, thereby reducing the risk of late-onset foreign body reactions.[2] A notable advance attributed to Japanese material engineering was the reformulation of PDLA devices from thick and flexible configurations to thin, stiff plates better suited to anatomically prominent and palpable craniofacial regions such as the periorbital rim and frontozygomatic process, where inadvertent hardware visibility had previously been a clinical concern.[13]

Poly-L-Lactic Acid (PLLA)

PLLA remains the most clinically widespread bioresorbable polymer for rigid maxillofacial fixation. Its semicrystalline nature endows it with high initial tensile and flexural strength comparable, in optimised formulations, to cortical bone. Degradation occurs over two to five years through bulk hydrolysis, providing sustained mechanical support well beyond the fracture consolidation period.[10] The principal clinical concern with pure PLLA is the potential for a delayed sterile inflammatory reaction occurring one to three years postoperatively, coinciding with the phase of accelerated crystalline particle release. This phenomenon, although self-limiting in most cases, may manifest as localised soft tissue swelling, osteolytic lesions on radiography, and occasional hardware failure. Second-generation copolymers have substantially mitigated this risk through the introduction of amorphous co-monomers that suppress crystalline phase separation during degradation.[14]

Second-Generation Co-polymers: PLGA and Poly(L/DL-Lactide)

Second-generation copolymers such as PLGA and poly(L/DL-lactide) blends represent a deliberate engineering response to the limitations of first-generation homopolymers. By varying the glycolide-to-lactide ratio or the L-to-DL-lactide ratio, degradation rates and mechanical profiles can be precisely tailored. These copolymers resorb more rapidly than pure PLLA while maintaining adequate short-term mechanical competence, and their amorphous or partially amorphous microstructure reduces crystalline particle generation.[9] In clinical practice, a 70:30 poly(L/DL-lactide) composition has demonstrated a favourable balance between early structural rigidity and complete resorption within 12–18 months, making it the preferred formulation in many commercially available bioresorbable plate-and-screw systems.

Third-Generation Composite: uHA/PLLA

Uncalcined/unsintered hydroxyapatite (uHA) reinforced PLLA composites represent the state of the art in bioresorbable maxillofacial fixation. The incorporation of uHA nanoparticles into the PLLA matrix significantly enhances the flexural strength and rigidity of the composite, partially bridging the mechanical performance gap with titanium. More importantly, uHA confers intrinsic osteoconductive bioactivity: as the polymer matrix degrades, uHA particles are progressively released at the bone–implant interface, stimulating new bone formation and facilitating faster osseous consolidation.[9,11] The bioactive regeneration potential of uHA/PLLA-co-GA has been demonstrated in in vivo maxillofacial reconstructive studies, confirming superior bone–implant integration compared to conventional PLLA systems.[11]

MECHANICAL PROPERTIES: BIODEGRADABLE VERSUS TITANIUM

A critical determinant of the clinical applicability of any osteosynthetic system is its mechanical performance under physiological loading conditions. Titanium alloy (Ti-6Al-4V) used in maxillofacial fixation exhibits a Young's modulus of approximately 110 GPa and ultimate tensile strength exceeding 900 MPa, far surpassing the requirements of craniofacial osteosynthesis. In contrast, bioresorbable polymers and composites exhibit substantially lower moduli, necessitating compensatory design adaptations including increased plate thickness and modified screw geometry.[6] A comparative biomechanical study confirmed that biodegradable plates and screws demonstrated significantly lower mechanical properties than titanium counterparts under identical in vitro loading conditions; however, both systems provided clinically adequate stability for low-to-moderate biomechanical demand zones of the craniofacial skeleton.[6,15]

Property	Titanium (Ti-6Al-4V)	PLLA / Co-polymer	uHA/PLLA Composite
Young's Modulus	~110 GPa	2–4 GPa	4–8 GPa
Tensile Strength	>900 MPa	50–80 MPa	80–120 MPa
Degradation	Non-degradable	2–5 years (PLLA)	1–3 years
Radiolucency	Radiopaque (artefact)	Radiolucent	Radiolucent
Second surgery needed	Often required	Not required	Not required
Osteoconductivity	Absent	Absent	Present (uHA particles)

CLINICAL SIGNIFICANCE IN MAXILLOFACIAL FRACTURE MANAGEMENT

The primary and most clinically significant application of bioresorbable osteosynthetic implants is the stabilisation of maxillofacial fractures. The facial skeleton is particularly well suited to the use of biodegradable fixation because its fracture sites are generally accessible to surgical approach, and the biomechanical demands of facial bones—excepting the mandible in functional loading zones—are comparatively lower than those of the long bones of the appendicular skeleton.[13] As such, the mechanical limitations of bioresorbable systems are less consequential in many craniofacial applications than they would be in load-bearing orthopaedic contexts. Bioresorbable plates and screws have been demonstrated to produce reliable outcomes in the fixation of zygomatic, orbital, frontal, and midface fractures. Kang et al. conducted a prospective comparison of titanium and biodegradable miniplates in midfacial fractures and reported no significant difference in clinical outcomes, complication rates, or patient satisfaction between the two groups, concluding that biodegradable fixation represents a viable alternative to titanium for midfacial fracture repair.[13] Bell and Kindsfater documented their institutional experience with bioresorbable plates and screws across a spectrum of facial fractures, demonstrating satisfactory stability and low complication rates, and advocating for their use as an alternative to titanium in craniomaxillofacial trauma.[9] In Le Fort I fractures, bilateral stabilisation with four L-shaped bioresorbable plates at the pyriform aperture and zygomatic buttress has produced reliable results, with bioresorbable mesh also demonstrating efficacy in orbital floor reconstruction.[2] Bhatt et al. evaluated biodegradable plating in a prospective cohort of maxillofacial fracture patients, confirming adequate stability and acceptable inflammatory complication profiles, thereby supporting their use in routine maxillofacial trauma management.[16]

CLINICAL SIGNIFICANCE IN ORTHOGNATHIC SURGERY

Orthognathic surgery involves the osteotomy and three-dimensional repositioning of maxillary and/or mandibular segments to correct skeletal discrepancies producing dentofacial deformities. Stable fixation of the osteotomy segments in their predetermined positions is critical for achieving the planned functional and aesthetic correction and for preventing postoperative skeletal relapse.[1] Bioresorbable fixation systems have been extensively evaluated as alternatives to titanium for Le Fort I maxillary osteotomies, bilateral sagittal split ramus osteotomies (BSSRO), and genioplasties. A Cochrane systematic review by Agnihotry et al. examining resorbable versus titanium plates for orthognathic surgery found no statistically significant differences in overall clinical outcomes between the two modalities. Subgroup analyses comparing complication rates, infection, temporomandibular joint disorders, paraesthesia, palpability, dehiscence, material-related complications, implant exposure, and postoperative relapse revealed similar rates in both groups.[7] In BSSRO specifically, a recent meta-analysis demonstrated no significant difference between biodegradable and titanium plate fixation, reinforcing the equivalence of bioresorbable systems for this technically demanding procedure.[2] Turvey et al. reported satisfactory clinical outcomes using self-reinforced biodegradable bone plates and screws in a series of orthognathic surgical cases, noting particular benefits in avoiding the need for hardware removal surgeries which are routinely performed in many centres using titanium fixation.[1] The primary advantage of bioresorbable fixation in orthognathic surgery is precisely the elimination of this planned second intervention, which carries its own risks of nerve injury, surgical site infection, and anaesthetic morbidity.

CLINICAL SIGNIFICANCE IN PAEDIATRIC MANAGEMENT

The paediatric maxillofacial skeleton presents unique biological and anatomical characteristics that make the case for bioresorbable fixation particularly compelling. The developing facial skeleton is characterised by ongoing active growth, thin cortical bone, densely packed tooth follicles and unerupted dentition in the mandible and maxilla, and a substantially higher inherent healing capacity compared to the adult skeleton. These features render conventional titanium fixation both technically challenging and potentially deleterious in children.[4] Metallic implants in the growing facial skeleton carry a documented risk of impeding sutural and condylar growth, producing facial asymmetry, skeletal dysharmony, and dentofacial deformity that may require extensive corrective procedures. Consequently, the removal of titanium fixation hardware is routinely recommended following paediatric maxillofacial surgery, necessitating a second anaesthetic and operation.[4] Bioresorbable fixation eliminates this second procedure entirely by virtue of its gradual resorption into biocompatible metabolic products. An et al. conducted a retrospective review of biodegradable plate application for paediatric mandibular fractures and reported reliable fracture healing, satisfactory occlusal outcomes, and no adverse effects on mandibular growth trajectory, thereby validating bioresorbable fixation as the preferred approach for children.[4] A prospective study on biodegradable fixation of paediatric mandibular fractures confirmed that osteolysis, while a recognised sequela, did not adversely affect fracture healing and resolved spontaneously in all cases.[4] Early institutional experience with biodegradable fixation in paediatric craniofacial surgery further demonstrated that bioresorbable plates and screws provided adequate stability for cranial vault remodelling procedures and mid-facial fracture

repair, with outcomes comparable to those of titanium counterparts.[14]

The mandible is the most commonly fractured bone of the facial skeleton in children, typically managed with open reduction and internal fixation when displacement is significant. Lee et al. conducted a comparative study of titanium and biodegradable miniplates for mandibular fracture fixation and demonstrated equivalent efficacy in terms of fracture stability, complication rates, and functional recovery, supporting the use of bioresorbable systems as the first-line fixation approach in the paediatric mandible.[12] A biomechanical evaluation of titanium versus PLLA trapezoidal plates for subcondylar fracture fixation confirmed that while PLLA plates exhibited lower initial stiffness than titanium, both constructs provided clinically acceptable stability under simulated functional loading, with PLLA systems offering the critical additional advantage of gradual stress transfer to the regenerating bone.[15]

COMPLICATIONS AND THEIR MANAGEMENT

Despite their clinical advantages, bioresorbable osteosynthetic systems are associated with a characteristic spectrum of complications that must be understood and anticipated by the operating surgeon. These may be categorised as early (perioperative and immediate postoperative) or late (occurring during the degradation phase). Early complications include perioperative screw breakage during insertion, which occurs at a higher rate than with titanium screws due to the lower shear strength and brittleness of polymer-based screws. Most bioresorbable systems require pre-drilling of a pilot hole to reduce screw insertion torque and minimise breakage risk.[7] This additional drilling step prolongs operative time compared to titanium placement and requires precise technique. Screw head stripping, plate cracking during contouring, and inadequate initial fixation rigidity are other perioperative concerns specific to bioresorbable systems.[6]

Late complications are predominantly related to the degradation process itself. Aseptic (sterile) foreign body inflammatory reactions represent the most clinically significant delayed complication, occurring in approximately 1–10% of cases depending on the polymer used and the patient population.[10] These reactions typically manifest six months to several years postoperatively as localised erythema, swelling, and sinus tract formation overlying the implant site, without microbiological evidence of infection. Histologically, a granulomatous reaction with multinucleated giant cells surrounding polymer degradation particles is observed. The incidence of this complication is highest with first-generation crystalline homopolymers (pure PLLA) and substantially reduced with second-generation amorphous copolymers.[10] Management typically consists of conservative observation, as most reactions resolve spontaneously; persistent or symptomatic cases may require curettage and irrigation of the affected site. Osteolytic reactions—cystic bone changes adjacent to degrading implants—have been reported, particularly in paediatric cases, and generally resolve without clinical consequence once degradation is complete.[4] Implant palpability, while less problematic than with titanium (given eventual resorption), may be transiently noticeable in anatomically prominent regions such as the frontal or zygomatic areas during the early postoperative period. Comparative analyses between biodegradable and titanium fixation confirm that, beyond these specific polymer-related phenomena, overall complication profiles—including infection, wound dehiscence, and malocclusion—are statistically equivalent between the two systems.[7]

FUTURE PERSPECTIVES AND THIRD-GENERATION MATERIALS

The trajectory of bioresorbable osteosynthetic development is directed towards systems that not only provide temporary mechanical support and degrade safely, but that actively participate in bone regeneration—transforming passive spacers into bioactive scaffolds. Third-generation materials, particularly uHA/PLLA and uHA/PLLA-co-GA composites, represent the closest current realisation of this aspiration. The uncalcined/unsintered form of hydroxyapatite is uniquely characterised by its nanoscale particle size, high surface area, and preserved surface reactivity—properties that facilitate superior osseointegration compared to conventional sintered hydroxyapatite ceramics.[9,11] Experimental and early clinical data confirm that uHA/PLLA composite implants demonstrate bioactive new bone formation at the implant–bone interface, superior mechanical integration, and enhanced postoperative bone density compared to plain PLLA devices.[11]

Beyond material composition, future advances in bioresorbable fixation are anticipated across several domains. Smart degradation control, achieved through the engineering of copolymer ratios and nanocomposite architectures, will allow degradation timelines to be precisely calibrated for specific anatomical sites and patient populations. The incorporation of osteoinductive growth factors—such as bone morphogenetic proteins (BMPs) or platelet-derived growth factor (PDGF)—within the polymer matrix represents a promising avenue for producing drug-eluting biodegradable fixation devices that actively promote bone formation at the fixation site.[5] Three-dimensional (3D) printing technologies are beginning to enable patient-specific bioresorbable implants fabricated from PLLA and related polymers, potentially extending the applicability of biodegradable fixation to complex reconstructive scenarios currently dominated by custom titanium prostheses. Reduction of the inflammatory foreign body reaction through surface functionalisation and the use of biocompatibility-optimised polymer formulations remains a priority

research objective.[2] The development of composite systems that synergistically combine the compressive strength of calcium phosphate ceramics with the flexibility of PLLA matrices may ultimately yield bioresorbable implants capable of reliably withstanding the biomechanical demands of mandibular and condylar fixation—currently the most challenging frontier for biodegradable osteosynthetic systems.

CONCLUSION

Biodegradable osteosynthetic armamentarium has undergone remarkable evolution since its introduction to maxillofacial surgery in 1987 and has established itself as a clinically viable and evidence-supported alternative to titanium fixation for a defined and growing range of indications. The fundamental advantage of bioresorbable plates and screws—their gradual, predictable degradation and absorption within the body, precluding the need for implant removal surgery—constitutes a clinically meaningful benefit for both patients and surgeons, reducing operative morbidity, anaesthetic exposure, and healthcare costs.

The progressive development from first-generation homopolymers (PLLA, PGA) through second-generation copolymers (PLGA, poly(L/DL-lactide)) to third-generation bioactive composites (uHA/PLLA) has substantially addressed the early limitations of bioresorbable systems, improving mechanical strength, reducing foreign body inflammatory complications, and adding osteoconductivity. Comparative clinical studies and systematic reviews, including a Cochrane review, consistently demonstrate equivalent clinical outcomes between bioresorbable and titanium fixation for craniofacial fractures, midface trauma, and orthognathic surgery, with complication profiles that are broadly comparable.

The advantages of bioresorbable fixation are particularly pronounced in paediatric maxillofacial surgery, where avoidance of growth-restricting metallic implants and elimination of mandatory hardware removal surgeries represent compelling clinical imperatives. As the evidence base for bioresorbable systems matures and as third-generation composite materials approach clinical implementation, the potential for biodegradable armamentarium to progressively replace titanium as the standard of care across a broader spectrum of maxillofacial applications becomes increasingly plausible. Future research priorities should focus on further reducing inflammatory tissue reactions, improving mechanical strength for high-load applications, developing bioactive drug-eluting formulations, and establishing the role of patient-specific 3D-printed bioresorbable implants in complex maxillofacial reconstruction. With continued refinement, biodegradable armamentarium is poised to fulfil its promise as the preferred fixation modality for oral and maxillofacial surgery in the foreseeable future.

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