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Treatment and return to sport following a Jones fracture of the fifth metatarsal: a systematic review

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Abstract
Purpose The aim of this study is to better inform the sports surgeon of current evidence for the treatment of Jones fractures of the base of the 5th metatarsal. The study aimed to establish what the outcomes were for different treatments modalities. By doing this, the clinician will be better prepared to institute a logical, evidence-based approach to the treatment of their patients with this injury.
Methods A thorough literature search was performed from 1980 to present day. Studies were included based on set criteria and analysed for their validity, and their results were scrutinised. Jones fractures were segregated into acute fractures, delayed unions and non-unions.
Results Twenty-six studies were included, of which 22 were level 4 evidence, with only 1 randomised controlled trial. Functional outcome data were limited to return to sports in most studies with few studies using established scoring systems. Return to sports following intra-medullary screw fixation for acute fractures ranged from 4 to 18 weeks. Acute fractures treated non-operatively had a union rate of 76 % (pooled), whereas in fractures treated with a screw it was 96 % (pooled). Delayed unions treated non-operatively had a union rate of 44 and 97 % treated operatively. Non-unions treated with screw fixation healed in 97 % of cases.
Conclusions Although supported by mostly level 4 evidence, intra-medullary screw fixation is more likely to lead to successful union of all types of Jones fractures compared to non-operative treatments. Early return to play in athletes prior to full radiological union is not advised in case of re-fracture.
Level of evidence IV.

Keywords 5th · Metatarsal · Jones fracture · Sport · Treatment

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Introduction

Sir Robert Jones first reported a unique type of fracture of the base of the fifth metatarsal in the literature in 1902. He diagnosed the injury on himself following dancing [10]. This report has since been responsible for many clinicians labelling any fracture of base of the fifth metatarsal a "Jones fracture" or variant thereof. It is important to realise, however, that Jones specifically described this fracture as being ¾ inch from the base. What he was describing was a fracture at the metaphyseal–diaphyseal junction. He was not describing a fracture of the metaphysis or the diaphysis as often represented in the literature [14, 25]. This classification proposed by Lawrence et al. is probably still the most user-friendly, separating the fractures into tuberosity, Jones-type and diaphyseal fractures, although their zonal description (type 2) is still a slight mis-representation of the true Jones fracture. Most classifications over-complicate the issue [15] but one must remember every fracture pattern is subtly different and classifications are simply a guide and not all fractures will fit a classification exactly. The treatment of fractures of the base of the fifth metatarsal may vary depending on the location of the fracture and the

expectations of the patient. Another factor that may influence the treatment is the specific type of Jones fracture. A classification proposed by Torg et al. in 1984 redefined the Jones fracture by sub-classifying it into acute, delayed or non-unions. This classification is used to guide the surgeon to the most suitable treatment option based on likely treatment outcomes, but even Torg [29] realised that the Jones fracture is difficult to define. The rate of non-union following treatment of an acute fracture is probably dependent on the type of treatment [19]. The return to activity following a fracture is often indicative of a successful outcome; however, further complications such as re-fracture can occur [13] or even prolonged significant morbidity from sural nerve injury [32]. Numerous review articles have been written by authors providing an overview and guidelines on treatment of base of 5th metatarsal fractures [6, 14, 21, 25, 33] but to date, to the authors knowledge, there has never been a systematic review detailing treatment in different types of Jones fracture in the modern literature. For the purposes of this review, the Jones fracture is referring to as a fracture of the metaphyseal–diaphyseal junction, but clearly there may be overlap or a difference of opinion between authors.

The questions this systematic review will attempt to answer are:

> What are the outcomes following different treatment modalities for Jones fractures of the base of the 5th metatarsal?
>
> > Specifically what are the complications, rates/time to union and return to activity?

Materials and methods

To attempt to provide answers for the above-focused statements, a systematic review of the literature was performed. To be able to identify the appropriate research studies, the authors applied inclusion and exclusion criteria:

All studies were retrieved from the English language literature and limited to articles published between 1980 and 2012 so as to include only studies classified according to Torgs criteria. Fractures described as a Jones fracture or metaphyseal–diaphyseal junction were included. Studies must have reported on clinical or radiological outcome, return to activity or sport, or a combination of all of these parameters. Exclusion criteria for this review included non-English language studies, expert opinions, review articles, case reports and technical tips unless they contained original patient data to fulfil the inclusion criteria. Studies with less than 5 patients were also excluded. Fractures involving the metatarsal shaft, neck or tuberosity were also excluded; however, the authors accept that some overlap can occur with classifying these injuries.

Search strategy and study identification

Commonly used search engines PUBMED/MEDLINE, OVOID and the National Health Information resources were used. Using "athlete" OR "sport" as an identifier or limits, "Human, English language" narrowed the search significantly with loss of relevant studies during initial; therefore, searching with more general terms was used.

Grey literatures such as theses/dissertations and unpublished expert data were explored and retrieved if appropriate with sufficient data. These searches included the COPAC library, ETHOS UK and journal proceedings from the Journal of Bone and Joint Surgery (British Volume). The databases were searched, and relevant abstracts were identified. It was not only definite primary research articles that were identified from abstracts but also a number of review articles and expert opinions as some of these may have also reported on primary research data within their manuscripts. All potential studies were retrieved in full and their relevance to the research question further assessed. Bibliographies of all papers retrieved in full print were then scrutinised for missing articles. Individual journals were also searched including Foot and Ankle International, American Journal of Sports Medicine and the Journal of Bone and Joint Surgery (American/British). Whilst writing the article, these searches were repeated to attempt to include all relevant recent data. The last search was performed in February 2012.

Data extraction

Data were collected on Microsoft Excel spreadsheets (Microsoft Inc., WA), and the following variables were extracted for discussion:

Patient age and gender, fracture type and Torg sub-classification: acute/delayed/non-union, intervention and operative description, rehabilitation procedure, that is, non-weight bearing, weight bearing, plaster, etc., complications encountered, radiological and clinical time to union, return to sporting activity and documented length of follow-up.

Data analysis

Methodological quality of each article was assessed using the Critical Appraisal Skills Programme (CASP) [2]. The authors adapted this tool to appraise the literature and found it had good inter-observer agreement as no disagreements of significance arose as to what literature to omit or include. The final papers included were pooled where possible and discussed in the results. Data were

analysed descriptively by using proportions and frequencies for categorical variables. Means and ranges were used for continuous variables where appropriate.

Results

Search 1: Pubmed
Combining the terms with "OR"—Jones fracture, Jone's fracture, 5th metatarsal fracture, fifth metatarsal fracture, 5th metatarsal, fifth metatarsal: Total 648
Search 2: Ovoid SP
(jones fracture or fifth metatarsal).af 536
removing duplicates Total 411
Search 3: Health information resources/National library for health (MEDLINE, AMED, BNI EMBASE, HMIC, CINAHL, Medline from Pubmed)
fifth AND metatarsal AND fracture.af 698
"Jones fracture".af 228
5th AND metatarsal AND fracture.af 110
Combine all with "OR" Total 872

Following the database searches and journal abstract searches, forty-five studies were retrieved in full for further analysis. No additional data were found searching library databases for post-graduate studies. The majority of studies were level 4 evidence. Seventeen studies were excluded from final analysis on the basis of criteria as set out in Table 1.

This left a total of twenty-eight articles found with adequate inclusion criteria and relevance to the systematic review. The levels of evidence were as follows: I-1, II-1, III-2, IV-24.

Two studies were written to analyse failures of treatment of this fracture type, thus were not representative of a normal population with this fracture and were considered separately in the discussion [8, 30].

Study demographics

In the twenty-six studies (i.e. not including two analysis of failure studies), there were a total of 630 fractures. Where stated, all studies included 437 male and 154 female patients with ages ranging from 15 to 80 years. Mean documented follow-up was 2.5 years.

Table 1 The studies excluded from the detailed review

Study exclusion criteria	Number of studies
(a) ≤5 Fractures	4
(b) Outcome not specified for the fracture type	3
(c) Inadequate or poorly defined outcome measures	2
(d) Not a definite Jones fracture	3
(e) Jones fracture sub-type or number not clear	5

Outcomes assessed

All studies reported on success or failure of bone union. This was either indicated by a time to clinical union, time to radiological union or time to return to sport. Where it simply stated "time to healing or time to union", this was assumed to indicate radiological healing as patients had radiographs on follow-up according to the methods used. It was not clear from some studies when union for particular fracture sub-types occurred to allow return to activity but all reported on success or failure of bone union. This was adequate as an outcome to be considered for inclusion as all studies recorded their complications; hence, any delay or failure to unite would have been detailed in the study. Only three authors used varying functional assessment scoring systems [5, 23, 24] and did not contribute to the pooled study data.

Surgical intervention

Three hundred and fifty-eight fractures were treated surgically. Those treated with intra-medullary screws included AO malleolar, 4.0, 4.5, and 5.0–6.5 mm. The commonest size was a 4.5-mm stainless steel screw, the largest being a 6.5-mm screw. One study compared 4.5 and 5.5-mm screws [23]. Neither screws demonstrated significantly better clinical or radiological outcomes, however, the larger screw was more likely to cause an intra-operative fracture. Infection was reported in 6 cases (1.7 %) of which none caused long-term morbidity. Sural nerve injury was reported in 3 cases (0.8 %). Only one was following percutaneous screw insertion. In one case, it was sufficiently severe to force an athlete into early retirement following a neuroma formation after an open bone graft procedure for a re-fracture. Intra-operative fracture was reported in 5 cases (1.4 %) either a tuberosity fracture or metatarsal shaft penetration on insertion. Removal of internal metalwork was not routinely undertaken. Twenty cases in all had removal due to prominent screw heads.

Acute fractures

Non-operative management

The pooled union rate without complication was 76 %. The effect of immediate weight bearing was undetermined. Two studies clearly demonstrated immediate weight bearing with union rates of 0 % [29] and 94 % [27]. The mean time to radiographic union ranged from 7.4–47 weeks in six studies. The mean time to clinical union ranged from

8.1–21 in four studies. Return to sports ranged from 9 to 22 weeks.

Intra-medullary screw fixation

Periods of immobilisation ranged from 1 to 6 weeks. Weight bearing was variably instituted. The pooled bony union rate was 96 %. In one study, bone marrow aspirate was used with union in 96 % [20]. Time to clinical union ranged from 3 to 11 weeks; radiographic union, 4–24 weeks and return to sport, 4–18 weeks. In the 6 cases that did not heal in all studies, one remained an asymptomatic non-union, one healed with an ultrasound bone healing system, one healed with bone graft augmentation, two healed with re-screw and bone graft and one delayed union united after a platelet rich plasma injection with ultrasound.

The only level-1 evidence in this review randomised early screw fixation and casting for acute fractures [19]. The cast group was kept non-weight bearing for 8 weeks, and the screw fixation group was kept non-weight bearing for 2 weeks in a splint. Median time to clinical union was 7.5 for screws and 14.5 for casts. The median time to return to sports for casts was 15 and 8 weeks for screws ($p < 0.001$). Union rates were 95 % with screws and 67 % for casts. Details for acute fractures can be seen in Table 2.

Delayed union

The time to union or return to activity was not always clearly defined in the studies (Table 3).

Non-union

Ten studies defined outcomes in treatment of non-unions (Table 4). One study reviewed patients treated with shock wave therapy and compared to a cohort treated with screw fixation. The groups were “similar” but little else supports any case-matching. Ninety-six united with shock wave therapy and 90 % with screw fixation [7]. The pooled union rate following screws was 97 %. Autologous bone graft was used in 1 study [9]. In this study all patients, irrespective of whether they had graft or not, healed and there was no influence on time to return to sport.

Stress fractures

The studies included here defined their cohorts as stress injuries with significant prodromal symptoms and radiological findings. Zogby et al. treated 10 fractures in non-weight-bearing plaster. Three were classed as acute and 7 as sub-acute. Interestingly, time to radiographic union was much longer in the acute fractures (22 vs. 47 weeks). However, the 3 acute injuries were in non-athletes and 6/7 sub-acutes were in high-level athletes [32]. Twenty-eight were treated surgically with screws in 2 studies [4, 22]. All fractures healed clinically between 3 and 8 weeks and radiographically by 6 and 12 weeks. Return to sport was seen between 7 and 14 weeks. The use of iliac crest bone graft by Popovic et al. resulted in slightly quicker bone union on radiographs but its significance level was not noted (10.1 vs. 11.3 weeks).

Re-fractures

Re-fractures occurred in 18 patients in all studies. Details can be seen in Table 5.

Study quality

The literature was appraised using a derivative of the CASP tool. Each study was assessed with 12 questions for which the reply was YES (1)/NO (0)/DON’T KNOW (dk) as detailed in Table 6.

Most studies scored poorly with this assessment. The YES scores ranged from 5 to 9 with a mean of 6. Most studies failed to ask a pertinent research question; therefore, arguably the CASP assessment tool could have finished at question 1. Patient recruitment was defined in many studies but other failed to ascertain whether the cohorts assessed represented all patients seen with a Jones fracture. Interventions and outcomes were measured in every study; however, only a few studies measured each of clinical and radiographic outcomes along with return to sport [4, 7, 16, 18, 22, 26, 32]. Commendable for each paper is the proportion of patients followed up in the majority of papers. The outcome of any fracture could be influenced by confounding factors such as smoking, co-morbidities or injury mechanism. These were rarely mentioned. As a result, it is difficult to assess the reproducibility of these results for the general population. One factor that could influence this is the results of other studies and to determine whether any similarities exist between studies, to strengthen results seen in a study. In this review, the results of most studies are consistent with few exceptions.

There is no doubt that a single retrospective case series rarely provides strong enough evidence to influence clinical practice; however, multiple studies with additional prospective evidence can sometimes allow recommendations to be made no matter what level the evidence is. In this review, there were a number of methodological flaws in each paper, but this was a reflection of the design of each study.

Table 2 A summary of the details of the acute fractures

Author	No. of fractures	Treatment	X-ray union (weeks)	Clinical union (weeks)	Return to sport (weeks)	Union rate (%)	Complications
Fernandez	8	Non-op	9 (8–13)	–	12 (9–19)	50	4 Non-union
Low	62	i.m screw	–	–	–	95	3 Non-union, 4 re-fracture
Low	40	Non-op	–	–	–	80	8 Non-union
Porter	6	i.m screw-open	–	–	–	100	3 Screw penetrations (not clear if in acute pts)
Porter	3	i.m screw-open	–	–	–	100	–
Torg	10	Non-op weight bearing	–	–	–	0	6 Delayed, 4 non-union
Torg	15	Non-op	7.4 (6–12)	–	–	93	1 Non-union
Clapper	25	Non-op	21.2	–	–	72	7 Non-union
Khan	14	Non-op	–	–	–	57	2 Delayed, 4 non-union
Konkel	10	Non-op	14	14	–	80	2 Delayed union
Lombardi	10	Ex-fix	6.5 (6–7)	5.7 (4–9)	9 (7.5–12)	90	1 Non-union, 1 infection, 1 re-fracture
Mologne	18	Non-op	–	14.5 (8–22)	15.6 (10–22)	67	1 Delayed, 5 non-union, 2 re-fracture
Mologne	19	i.m screw-open	–	6.9 (4–11)	7.9 (4–11)	95	1 Non-union, 1 infection, 3 metal removal
Murawski	26	i.m screw-percut	5 (4–24)	–	10.1 (8–14)	96	1 Delayed union, 1 nerve injury, 1 re-fracture, 2 metal removal
Portland	15	i.m screw-open	6.75 (6–8)	–	–	100	1 Metal removal (not clear if in acute pts)
Mindrebo	9	i.m screw-open	6 (5–7)	5.5 (3–10)	8.5 (7–12)	100	–
Seitz	36	Non-op weight bearing	–	8.1 (3–64)	–	94	2 Delayed union
Inokuchi	29	Non-op	11.4	–	–	86	4 Non-union
Raikin	9	i.m screw-percut	(7–14)	–	(8–18)	100	–
Larson	8	i.m screw-open	–	–	9 (8–12)	88	1 Non-union, 1 infection, 1 re-fracture
Zogby	3	Non-op	47 (32–70)	21 (14–30)	–	100	–

i.m intramedullary, *non-op* non-operative, *ex-fix* external fixation, *percut* percutaneous, *pts* patients

Table 3 A summary of the details of the delayed unions

Author	No. of fractures	Treatment	X-ray union (weeks)	Clinical union (weeks)	Return to sport (weeks)	Union rate (%)	Complications
Hens	6	Bone graft		10	12	100	1 Re-fracture, unclear which group
Porter	10	i.m screw		–	–	100	3 Screw penetrations, unclear which group
Porter	10	i.m screw		–	–	100	–
Sarimo	20	TBW	11.8 (8–16)	9.8 (8–16)	13 (8–20)	100	1 Nerve injury, unclear which group
Torg	10	Non-op	59 (32–104)	–	–	70	3 Non-union
Torg	1	Bone graft	–	–	–	0	1 Non-union
Khan	15	Non-op	56–64	–	–	27	11 Non-union
Portland	7	i.m screw	8.3 (7–12)	–	–	100	1 Screw removal
Holmes	5	EM	14.4 (12–24)	–	–	100	–
Larson	7	i.m screw	–	–	7 (3–12)	86	3 Re-fractures, 1 non-union

i.m intramedullary, *TBW* tension band wire, *non-op* non-operative, *EM* electromagnetic fields

Table 4 A summary of the details of the non-unions

Author	No. of fractures	Treatment	X-ray union (weeks)	Clinical union (weeks)	Return to sport (weeks)	Union rate (%)	Complications
Furia	23	Shock wave	12–28	–	12	96	1 Non-union
Furia	20	i.m screw	by 12 weeks	10	20	90	2 Non-union, 2 infection, 9 metal removal, 1 re-fracture
Hens	4	Bone graft		–	12	100	1 Re-fracture unclear which group
Porter	4	i.m screw		–	–	100	3 Screw penetrations, unclear which group
Porter	11	i.m screw			–	100	–
Sarimo	7	TBW	15 (12–16)	12.6 (8–16)	19.4 (12–20)	100	1 Nerve injury, unclear which group
Torg	9	Bone graft	12.2 (10–16)	–	–	89	1 Non-union
Khan	2	Bone graft	10	–	–	100	–
Habbu	14	i.m screw	13.3 (8–20)	10.2 (6–16)	–	100	1 Neuroma, 1 infection
Holmes	4	EM	18 (12–32)	–	–	100	–
Hunt	21	i.m screw		–	12.3 (6–16)	100	1 Re-fracture

i.m intramedullary, *TBW* tension band wire, *EM* electromagnetic fields

Table 5 Details of the re-fractures sustained

	Re-fractures	Initial treatment	Fracture type	Return to sport from initial injury (weeks)	Time to re-fracture, if known (months)
Low	4	Screw	Acute	Unknown	8, 8
Zogby	1	Non-op	Stress	Unknown	12
Popovic	3	Screw	1 Acute, 2 delayed union	All at 12	4.5, 5.2, 6.0
Furia	1	Screw	Non-union	Unknown	12
Hunt	1	Screw	Non-union	Unknown	12 (car crash)
Lombardi	1	Ex-fix	Acute	7.5	Unknown
Hens	1	Reverse graft	Unknown	Unknown	Unknown
Larson	4	Screw	1 acute, 3 delayed union	10, 9, 8, 4	4.5, 3.5, 11, 4
Mologne	2	Screw	Acute	Unknown	8, 12

Non-op non-operative, *ex-fix* external fixation

Table 6 Questions used to assess the quality of the literature

Did the study address a focused issue with a question?
Was an appropriate method used to address the issue raised?
Were patients recruited appropriately?
Was bias reduced by defining the intervention, that is, op/non-op?
Were outcomes accurately measured for each fracture type?
Were confounding factors identified?
If identified, were the confounding factors taken into account?
Was patient follow-up complete (>80 %)?
Were results all clearly defined (X-ray, clinical, return to sport)
Are the results realistic?
Are the results applicable to normal populations?
Are the results proportional to other available evidence?

Discussion

The most important finding to appreciate in this review is the significant difference in union rates following non-operative treatment and screw fixation for acute fractures. To the authors knowledge, this is the first comprehensive, systematic review specific to the treatment of the Jones fracture and return to sport in the modern literature. One of the most difficult aspects of this review has been the amalgamation of studies that are all treating the same fracture because many different subtle descriptions exist. We have hopefully successfully achieved this.

A recent published meta-analysis of the current evidence base for treating proximal 5th metatarsal fractures was

performed [28]. The authors performed a meta-analysis of only two studies treating Jones fractures. Their interpretation of the data demonstrates study validity; however, they did not interpret all the relevant data, most notably non-union rates following operative and non-operative treatment, which they simply went on to discuss as a narrative review. We felt that omission of the level 4 evidence was an important error because the treatment of this condition has arguably been shaped by this literature. The author's clarity on their methodology and inclusion criteria was, however, well explained only including comparative studies and their searches seemed thorough.

Kerkhoffs et al. [12] recently published a review of treatments of 5th metatarsal fractures. They found similar results to our study but did not analyse outcomes in different sub-types according to Torgs classification.

The evidence presented here suggests that treating acute fractures conservatively is likely to lead to a higher failure rate than early surgical intervention. Two studies reported on both treatments and came to this conclusion [17, 19]. In the randomised study by Mologne et al., they concluded early cast has a higher non-union rate than early screw fixation (95 vs. 67 %). The other individual case series also suggested this. The risk of surgical intervention was low but must be taken seriously as one author reported an early retirement in an athlete due to a sural neuroma [32]. This would support the use of a mini-open approach to ensure the nerve is not damaged with screw fixation.

Stress fractures, delayed union or even non-unions treated operatively have high success rates. The main method of treatment is by screw fixation. It is worth noting that the addition of bone graft to augment internal fixation, albeit quite sporadic, did not seem to influence the rate of union in the treatment of delayed or non-unions. Alternative therapy is described here, in particular shock wave therapy and electromagnetic fields with good results. A more recent study using shock wave therapy also showed 89 % success to union using shock wave treatment 6 months following start of therapy [1]. This study included fractures of the 2nd, 3rd, 4th and 5th metatarsal and did not clearly identify the numbers or outcomes of the 5th metatarsal fractures, so data could not be accurately extracted to use for this systematic review and therefore was not included. Further randomised controlled trials are needed to assess its true effectiveness. Non-operative treatment for these fractures had questionable success. Although union may occur eventually with non-operative management of delayed unions, it is likely to be a lengthy process [29]. From reviewing the literature, there is no evidence to support non-operative management of symptomatic non-unions.

It is important to note that despite the quoted results for surgical treatments, there can be complications requiring re-operation. The pooled results need to read with caution—although the overall rate of metal removal was <10 %, the rate of secondary surgery to remove painful screws can be almost 50 % [7].

The size of screw was varied in all studies. Many authors used a 4.5 mm size. To correctly determine the size, sequential tapping to fit is likely to be the most reliable method. There is no strong evidence to recommend any specific size or type of screw.

Many of these injuries were sustained in athletes. Return to sport was unfortunately not clearly documented in all studies. In the elite athletes, return was less than 3 months in most series with low complication rates. In some studies, minimum return was less than 3 weeks. Undoubtedly, this is earlier than complete radiological bone healing, and as a result, re-fracture is often a concern. However, in the 18 cases reviewed in these studies, many authors did not consider that their patients had returned to full activity prematurely. The overall rate of re-fracture is low. Wright et al. reported a series of 6 re-fractures. Five of the 6 were elite athletes placing more recurrent and significant stresses on the bone than a non-athlete whilst probably under pressure to perform as early as possible [30]. Unfortunately, return to sport was not specified for some other studies in the re-fracture patients. Glasgow et al. analysed treatment failure and also found re-fractures in athletes. On careful review of their post-operative radiographs, many patients had incomplete consolidation just prior to allowing return to activity [8]. Many reading this may also allow athletes to return to full activity after "clinical union" but before "radiological union" has occurred. This is probably a mistake, but as Wright et al. showed in their series, even after radiological union, re-fracture soon after resumption of full activity can still occur. However, in their series of failures, their range to full union was 5.5–12 weeks [30]. We would then question their definition of bony union on radiographs. The range of time to radiological union following intramedullary screw was 4–24 weeks in this review. We would question the ability of the 5th metatarsal to solidly unite by 4 weeks. It is possible that CT scanning, despite in situ metalwork, may provide a more reliable measure of sufficient bone healing than plain radiographs and should be performed especially in the high-level athlete.

There are limitations to this study. We omitted studies from our review that do contribute to the literature on this subject but did not have sufficient detail to fulfil the inclusion criteria. We could also be criticised for omitting non-English studies. Although we used broad search terms we acknowledge some studies may have be overlooked, we tried to minimise this by further searching bibliographies and relevant journals. Literature published prior to 1980 is also widely cited [3, 11, 31] but was not included. The majority of the literature is level IV literature. The

interpretation of a Jones fracture or stress fracture adopted for this study may vary from other readers and hence may introduce selection bias whilst neglecting other studies. A meta-analysis technique was not used because of the heterogeneity of outcome measures, designs and treatments. Not all studies clearly reported on all clinical and radiological outcome parameters. Pooled outcome data only represent the averages from each study rather than individual patient outcomes, which was rarely reported.

The clinical relevance of this review is to assist the reader in generating an evidence-based approach to treating this injury on a day-to-day basis. It represents an objective summary of the modern literature, and although each study has been included based on certain criteria, they have not been critiqued individually at length, which is beyond the scope of this study.

Conclusion

Current evidence, although mostly level 4, supports intramedullary screw fixation for all types of fractures, especially in the athlete. Patients must be aware of the risks of surgery and that the metalwork may need removal. Non-operative treatment is an option with potentially good results, although outcomes are less predictable with times to union potentially increased, even in acute fractures. Early return to play in elite athletes without complete radiological union increases the risk of re-fracture, and routine CT scanning of elite athletes to confirm union is recommended. To further compare methods of treatment, it is clear that more high quality level 1 studies are required with long follow-up to truly ascertain risks and benefit for different treatments.

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