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Retrospective Cohort Study

A case series of peri-articular elbow fracture fixations with magnesium implants and a review of current literature

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Abstract

BACKGROUND

In recent years, the use of Magnesium alloy implants have gained renewed popularity, especially after the first commercially available CE approved Magnesium implant became available (MAGNEZIX® CS, Syntellix) in 2013.

AIM

Our study aims to document our clinical and radiographical outcomes using magnesium implants in treating peri-articular elbow fractures.

METHODS

Our paper was based on a retrospective case series design. Intra-operatively, a standardized surgical technique was utilized for insertion of the magnesium implants. Post – operatively, clinic visits were standardized and physical exam findings, functional scores, and radiographs were obtained at each visit. All complications were recorded.

RESULTS

5 patients with 6 fractures were recruited (2 coronoid, 3 radial head and 1 capitellum). The mean patient age and length of follow up was 54.6 years and 11 months respectively. All fractures healed, and none exhibited loss of reduction or complications requiring revision surgery. No patient developed synovitis of the elbow joint or suffered electrolytic reactions when titanium implants were used concurrently.

CONCLUSION

Although there is still a paucity of literature available on the subject and further studies are required, magnesium implants appear to be a feasible tool for fixation of peri-articular elbow fractures with promising results in our series.

INTRODUCTION

In recent years, the use of Magnesium alloy implants in orthopaedic surgeries have gained renewed popularity. Apart from being bioabsorbable, negating the need for implant removal, magnesium also has good osteoconductive properties [1-4]. Biomechanically, it exhibits greater biomechanical strength than any pre-existing polymers, and reduces the stress-shielding effect associated with titanium and steel implants as it has a Young's modulus closer to bone [4].

Currently, the main utility of magnesium implants in the orthopaedic community is within the foot and ankle community where satisfactory results have been reported with its utility in forefoot osteotomies [5-7]. However, its utility in the setting of orthopaedic trauma has been steadily increasing [8].

Our study aims to document our clinical and radiographical outcomes using magnesium implants to treat peri-articular elbow fractures. To our knowledge, our study is the first study analyzing outcomes in radial head and coronoid fractures in the English literature.

MATERIALS AND METHODS

This study is a retrospective case series analyzing the clinical and radiographical outcomes of patients with peri-articular fractures of the upper limb, specifically the radial head, coronoid and capitellum, that were surgically treated with bioabsorbable magnesium screws (MAGNEZIX®, Syntellix AG, Hanover, Germany).

Domain specific review board (DSRB) approval was obtained prior to initiation of the study. Patients were recruited over the duration of 8 months from May 2019 to December 2019. All patients recruited were adult aged 21 years old and above, with isolated, closed peri-articular fractures of the elbow and no neurovascular compromise presenting to our institution. Pre-operatively, all patients were counselled regarding the usage of the magnesium implants and the risks and benefits of surgical fixation were extensively explained.

Surgical technique

All patients recruited underwent surgery performed by one of the senior authors of this study with a standardised surgical technique for implantation of the magnesium compression screws in accordance with the manufacturers recommendation.

Intra-operatively, after temporary reduction with Kirschner-wires, a cannulated drill was utilised to create a pilot hole before the main hole is drilled and the screw inserted over the Kirschner-wire. Care was taken not to apply excessive torque during screw insertion.

Post-operative regime

Post-operatively, all patients were started immediately on a progressive occupational therapy regime. Passive range of motion was allowed immediately post operatively followed by graduated progression to active range of motion within 2-3 wk. All patients had regular therapy visits post-operatively for supervised sessions. Patients underwent a standardised follow up regime with the primary surgeon at 2 wk, 4 wk, 6 wk, 3 months, 6 months and 1 year post-operatively. During each visit, clinical notes were taken for each patient documenting relevant history and physical exam findings. Two functional scores, namely the Mayo Elbow Performance score (MEPS) and Disabilities of the Arm, Shoulder and Hand (DASH) score was also recorded at each visit. All complications were recorded.

RESULTS

Our study studied a total of 5 patients with 6 fractures, 2 of the coronoid, 3 of the radial head and 1 of the capitellum. The mean age at the time of surgery was 54.6 years of age ranging from 34 to 76 years old, and the mean length of follow up was 11 months, ranging from 7 to 13 months.

All 5 patients exhibited good short to medium term clinical outcomes with a mean MEPS of 100 points and a mean DASH score of 2.72 points (0.8 – 10.3 points) at final follow up. No fractures exhibited any loss of reduction at the point of final follow up, and there were no complications or revision surgeries required for all 5 patients. Notably, none of our patients developed any clinical signs or symptoms of synovitis of the elbow joint.

Patient one

Patient one is a 67 year old, functionally active chinese lady with no past medical history who sustained a closed left Bryan and Morrey type 3 capitellar fracture after a mechanical fall from standing height. (Figure 1)

Access to the elbow was obtained *via* a mid-axial approach after which fracture reduction was achieved under direct visualization and held with Kirschner wires. Four magnesium screws were then used to compress the fracture site before a 4 hole 1/3 tubular plate was cut and applied in a buttress fashion.

Clinically, the patient was pain free by 2 wk and had obtained 25 to 130 degrees of elbow flexion and full prono/supination by the 6 months. At the point of latest follow up, she reported good functional outcomes scores, with a MEPS of 100 points and a DASH score of 0.8. She had also returned to her full time work as a cleaner without any difficulties.

One magnesium screw was noted to have broken at the 6 wk radiograph. However, there was no loss of fracture reduction and the fracture was noted to have united at 6 months post-op. (Figure 2)

Patient two

Patient two is a 34 year old male with no significant past medical history who sustained an isolated closed Regan and Morrey type 2 coronoid fracture. (Figure 3) Intra-operatively the coronoid fracture was fixed using a Zimmer ALPS Coronoid plate applied in a buttress fashion and a Magnezix CS 2.7mm compression screw for compression.

Fracture union was noted at 6 wk post-op, and by 6 months, he had obtained 10-130 degrees of elbow flexion, and managed to return to full work duties as well as recreational football. (Figure 4) At the point of final follow up, he reported satisfactory functional outcome scores with a MEPS of 100 and a DASH score of 0.8 points.

Patient three

Patient three is a 58 year old functionally well lady with a significant past medical history of poorly controlled diabetes mellitus and hyperlipidaemia who sustained a closed Monteggia - variant fracture dislocation after a fall from standing height. (Figure 5) Pre – operatively, a computer tomography scan confirmed a comminuted olecranon fracture with a large ulnar butterfly fragment as well as a comminuted radial head fracture.

Intra-operatively, the olecranon fracture was fixed with traditional titanium implants (Zimmer ALPs system) whilst the radial head fracture was fixed with two Magnezix CS 2.7mm headless compression screws.

By 6 wk post-operatively, she had obtained 10 to 130 degrees of elbow flexion, as well as 60 degrees and 50 degrees of pronation and supination respectively. At 6 months, this further improved to 0 to 150 degrees of flexion and 80 degrees of pronation and supination. At this point, she was pain free, and had returned to work as a machine operator without any difficulties. Fracture union was noted.

Radiographically, peri-implant radiolucencies became prominent around the 6 wk post-op, and gradually reduced up to the point of latest follow up at 1 year. At 6 months post-op, we noted breakage of one of the radial head screws, and by the 1 year post-op, the embedded magnesium implants were barely visible on the lateral view. (Figure 6)

Patient four

Patient four is a 38 year old male with no significant past medical history who sustained a closed Mason type 2 radial head fracture after a fall from a height. (Figure 7)

Intra-operatively, two Magnezix CS 2.7mm screws were utilised for fixation and compression of the fracture. Full elbow range of motion was confirmed intra-operatively prior to closure. (Figure 8)

By 6 wk post-op, he had obtained 0 to 150 degrees of elbow flexion and 90 degrees of both pronation and supination, almost identical to the contralateral limb. (Figure 9)

Radiographically we noted the appearance of peri-implant radiolucencies at 2 wk post-operatively, which became more pronounced by 4 wk before reducing significantly by 6 months and almost completely disappearing by 1 year. This observation is in keeping with gradual dissipation of hydrogen produced as a result of magnesium degradation. The distal tip of one of the Magnezix CS screws was noted to have broken off at 6 months post-operatively, during which time the fracture had already healed with no loss of fracture reduction. At 1 year, the broken screw tip had resorbed and was barely visible. (Figure 10)

At the point of last follow up, the patient remained clinically asymptomatic and reported no perceivable differences functionally with the contra-lateral limb with a MEP of 100 points and a DASH score of 0.8 points.

Patient five

Patient five is a 76 year old lady with good pre-morbid function who sustained a closed terrible triad injury (Regan and Morrey type 3 coronoid fracture and Mason 4 radial head fracture). (Figure 11)

Intra-operatively, both the radial head fracture and the coronoid fracture were fixed with a combination of one titanium (Medartis 2.0/2.5mm Low Compression Screw) and one Magnezix CS 2.7mm screw. (Figure 12)

At 6 months post-op, the patient was noted to have elbow flexion from 10 – 130 degrees and full prono/supination which was identical to the contra-lateral limb. At the point of last follow up, she was pain free and was independent in all activities of daily living, and reported a MEPS of 100 points and a DASH score of 10.3 points. (Figure 13)

In similar fashion to patient two, at the 4 wk post-op, radiolucencies were noted over both Magnezix CS screws which reduced significantly by 6 months and almost completely disappeared by 1 year. Neither of screws had broken at 1 year post-op. (Figure 14)

Radiographical findings

In our series of patients, we noted the presence of radiolucencies as early as 2 wk post-operatively, which consistently became more pronounced by 4 to 6 wk post-operatively. Significant reduction in radiolucencies were noted by 6 months post-operatively, and radiolucencies were minimal and barely visible by 1 year post-operatively.

At the one year mark post-operatively, we noted screw breakage in 3 out of 6 fractures, of which 2 occurred at 6 months post-operatively and 1 occurred within the first 6 wk. Two of these breakages (Patient three and four) occurred along the distal screw threads, whilst in the remaining case (Patient one), screw breakage occurred before the 6 wk post-operatively proximally near the screw head. We postulate that a potential reason for the earlier breakage is due to the longer length of screw used.

DISCUSSION

Magnesium implants were first described in an orthopaedic setting in 1906 by Lambotte [9] who then utilized a magnesium plate to treat a seventeen-year-old child with pseudoarthrosis and severe malalignment of the distal third of the tibia. Despite that, its

popularity never took off due to two key reasons. Firstly, rapid corrosion of magnesium inadvertently resulted in pre-mature implant failure and secondly, contact of the magnesium implant with other metals resulted in a florid electrochemical reaction as Lambotte found out in his index experiment after his patient developed severe pain and extensive subcutaneous gas cavities post operatively due to the aforementioned reaction [9].

The advent of technologically advanced Magnesium Alloys, such as MgYREZr which solved the problem of rapid magnesium degradation, has prompted a re-birth in the utilization and popularity of these implants when the first commercially available CE approved magnesium implant became available in 2013 (MAGNEZIX® compression screw from Syntellix).

During this period of time, the vast majority of clinical studies published were in the setting of forefoot deformity correction surgeries such as chevron osteotomies of the first metatarsal, with only a handful of clinical studies documenting its use in the orthopaedic trauma setting.

In our review of the existing literature, we identified a total of 10 existing studies [10-19] reporting on the utilization of magnesium implants in the setting of orthopaedic trauma. Of these 10 studies, only 1 reported unsatisfactory outcomes [13] and did not recommend the use of magnesium implants, with 1 study still ongoing [15].

In fractures involving the elbow, Biber *et al* [10] and Aktan *et al* [11] both reported positive results utilizing magnesium implants intra-articular distal humerus fractures. Biber's case report documented the utility of the Magnezix CS cannulated compression screw in a patient with a prior radial head replacement who suffered a capitellar fracture and Aktan *et al* documented their experience utilizing two magnesium compression screws for reduction of the distal humerus articular surface in a patient with a distal humerus

fracture. Both patients reported successful results with complete fracture union and functional elbow range of motion at the time of latest follow up.

Although there have been reports of magnesium screws being utilized for fractures of the phalanges mentioned, we were unable to find any case reports or studies in the English literature. Apart from Turan *et al* [12] case series documenting successful outcomes in two radial styloid fractures, the remaining existing studies in the setting of hand trauma primarily pertain to its utility in scaphoid fractures. This is natural as the Magnezix CS screw is based on a Herbert screw design (variable pitch, headless, cannulated design) which was originally developed for use in compressive osteosynthesis of scaphoid fractures [3].

In Meier *et al's* [13] 2016 review, a single magnesium compression screw was used for fixation of various scaphoid fractures. Although all patients eventually exhibited excellent wrist functional outcome scores 1 year post-operatively and all fractures eventually consolidated, he observed significant osteolysis and bone cysts in 3 out of 5 patients which resulted in a significant delay of around six months before sufficient consolidation occurred to allow return to physical work, and hence did not recommend its use in scaphoid fractures. Conversely, Grieve *et al* [14] documented positive results in his series of 3 scaphoid fractures. At present, a multi-centre, randomized control trial comparing outcomes of scaphoid fractures treated with magnesium and titanium screws by Konneker *et al* [15] is ongoing (stated to conclude by late 2020) and will hopefully shed more light on the topic.

In fractures involving the lower limb, there is existing literature documenting outcomes when used as an adjunct in young neck of femur fractures [16], tibial spine fractures [17] in paediatric patients, as well as isolated lateral [18] and medial malleolus [19] fractures. All reported positive clinical and radiological outcomes.

Despite the multiple benefits [1-4, 20-24] of these magnesium implants (as summarized in Table 3) and the emergence of these aforementioned studies citing positive outcomes, it is important to also highlight several considerations when opting to utilize these implants.

The first important consideration, and arguably the biggest disadvantage of utilizing magnesium implants are the expected production of peri-implant lucencies due to hydrogen gas produced during the process of magnesium degradation. Clinicians may find it difficult to differentiate this from post-operative complications such as-infection or loosening of implants. Although studies have demonstrated that these radiolucencies do gradually disappear from anywhere between 3 to 17 months [3], the presence of persistent radiolucencies (which appear as early as 2 wk post-operatively as seen in our series), may cause anxiety to both the clinician and the patient.

Secondly, magnesium implants are also known to be associated with osteolysis [24], which was postulated to occur when the body is unable to adequately clear the products of magnesium degeneration from the implantation site, leading to the migration of osteoclasts to the implantation site. This, coupled with the aforementioned issue of expected post-operative radiolucencies is particularly concerning given the fact that symptoms of osteolysis do not usually occur [25] until there is sufficient bone loss to result in aseptic loosening of the implant, by which point implant failure is likely to occur.

Comparison with conventional titanium implants

Our review of the literature identified 3 studies [5,26-27] comparing outcomes in magnesium and conventional implants. May *et al*'s [26] study recruited a total of 48 patients with medial malleolus fractures undergoing compression screw fixation of which 23 had magnesium screws implanted whilst 25 had conventional screws

implanted. In his study, with a minimum follow up of 1 year, no differences in clinical outcomes between both groups were noted, with similar AOFAS clinical outcome scores, and a 100% union rate in both groups. Complication rates were also similar with no deep infection or osteomyelitis noted in both groups. However, 5 patients with conventional titanium implants, compared to none in the magnesium screw group required removal of implants for symptomatic hardware, highlighting the key benefit of using magnesium implants.

The remaining two studies recruited patients undergoing distal metatarsal osteotomies for hallux valgus. Acar *et al* [5] retrospectively compared two groups of 17 patients undergoing surgery with both implants, whilst Plaass *et al* [27] conducted a randomized control trial of 26 patients. Both studies reported similar therapeutic outcomes with regards to functional and radiographical outcomes, with no differences in complication rates or union rates.

Although the literature appears to suggest that these bioabsorbable magnesium screws provide similar efficacy to conventional implants, interpreting the data must performed with caution at this juncture due to the small collective number of patients analysed, and the heterogeneity of clinical indications amongst studies. In our search of the literature, there were no comparative studies analyzing the efficacy of both implants when used in peri-articular fractures around the elbow, with only two case reports [10-11] available in the literature, similarly documenting successful outcomes as reported in our series.

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Limitations of study

Limitations of our study include a relatively small sample size although our case series represents one of the largest case series documenting the outcomes of magnesium screws in upper limb fractures. Furthermore, as there are few other studies on the topic,

comparing and analysing our outcomes is challenging. Further studies are needed to evaluate the topic further such as a study with a control group.

CONCLUSION

Our case series serves to add to the paucity of literature on the utilization of magnesium screws in upper limb fractures. In our series, all patients exhibited good short to medium term clinical outcomes with no complications or revision surgeries required, and significantly none of our patients developed any clinical signs or symptoms of synovitis or allergic reactions. Although further larger studies with longer follow-ups are required before the implant can be unequivocally proven superior or equal to conventional existing implants, these implants appear to be a promising innovation for the modern orthopaedic surgeon.

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