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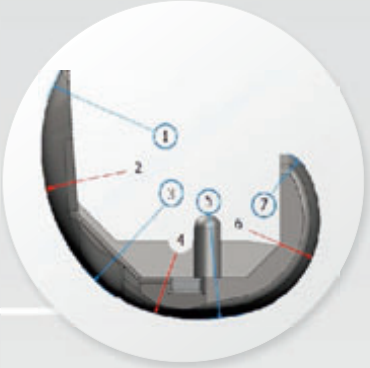

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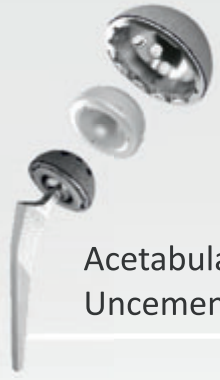

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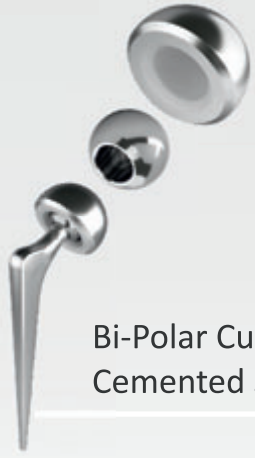

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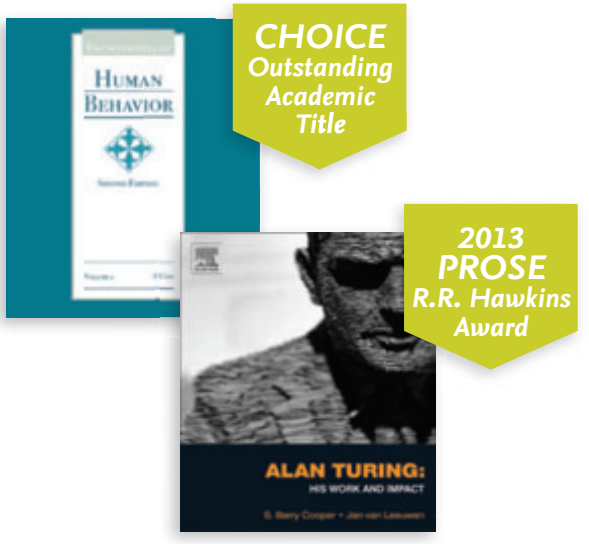

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Aims and Scope

Journal of Arthroscopy and Joint Surgery (JAJS) is committed to bring forth scientific manuscripts in the form of original research articles, current concept reviews, meta-analyses, case reports and letters to the editor. The focus of the Journal is to present wide-ranging, multi-disciplinary perspectives on the problems of the joints that are amenable with Arthroscopy and Arthroplasty. Though Arthroscopy and Arthroplasty entail surgical procedures, the Journal shall not restrict itself to these purely surgical procedures and will also encompass pharmacological, rehabilitative and physical measures that can prevent or postpone the execution of a surgical procedure. The Journal will also publish scientific research related to tissues other than joints that would ultimately have an effect on the joint function.

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Review article

The Promise of Silicon: bone regeneration and increased bone density

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ABSTRACT

Historically, silicon has been accorded low importance as a trace element. Its role has generally been regulated to that of minor influence on bone and connective tissue development. However, in vitro and in vivo studies have shown that these assumptions are incorrect. Silicon plays a key role in bone biology, improving bone regeneration and increasing bone mineral density. The aim of this review is to provide an understanding of the role of silicon in bone biology and its clinical application.

Contents

1. Introduction

Historically, silicon has been accorded low importance as a trace element. Nielsen proclaimed that silicon was an inert universal element, a "fortuitous reminder of our geochemical origin or an indicator of environmental exposure".[1] However, animal studies in the 1970's showed that dietary silicon deficiency produces defects in connective and skeletal tissues,[2,3] and that silicon is concentrated at the mineralization front of growing bone.[3] Over the past few decades we have improved our understanding of the essential role of silicon in bone biology, with renewed interest recently for its application as a potential treatment for osteoporosis and other forms of bone loss. The aim of this review is to provide an understanding of the role of silicon in bone biology and its clinical application.

2. Silicon – the important trace element

Silicon (Si) is a non-metallic trace element, with a distribution in the body of 1–2 g (the third most abundant element after iron and zinc).[4]Dietary intake of Si is between 20–50 mg Si/day for most Western populations,[5] more than two fold higher than the typical intake of iron and zinc. In China and India, plant based societies, the intake is higher (140–204 mg/day).[6,7] In children, the major source is from cereals (68% of total dietary intake), whereas beer ingestion

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forms the major source in adults (44% of total dietary intake).[5] Other source of Si include drinking water, plant foods (cereals, rice, barley, oats etc), some vegetables (beans, spinach and root vegetables), seafood (mussels) and supplements.

In vivo, silicon is widely distributed throughout the body with a strong predilection for bone and connective tissue.[4] Within bone, silicon appears to be extensively bound to gylycosaminoglycans, key component of the extracellular matrix (ECM) in addition to collagen and proteoglycans. This suggests that silicon plays an important role in bone structure and formation. Silicon depravation studies have showed the detrimental effects on bone and connective tissue.

On the contrary, silicon is rarely toxic when taken orally.[8] Humans have used magnesium trisiclate, a gastric antacid, for more than 40 years without adverse reaction.

3. In vitro and in vivo studies

The Carlisle in vivo studies of the 1980's found that silicon increased bone matrix synthesis in chick tibias and that Si had a dose dependent increase in prolyl hydroxylase activity, the enzyme involved in collagen synthesis.[4] This suggests that silicon is involved in bone matrix synthesis, through the upregulation of enzymes.

Recent studies with human osteoblast cell lines showed increased osteoblast proliferation, ECM synthesis, ALP activity and osteocalcin synthesis.[9] Feng et al (2007) and Zou et al (2009) also found that silica containing nanospheres have a significant effect on proliferation of osteoblast cell lines in vivo and in vitro, in a dose dependent manner.[10,11]

Recently, Martinez et al (2015) and Ghanaati et al (2010) have found that a when silicon is converted into a gel scaffold, it promotes osteoblast differentiation and vasculogenesis, and may also aid in drug delivery.[12,13]

Thus silicon has been shown both in vivo and in vitro to have significant effects in promoting bone formation, bone regeneration and vasculogenesis.

4. Silicon in bone implants and cement

Silicon containing implants and ceramics such as Si-substituted hydroxyapatite and Bioglass have been shown to bond better to bone that their non-Si containing counterparts due to the spontaneous formation of a biologically active apatite-like layer on their surface, with an additional positive effect of vascularized soft tissue regeneration.[14] Silica is postulated to undergo partial dissolution on these materials to form an amorphous Si layer and the dissolved Si has been implicated in the in vivo efficacy. Further, the addition of Si to hydroxyapatite leads to faster bone remodeling at the bone-HA interface.[15]

Coathup et al. conducted an in vivo study on female sheep of a silicate-subsituted calcium phosphate ectopic implant in the paraspinal muscles.[16] After twelve weeks, they found that Si had a significant effect on the formation of bone both within the implant and on the implant bearing surface versus a non-Si calcium phosphate control group.

Thus, silicon based implants promote bone formation and vasculogenesis.

5. Silicon and bone mineral density (BMD)

The Farmingham Offspring cohort study found that higher intake of dietary silicon was significantly associated with more positive BMD at the hip in men and pre-menopausal women, but not in post-menopausal women.[17] These findings were also reported in the APOSS (Aberdeen Prospective Osteoporosis Screening Study) cohort, a women only cohort, where dietary silicon intake was positively associated with BMD at the hip and spine in pre-menopausal women. Similar findings were seen in post-menopausal women who were on concurrent HRT.

There have been no silicon depravation studies conducted in humans till date. In chicks, silicon depravation leads to thinner and more flexible legs with increased fracture risk.[18] In rats, defects to the skull are prevalent in the silicon deprived.[2]

In osteoporotic subjects, silicon supplementation leads to increased bone volume[19] and increased femoral and lumbar spine BMD.[20] Interestingly, Eisinger and Clairet found that silicon is more effective than Etridonate and sodium fluoride in increasing BMD. A recent study by Spector also found that silicon increased both BMD and bone formation markers (pro-collagen type 1 N-terminal propeptide) in osteopenic and osteoporotic subjects, with a dose dependent relationship between the marker and increasing choline-stabilized orthosilicic acid dose (ch-OSA). Similarly, in ovariectomized rats, chicks and horses, supplementation with Si or ch-OSA reduced bone resorption and bone loss and increased bone formation and BMD.[21–24] In a recent review,[25] Price et al. found overwhelming evidence for further research into silicon as an important component of osteoporosis treatment.

Thus silicon works has a compounded effect to increase bone mineral density and should be an essential part of the diet of osteoporotic patients.

6. Mechanism of action

The mechanism of action of silicon is poorly understood at present. In Fig. 1 we present our proposed mechanism of action. It is postulated to be involved in bone formation through the synthesis and/or stabilization of collagen and ECM. It is also implicated in gene transcription of the type 1 collagen gene, a cofactor for prolyl hydroxylase the enzyme of collagen synthesis, promoting the absorption of essential elements needed for bone synthesis such as copper, calcium and magnesium, and in the scavenging of toxic aluminium.[4] Carlisle postulated that silicon probably acts by making the bone matrix more calcifiable.[3]

Fig. 1. Proposed mechanism of action of silicon.

7. Conclusion

Silicon has a key role to play in bone biology. Although poorly understood, its mechanism of action is likely related to the synthesis and stabilization of collagen in bone matrix. In vivo and in vitro studies have demonstrated its importance in improving bone regeneration and increasing bone mineral density. Clearly, this forgotten element holds much promise for the future of orthopaedics.

Conflict of interest

None.

Acknowledgement

None.

References

1. Nielsen FH. Nutritional requirements for boron, silicon, vanadium, nickel, and arsenic: current knowledge and speculation. *FASEB J Off Publ Fed Am Soc Exp Biol*. 1991;5(12):2661–2667.
2. Schwarz K, Milne DB. Growth-promoting effects of silicon in rats. *Nature*. 1972;239(5371):333–334.
3. Carlisle EM. Silicon as an essential trace element in animal nutrition. *Ciba Found Symp*. 1986;121:123–139.
4. Jugdaohsingh R. Silicon and bone health. *J Nutr Health Aging*. 2007;11(2):99–110.
5. Jugdaohsingh R, Anderson SHC, Tucker KL, et al. Dietary silicon intake and absorption. *Am J Clin Nutr*. 2002;75(5):887–893.
6. Anasuya A, Bapurao S, Paranjape PK. Fluoride and silicon intake in normal and endemic fluorotic areas. *J Trace Elem Med Biol Organ Soc Miner Trace Elem GMS*. 1996 Sep;10(3):149–155.
7. Chen F, Cole P, Wen L, Mi Z, Trapido EJ. Estimates of trace element intakes in Chinese farmers. *J Nutr*. 1994;124(2):196–201.
8. Pérez-Granados AM, Vaquero MP. Silicon, aluminium, arsenic and lithium: essentiality and human health implications. *J Nutr Health Aging*. 2002;6(2):154–162.
9. Keeting PE, Oursler MJ, Wiegand KE, Bonde SK, Spelsberg TC, Riggs BL. Zeolite A increases proliferation, differentiation, and transforming growth factor beta production in normal adult human osteoblast-like cells in vitro. *J Bone Miner Res Off J Am Soc Bone Miner Res*. 1992;7(11):1281–1289.
10. Feng J, Yan W, Gou Z, Weng W, Yang D. Stimulating effect of silica-containing nanospheres on proliferation of osteoblast-like cells. *J Mater Sci Mater Med*. 2007;18(11):2167–2172.
11. Zou S, Ireland D, Brooks RA, Rushton N, Best S. The effects of silicate ions on human osteoblast adhesion, proliferation, and differentiation. *J Biomed Mater Res B Appl Biomater*. 2009;90B(1):123–130.
12. Ghanaati SM, Thimm BW, Unger RE, et al. Collagen-embedded hydroxylapatite-beta-tricalcium phosphate-silicon dioxide bone substitute granules assist rapid vascularization and promote cell growth. *Biomed Mater Bristol Engl*. 2010;5(2):25004.
13. Martínez-Vázquez FJ, Cabañas MV, Paris JL, et al. Fabrication of novel Si-doped hydroxyapatite/gelatine scaffolds by rapid prototyping for drug delivery and bone regeneration. *Acta Biomater*. 2015;15:200–209.
14. Hench LL, Xynos ID, Polak JM. Bioactive glasses for in situ tissue regeneration. *J Biomater Sci Polym Ed*. 2004;15(4):543–562.
15. Porter AE, Patel N, Skepper JN, et al. Effect of sintered silicate-substituted hydroxyapatite on remodelling processes at the bone-implant interface. *Biomaterials*. 2004;25(16):3303–3314.
16. Coathup MJ, Samizadeh S, Fang YS, et al. The osteoinductivity of silicate-substituted calcium phosphate. *J Bone Joint Surg Am*. 2011;93(23):2219–2226.
17. Jugdaohsingh R, Tucker KL, Qiao N, et al. Dietary silicon intake is positively associated with bone mineral density in men and premenopausal women of the Framingham Offspring cohort. *J Bone Miner Res Off J Am Soc Bone Miner Res*. 2004;19(2):297–307.
18. Carlisle EM. Silicon: an essential element for the chick. *Science*. 1972;178(4061):619–621.
19. Schiano A, Eisinger F, Detolle P, et al. Silicon, bone tissue and immunity. *Rev Rhum Mal Ostéo-Articul*. 1979;46(7–9):483–486.
20. Eisinger J, Clairet D. Effects of silicon, fluoride, etidronate and magnesium on bone mineral density: a retrospective study. *Magnes Res*. 1993;6(3):247–249.
21. Hott M, de Pollak C, Modrowski D, et al. Short-term effects of organic silicon on trabecular bone in mature ovariectomized rats. *Calcif Tissue Int*. 1993;53(3):174–179.
22. Rico H, Gallego-Lago JL, Hernández ER, et al. Effect of silicon supplement on osteopenia induced by ovariectomy in rats. *Calcif Tissue Int*. 2000;66(1):53–55.
23. Merkley JW, Miller ER. The effect of sodium fluoride and sodium silicate on growth and bone strength of broilers. *Poult Sci*. 1983;62(5):798–804.
24. Calomme MR, Vanden Berghe DA. Supplementation of calves with stabilized orthosilicic acid. Effect on the Si, Ca, Mg, and P concentrations in serum and the collagen concentration in skin and cartilage. *Biol Trace Elem Res*. 1997;56(2):153–165.
25. Price CT, Koval KJ, Langford JR. Silicon: a review of its potential role in the prevention and treatment of postmenopausal osteoporosis [Internet]. *Int J Endocrinol*. 2013; cited 2017 Aug 29. Available from: https://www.hindawi.com/journals/ije/2013/316783/.

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Research paper

Surgical outcomes of arthroscopic lateral clavicle excision for osteolysis

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ABSTRACT

Background: Lateral clavicle osteolysis has been attributed to repetitive stress; particularly in activities requiring excessive overhead motions such as weightlifting or rugby. Arthroscopic lateral clavicle excision is recommended for symptomatic acromioclavicular joint that has failed conservative treatment.
Aim: The present study aims to assess patient-reported outcomes of arthroscopic lateral clavicle excision for osteolysis.
Methods: Sixteen patients with a mean age of 33.56 ± 12.2 (range 18–59) underwent lateral clavicle excision over a 24 month period, by one senior shoulder surgeon. All patients participated in sport and professional athletes accounted for 56% of the patient cohort. Constant (CS) and QuickDASH (QD) outcome scores were obtained by questionnaire at a mean 21 months following surgery (range 3–40).
Results: A significant improvement in CS ($p < 0.001$) and QD ($p = 0.012$) was noted. Patient satisfaction increased from 3.7 ± 1.7 to 8.8 ± 2.5 on a 10-point visual analogue scale ($p = 0.0024$). 87% of patients were able to return to their former level of sporting activity. The average time to return to sport was 6.3 ± 4.8 months, ranging from 2–18 months.
Conclusions: Acromioclavicular joint excision for lateral clavicle osteolysis is associated with significant improvements in post-operative shoulder outcome scores, while providing adequate pain relief and improving the range of motion of the affected shoulder.
Level of Evidence: IV Case Series

1. Introduction

Osteolysis of the acromioclavicular (AC) joint has been regarded as an increasing cause of shoulder pain.[1] Traumatic lateral clavicle osteolysis was first described by Dupas et al. in 1936,[2] followed by atraumatic lateral clavicle osteolysis two decades later.[3] Recent work has reported similar findings on radiographic and magnetic resonance imaging (MRI) in both traumatic and atraumatic lateral clavicle osteolysis.[4]

Controversy surrounds the pathogenesis of lateral clavicle osteolysis, where Cahill proposed that the osteolytic process was induced by the presence of microfractures in the subchondral bone, caused by a repetitive stress.[5,6] He postulated that repetitive microtrauma activates an inadequate repair and remodeling process, which favours bone resorption over formation. Ultimately, Cahill's pathogenic theory still has a traumatic element, albeit in a more chronic and subacute manner. Numerous case reports have suggested alternative pathogeneses of lateral clavicle osteolysis, including autonomic dysfunction, hypertrophic synovial tissue, ischemic necrosis, and reactive hyperemia.[7–12] However, due of lack of sufficient evidence, Cahill's theory of osteolysis induced by microfractures in the subchondral bone still remains the most accepted.[5]

Lateral clavicle osteolysis, as described above, has been attributed to repetitive stress; particularly in activities requiring excessive overhead motions, reducing the ability of the bone to heal after loading. Therefore, lateral clavicle osteolysis most likely presents in strength and power athletes, such as weightlifters or rugby players, and jobs requiring heavy overhead lifting, such as builders or plasterers.[13] Cahill et al.[5] noted that 98% of radiographs indicating lateral clavicle osteolysis belonged to weightlifters, in which 50% had microfractures in the subchondral bone, and was the first case series detailing this occurrence. Since then, more than one hundred cases have been reported in male weightlifters[13];

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highlighting the association between weight training amongst athletes and lateral clavicle osteolysis. Additionally, the increased number of women in weight lifting and sports involving overhead throwing, coincides with an increase of females presenting with lateral clavicle osteolysis.[14]

Early management of lateral clavicle osteolysis consists of rest and activity modification. The use of non-steroidal anti-inflammatory drugs (NSAIDs) are recommended to reduce inflammation, however it has been debated that NSAIDs may reduce bone healing.[15] Additionally, intra-articular corticosteroid injections may temporarily relieve the pain. Worcester et al.[16] have argued that temporary relief of pain provided by a steroid injection may second as a diagnostic tool indicating that the pain is localised to the AC joint; patients who experienced only temporary relief of their symptoms after two injections, were candidates for surgery and noted full relief of their symptoms post-operatively.[16] Surgical intervention is recommended for a symptomatic AC joint that has failed conservative treatment. Typically there is point tenderness of the AC joint, combined with abnormalities on radiographs. The excision of the lateral clavicle has become the mainstay of surgical treatment.

The present study evaluates the outcome of lateral clavicle excision in patients with lateral clavicle osteolysis. The success of the procedure was evaluated based on pre- and post-operative shoulder outcome scores. Other epidemiological factors were also assessed with regards to their effect on surgical outcomes.

2. Materials and methods

2.1. Patient demographics

Data was extracted over a 24 month period from patients who required a lateral clavicle excision due to osteolysis. All patients were in the care of one senior shoulder surgeon and procedures carried out at one day-case unit. Nineteen patients were identified as eligible for the study, with a minimum follow up period of 3 months. Three patients could not be contacted to evaluate their post-operative outcomes and were subsequently excluded from the present study. As a result, 16 patients were included in this study; where 15 patients had unilateral surgery and one patient, bilateral.

The patient cohort consisted of two females and fourteen males, with a mean age of 33.56 ± 12.17 (range 18–59). Professional athletes accounted for 56% of the patient population (n = 9); where 50% of patients were professional rugby players (n = 8). Additionally, the current series included one professional water polo player and a semi-professional rugby player. The remaining patients participated in sports at a recreational level; ranging from weight lifting, triathlons and football. The diagnosis of osteolysis was made on MRI in 87.5% of cases and plain radiography alone in the remainder.

2.2. Surgical technique

Surgery was performed under general anaesthesia, with an interscalene brachial plexus block. The patient was placed in a beach chair position.[17] Following arthroscopic examination of the glenohumeral joint, the subacromial bursa was entered and the AC joint exposed inferiorly. Instruments were inserted into the AC joint via direct anterosuperior and posterosuperior portals to deride the lateral end of clavicle. Bony resection was kept to minimum due to the osteolysis of the lateral clavicle, in order to avoid any ligament damage and instability. The anterior, superior and posterior capsule and AC ligaments were not breached. After resection, the joint was then examined arthroscopically from both the anterior and posterior portals, to check for any loose bone fragments and the lateral clavicle was stressed to assess for any excess mobility after resection.[13]

2.3. Outcome measures

To investigate the efficacy of lateral clavicle excision for osteolysis, shoulder outcome scores were utilised both pre- and post-intervention. The present study employed Constant Shoulder Score[18] and QuickDASH[19] scoring instruments. Additionally, all patients were asked to rate their satisfaction with their affected shoulder. This was carried out using a visual analogue scale (1–10) both pre- and post-operatively.

2.4. Statistical analysis

Statistical analysis was conducted using IBM SPSS software version 20. Nonparametric statistics were used in the present study. Wilcoxon matched pairs tests were performed to assess the pre and postoperative difference between outcome scores and patient satisfaction. When $p < 0.05$ data is deemed as significant and highlighted with an asterix (*).

3. Results

In the present study, 81% of patients present with lateral clavicle osteolysis as a result of a sport (n = 13); 50% rugby, 12.5% lifting weights (n = 2), while 1 injury was related to cricket, water polo and cycling respectively (Fig. 1).

Prior to lateral clavicle excision surgery, 87.5% of patients received an AC joint corticosteroid injection (n = 14). Of those who had injections, 36% noted slight improvement (n = 5), 29% reported a significant improvement (n = 4), while 14% of patients reported no improvement at all (n = 2) (Table 1). The effect of the injections on a further 3 patients (21%) was not recorded.

The mean time taken from symptoms to surgery was 9 months (1–36 months). All patients were reassessed for shoulder outcome scores at mean follow-up time of 21.38 ± 10.69 months (range 3–40). A significant improvement in the Constant Shoulder Scores was noted, as depicted in Fig. 2A. The mean pre-operatively score improved from 52.3 ± 12.1 to 87.3 ± 17.8 post-operatively ($p < 0.001$), with a 95% confidence interval (CI) of 23.41 to 46.6. Improvement in QuickDASH scores were noted following lateral clavicle excision as depicted in Fig. 2B, from 30.5 ± 6.4 to 6.8 ± 1.2 ($p = 0.012$), with 95% CI of 39.97 to 7.51. The work module of the QuickDASH score averaged 25.0 pre-operatively and 0.0 post-operatively. Despite the decrease of 25.0 points, this improvement

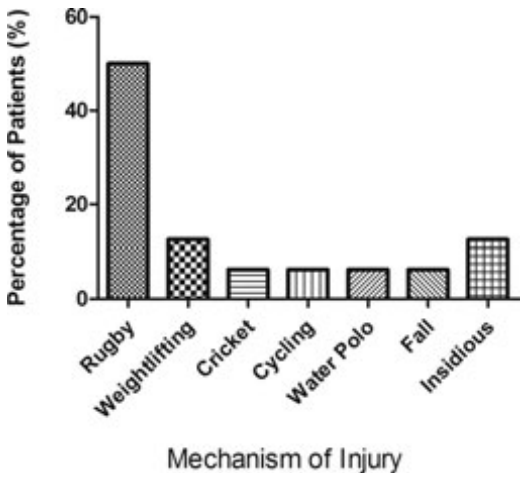

Fig. 1. Aetiology for lateral clavicle Osteolysis.

Table 1
Effect of corticosteroid injection for lateral clavicle osteolysis.

Effect of Steroid Injection	Number of Patients	Percentage
No Injection	2	12.5%
Injection	14	87.5%
No Improvement	2	14%
Slight Improvement	5	36%
Significant Improvement	4	29%
Effect not recorded	3	21%

was not shown to be statistically significant, where $p = 0.106$. The sport module of the QuickDASH score significantly improved from 69.7 to 13.4 post-operatively ($p = 0.001$). The time taken for patients to return to their previous level of sport was also noted, where 87% of patients were able to return to their former level of sporting activity. Of these patients, the average time it took to return to full sports was 6.3 ± 4.75 months, with a range of 2–18 months. Thirteen percent of patients could not return to their former level of sport after surgery. No significant difference was observed dependent on age ($p = 0.631$) or time to surgery ($p = 0.364$). There were no complications in this case series. As depicted in Fig. 2C, patient satisfaction significantly increased from 3.7 ± 1.7 to 8.8 ± 2.5 on a visual analogue 10-point scale, where ten is "most satisfied" ($p = 0.0024$).

4. Discussion

The current paper evaluated clinical outcomes of arthroscopic lateral clavicle excision to treat osteolysis and has shown significant improvements in post-operative shoulder outcome scores, while providing adequate pain relief. No complications were noted in patients who had undergone lateral clavicle excision.

It is well-recognised that lateral clavicle osteolysis occurs in weightlifting and power athletes. The present study supports this, accounting for 75% of all patients ($n = 12$). Furthermore, 81% ($n = 13$) of all injuries were attributed to sports. This data correlates well with early work from Cahill, who noted that 98% of radiographs indicating lateral clavicle osteolysis belonged to weightlifters.[5] However, it has been claimed that this figure is an overrepresentation, where Scavneius and Iversen report a much lower 27% incidence in weightlifters.[20]

Response to pre-operative steroid injections were shown to have no effect on the post-operative outcome. A mere 4 point difference in Constant Scores was observed between groups of patients who did not have an injection pre-operatively (31.5 points) and those who did (35.5 points). It should be noted that the current data cannot draw any conclusion on the efficacy of steroid injections in the non-operative cohort.

Arthroscopic resection of the clavicle has been reported to provide pain relief and allow a return to function comparable to open techniques.[21] Outcomes of arthroscopic lateral clavicle excision were described in 2000, however the study merely described 54% shoulders had excellent results, 39% had good results, and 7% were failures.[21] The current study aimed to explore the outcomes further, aided with shoulder outcome scores, satisfaction and return to sport.

A significant increase in Constant scores, 21 months following surgery, is indicative of improvement in range of motion and pain. Additionally, a significant improvement in QuickDASH scores highlights an enhancement in the quality of life of the patient following surgery. We have no knowledge of any other study utilising shoulder outcome scores as a measure of improvement following lateral clavicle excision. Patient satisfaction increased from 37% to 88% following lateral clavicle excision, in the present study. Petersson reported that 72.5% of patients were "pleased" following their procedure.[22]

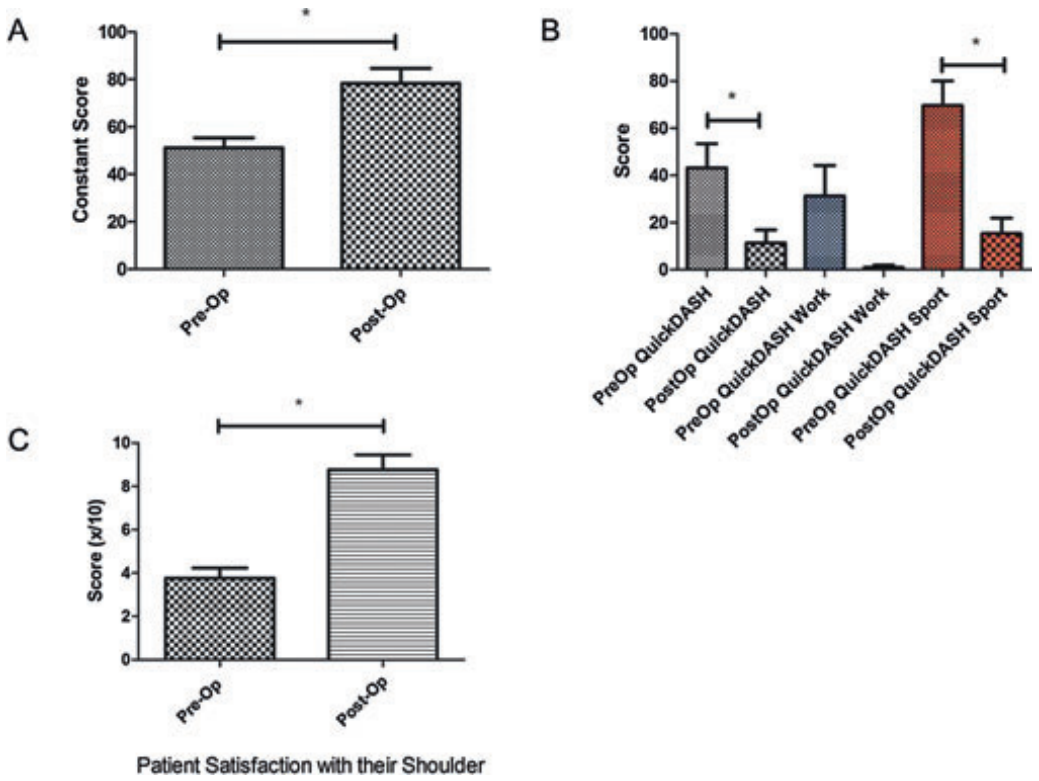

Fig. 2. A) Improvement in Constant score following lateral clavicle excision. B) Improvement in QuickDASH scores following lateral clavicle excision. C) Improvement in patient satisfaction following lateral clavicle excision.

One advantage of the current study is that all procedures were conducted by the same surgeon. This reduces the variability in surgical results between different surgeons, and as such the results obtained can be standardised to rule out any differences between differing surgical techniques. The limitations of this study were directly linked to the inherent problems of a level IV study. As such, there was no control group available to compare the results of this lateral clavicle excision surgery against.

Arthroscopic lateral clavicle excision is associated with significant improvements in post-operative shoulder outcome scores, while providing adequate pain relief and improving the range of motion of the affected shoulder, with a high rate of return to sport.

Conflict of interest

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

References

1. Scavenius M, Iversen BF. Nontraumatic clavicular osteolysis in weight lifters. *Am J Sports Med*. 1992;20(July-August):463–467.
2. Dupas J, Badilon P, Daydé G. Aspects radiologiques d'une ostéolyse essentielle progressive de la main gauche. *J Radiol*. 1936;20:383–387.
3. Ehricht HG. Osteolysis of the lateral clavicular end after compressed air damage. *Arch Orthop Unfallchir*. 1959;50:576–582.
4. de la Puente R, Boutin R, Theodorou DJ, Hooper A, Schweitzer M, Resnick D. Post-traumatic and stress-induced osteolysis of the distal clavicle: MR imaging findings in 17 patients. *Skeletal Radiol*. 1999;28:202–208.
5. Cahill BR. Osteolysis of the distal part of the clavicle in male athletes. *J Bone Joint Surg Am*. 1982;64(September):1053–1058.
6. Cahill BR. Atraumatic osteolysis of the distal clavicle. *Sports Med*. 1992;13:214–222.
7. Brunet ME, Reynolds MC, Cook SD, Brown TW. Atraumatic osteolysis of the distal clavicle: histologic evidence of synovial pathogenesis. A case report. *Orthopedics*. 1986;9:557–559.
8. Erickson SJ, Kneeland JB, Komorowski RA, Knudson GJ, Carrera GF. Post-traumatic osteolysis of the clavicle: MR features. *J Comput Assist Tomogr*. 1990;14:835–837.
9. Griffiths C, Glucksman E. Post-traumatic osteolysis of the clavicle. *Arch Emerg Med*. 1986;3:129–132.
10. Jeandel P, Garbe L, Dischino M, Martet G, Chouc PY, Dufour M. Post-traumatic osteolysis of the distal extremity of the clavicle: anatomopathologic study of 2 cases. *Rev Rhum Mal Osteoartic*. 1992;59:207–212.
11. Kahn MF, Khan MA. The SAPHO syndrome. *Baillieres Clin Rheumatol*. 1994;8:333–362.
12. Kaplan P, Resnick D. Stress-induced osteolysis of the clavicle. *Radiology*. 1986;158:139-.

[13]. Schwarzkopf R, Ishak C, Elman M, Gelber J, Straus DN, Jazrawi LM. Distal clavicular osteolysis: a review of literature. *Bull NYU Hosp Jt Dis*. 2008;66:94–101.
14. Beck A, Salem K, Krischak G, Kinzl L, Bischoff M, Schmelz A. Nonsteroidal anti-inflammatory drugs (NSAIDs) in the perioperative phase in traumatology and orthopedics effects on bone healing. *Operative Orthopadie Traumatologie*. 2005;17: 569-557.
15. Matthews LS, Simonson BG, Wolock BS. Osteolysis of the distal clavicle in a female body builder. A case report. *Am J Sports Med*. 1993;21:150–152.
16. Worcester Jr. JNJr., Green DP. Osteoarthritis of the acromioclavicular joint. *Clin Orthop Relat Res*. 1968;58:69–73.
17. Sellards R, Nicholson GP. Arthroscopic distal clavicle resection. *Oper Tech Sports Med*. 2004;12:18–26.
18. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. *Clin Orthop Relat Res*. 1987;160–164.
19. Beaton DE, Wright JG, Katz JN. Development of the QuickDASH: comparison of three item-reduction approaches. *J Bone Joint Surg Am*. 2005;87:1038–1046.
20. Scavenius M, Iversen BF. Nontraumatic clavicular osteolysis in weight lifters. *Am J Sports Med*. 1992;20:463–467.
21. Zawadsky M, Marra G, Wiater JM, et al. Osteolysis of the distal clavicle: long-term results of arthroscopic resection. *Arthroscopy*. 2000;16:600–605.
22. Petersson CJ. Resection of the lateral end of the clavicle: a 3- to 30-year follow-up. *Acta Orth Scand*. 1983;54:904–907.

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