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Use of bioresorbable plating systems in paediatric mandible fractures

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ABSTRACT

Aim: The aim of this study is to retrospectively evaluate the use of bioresorbable plating systems in the rigid fixation of paediatric mandible fractures.
Patients and methods: Our series consists of fifteen paediatric patients (11 male, 4 female, average age 8.13 years) with mandible fractures of varying severity treated with bioresorbable plates over a 54-month period at our institution. Fractures of the ramus, body, parasymphysis, and symphysis were treated by one surgeon with open reduction and internal fixation with 1.5 mm and 2 mm resorbable plates and monocortical screws, using 3 different plating systems, each with differing polymer concentrations of polyglycolic and poly-L-lactic acid. The patients were followed with respect to the following clinical categories: fracture location, postoperative occlusion, maximum interincisal opening (MIO), segmental mobility at the fracture site, and any abnormal swelling at the operative site.
Results: Our data shows a stable occlusion and maximum interincisal opening of thirty millimetres or greater was achieved in 14 of 15 patients seen in follow up, with 8 patients having an MIO of 40 mm or greater. No segmental mobility noted at any of the fracture sites. Thirteen patients had no postoperative sequelae or implant related complications. Two patients developed a seroma-like collection at the operative site. Postoperative films starting at 1 year showed significant bony osseous fill where the previous screw sites were located.
Conclusions: In our case series we found that the use of resorbable polyglycolic and poly-L-lactic acid plating systems when combined with a brief postoperative period of intermaxillary fixation is an effective method of internal fixation for mandibular fractures in the paediatric population.

1. Introduction

Mandibular trauma in the paediatric patient population presents the unique challenge of achieving a balance between the advantages of rigid fracture fixation and the risks involved with the use of metallic alloplastic material in the growing child with a developing mixed dentition. The ideal properties of an implant material for fracture fixation are biocompatibility, strength, ductility, and those that are easily adaptable to the bone surface (Imola et al., 2001). Titanium's unique properties of biocompatibility, strength, and ductility has made in the standard of care in the rigid fixation of traumatic mandibular fractures deemed by the surgeon to require operative intervention (Siy et al., 2011).

While biocompatibility is necessary, the retention of titanium based hardware used for fracture fixation is less than desirable especially in the paediatric population. The disadvantages associated with titanium based hardware include growth disturbances in children, chronic pain or infection, migration of hardware, temperature sensitivity, and interference with diagnostic imaging techniques (Manson, 1991; Murthy and Lehman, 2005; Tatum, 2012). Studies of the use of titanium implants in craniofacial trauma found that over 20% of cases resulted in complications including delayed/restricted growth, screw migration, and chronic postoperative pain which led to an 8% rate of reoperation for plate removal (Berryhill et al., 1999). As a result of these complications, some investigators have suggested routine removal of metal fixation once stable osteosynthesis has been achieved (Izuka and Lindquist, 1992; Bos et al., 1987; Persing, 1997). In a study by Iatrou et al., they advocated the removal of titanium hardware in all his paediatric study patients (Iatrou et al., 2010).

In the paediatric population surgeons have increasingly experimented with the use of bioresorbable fixation techniques. The major benefits of biosorbable implants include the avoidance of the risk of intracranial migration and growth interference as the

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paediatric craniofacial skeleton expands (Goldberg et al., 1995). Continuous efforts are being made to develop bioresorbable materials with improved ease of use and improved biomechanical strength for fracture fixation. Existing studies have shown that current resorbable plating systems provide flexural and tensile strength comparable to the microplate titanium systems, and resorbable plates and screws are considered to provide adequate immobilization for the fixation of upper and middle facial fractures (Wittenberg et al., 1991; Iatrou et al., 2010). However, mandibular fractures present a unique situation in which current resorbable plates may lack the necessary stability to counteract masticatory forces. This case series demonstrates our experiences with multiple resorbable plating systems in the treatment of paediatric mandibular trauma, their benefits over conventional metallic rigid fixation, and addresses some of the perceived shortcomings of bioresorbable plating systems.

2. Materials and methods

Our series consists of fifteen paediatric patients (11 male, 4 female, average age 8.13 years) with mandible fractures of varying severity treated with bioresorbable plates over a 54-month period at our institution. Our patient population sustained fractures as identified in Table 1 with the majority of cases involving the symphyseal/parasymphyseal region. The patients were followed with respect to the following clinical categories: fracture location, postoperative occlusion, maximum interincisal opening (MIO), segmental mobility at the fracture site, and any abnormal swelling at the operative site. Postoperative radiographic evaluation with panoramic films was also performed, with particular attention to the adequacy of the reduction and any new pathology that had developed postoperatively. The study was approved by the University of Pennsylvania institutional review board protocol #818240. The study was fully compliant with the World Medical Association Declaration of Helsinki on medical research protocols and ethics.

Fractures of the ramus, body, parasymphysis, and symphysis were treated by one surgeon with open reduction and internal fixation with 1.5 mm and 2 mm resorbable plates and monocortical screws, using 3 different plating systems, each with differing polymer concentrations of polyglycolic and poly-L-lactic acid (Table 1). The procedures were performed under general anaesthesia. Patients were first placed in intermaxillary fixation in standard fashion using Erich Arch Bars or Risdon wires or with skeletal fixation using circumandibular wires and either piriform rim wires or zygomatic arch wires. The fractures were typically exposed via an intraoral approach and after the fracture was identified and adequately reduced, a 1.5 or 2 mm resorbable plate was heated in a water bath and adapted to the fracture site (Figs. 3 and 4). A drill bit was used to place the monocortical screw holes, and a hand-held tap completed the width of the holes to accommodate the threads. Resorbable screws were then placed, typically 4 mm in length, on opposite sides of the fracture and are inserted until flush with the plate (Figs. 3 and 4). Typically, at least two screws are placed on either side of the fracture site, but as many screws as possible are positioned and placed depending on the type of plate.

In order to provide extra stability during the critical period of healing, each patient was kept in brief periods of intermaxillary fixation from 14 to 21 days in standard fashion with elastics and Erich Arch Bars or with skeletal fixation using circumandibular wires and either piriform rim wires or zygomatic arch wires. The fixation was removed with local anaesthesia in the office based on the patient's age and tolerance level, otherwise it was removed in the OR with general anaesthesia when appropriate.

Patients were recalled for follow up from the immediate post-op period and followed for up to 29 months postoperatively for clinical and radiographic examination. Objective clinical data such as occlusal relationships, maximum interincisal opening, presence or absence of segmental mobility and presence or absence of swelling were recorded. In addition, panoramic radiographs at varying postoperative intervals were interpreted for appropriate progression of healing at the fracture site and any obvious pathology involving the bioresorbable plates.

3. Results

Our data shows a stable occlusion and maximum interincisal opening of thirty millimetres or greater was achieved in 14 of 15 patients seen in follow up, with 8 patients having an MIO of 40 mm or greater. Based on bimanual palpation, there was no segmental mobility noted at any of the fracture sites after fixation with the bioresorbable plates at any of the follow-up examinations. Thirteen patients had no postoperative sequelae or implant related complications. Two patients developed a seroma-like collection at the operative site. One was treated with clindamycin for a questionable wound infection, and both resolved over several weeks suggesting that the collection was a seroma rather than infectious in nature. These collections did not require implant removal or any additional procedures.

Each patient underwent a postoperative panoramic radiograph postoperative day 1, as well as at varying intervals during the follow up period (Fig. 1). All films showed adequate reduction of the fracture segments without obvious pathology at the fracture/hardware sites on all patients followed. In addition, postoperative films starting at 1 year showed significant bony osseous fill where the previous screw sites were located (Fig. 2).

4. Discussion

Bioresorbable materials for rigid fixation have been in use in surgery for many years. Bostman et al. first reported the use of resorbable screws in an animal model in the orthopaedic literature (Bostman et al., 1991). Since then there has been ongoing development in manufacturing biodegradable implants with properties appropriate for osteosynthesis. While bioresorbable materials have been in use in maxillofacial surgery since the use of resorbable material for orbital floor fractures in 1972, resorbable plates and screws are a fairly recent development. Thus far, development of resorbable plates and screws has focused on polymers that are macromolecular chains composed of repeating subunits. Two polyalphahydroxy acids, polyglycolic acid (PGA) and polylactic acid (PLA), are polymers that have been used in the manufacturing of resorbable suture. The early systems focused on higher weight polylactic acid polymers which have greater strength, but also have prolonged resorption periods of up to 5 years which lead to foreign body reactions (Imola et al., 2001). Conversely, polyglycolic acid has the greatest flexural strength but undergoes the most rapid degradation with the majority of its strength lost by 6 weeks and complete volume loss by approximately 9 months (Imola et al., 2001). The combination of PLLA and polyglycolic acid (PGA) yields a copolymer which is currently used in the Lactosorb® system, and the ratio of the materials allows it to maintain almost 75% of its strength in the initial 3 months (Pietrzak, 2012). Another popular system that we used for the majority of our cases were Synthes Rapid Resorbable Fixation® implants which are manufactured from a ratio of 85:15 poly(L-lactide-co-glycolide). This polymer is readily resorbed by the body in 12 months (Eppley, 2005). Finally, in one case we placed Inion CPS® implants which are composed of L-lactic acid, D-lactic acid and trimethylene carbonate.

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