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Review

Early return to sport post maxillofacial fracture injury in the professional athlete: A systematic review

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ABSTRACT

Introduction: To summarize the current literature on return to sport times post-maxillofacial fracture injury in the professional athlete.
Materials and methods: A literature search on six databases for articles relating to maxillofacial fractures, professional athletes, and return to sport times. Study design, clinical data, and author recommendations were analysed.
Results: 17 studies were retrieved. One prospective study returned 17 athletes to competitive rugby union and soccer at 3 weeks post injury without complication. Two large retrospective studies (n = 278) returned patients to sport at approximately 7 weeks without complication. 64% (n = 7) of patients from case based studies returned to sport at 3–14 days, 4 of which utilized protective facemasks. Athletes generally returned to competition earlier for lower grade (3–10 days) compared to higher grade contact sport (21 days at least). 2 articles recommended a 3 months recovery period for combat sports. 8 articles supported the utility of protective facemasks.
Conclusion: Early return to sport (<6 weeks) in the professional athlete post maxillofacial fracture injury is achievable. The optimal clinical approach may be to grade the sport according to its impact forces, discuss an early return with reference to the available literature, the potential utility of facemasks, risks of refracture and its operative implications.

1. Introduction

Maxillofacial fractures are a common sequelae of elite level sport (Murphy et al., 2015; Roccia et al., 2008; Paoli et al., 1999). For the professional athlete, a competitive absence post injury may incur contractual and/or financial repercussions (Hickey et al., 2014), negatively impact on field performance due to deconditioning, and could impact upon an athletes psychologic wellbeing (Leddy et al., 1994; Crossman, 1997). Therefore, an early return to sport is an important patient priority.

The management challenge lies in the need to balance an early return to competition with sufficient recovery time to allow for fracture healing. The strength of fracture healing required to return to sport will not be the same for all athletes. Rather, the strength of fracture healing required to participate in competition will vary according to numerous factors including the presence and severity of collision contact during play, on field playing position, fracture location and configuration, and the use of protective equipment. The treating surgeon must therefore incorporate multiple considerations in recommending a return to sport time for the professional athlete post maxillofacial fracture injury.

To the knowledge of these authors, there are no evidence based practice guidelines on time to return to sport post maxillofacial fracture injury in the professional athlete. Currently, management may be guided by an understanding of complete fracture healing

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requiring approximately 6 weeks to be complete. This is evidenced in a survey by Mahmood et al. (2002) who investigated the management of zygomatic complex fractures in athletes amongst British maxillofacial surgeons. The most commonly recommended rest period to allow for fracture healing and return to sport was 6 weeks, possibly derived from studies on cellular processes during the fracture healing process demonstrating that remodelling of woven bone occurs from approximately 4 weeks onwards and continues for several weeks (Einhorn, 1998; McKibbin, 1978). However, given clinical context of an early return to sport decision, the assumption of a 6 week recovery period may lead to a an unnecessarily protracted competitive absence for some professional athletes.

The study's (Mahmood et al., 2002) findings underlined further issues that may have emanated from a lack of reference to an evidence base in this niche field of study. Surgeons exhibited significant practice variation, as their recommended time to return to sport varied from 0 to more than 12 weeks. Practice variation can result in suboptimal patient outcomes (Dieppe et al., 1999) and an inefficient utilization of healthcare resources (Wennberg, 2002; Pai et al., 2000). Most surgeons' reasoning behind their clinical recommendations were common sense and traditional practice rather than the evidence available in the literature. The paper reported a large disparity between these two understandings, and concluded the need for a national agreement among clinicians on management protocols.

If an evidence base could be established, this could form the basis for preliminary clinical recommendations that address the preference of professional athlete patients for an early return to sporting competition. To the knowledge of these authors, this line of inquiry has not been pursued in the form of a comprehensive systematic review of the published literature.

The purpose of this systematic review is to summarize the published data on return to sport times post-maxillofacial fracture injury in the professional athlete as reported in the literature. A secondary aim is to investigate the sporting, treatment and rehabilitation contexts of these presentations, and expert opinion recommendations. The third aim is to formulate basic recommendations on early return to sport based upon the sum total evidence and case load derived from the literature. The final aim is to delineate areas for further research that may allow for the establishment of sport and fracture specific evidence based practice guidelines in the future.

2. Material and Methods

This systematic review was performed according to the PRISMA 2009 guidelines. Key parameters for inclusion were pre-identified, including an adult patient population (age>18) sustaining facial fractures, operative or non-operative management as the nominated intervention, nil comparators, time to successful return to sporting activity as the outcome of interest. All studies that did not state a professional opinion on time to return to sporting activity after sustaining a facial fracture, or that included facial fractures of non-sporting cause or complicated facial fractures (including open fracture, and fractures involving neurovascular or ocular damage) were excluded.

On 19th of May 2018, a literature search using the full historical range was performed on Medline, Embase, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, SCOPUS, Sports Discus databases, and returned 62, 60, 0, 0, 39, and 28 articles respectively. Articles pertinent to the topic areas of facial fracture, professional athletes, and return to sport were searched using both subject headings and keywords (Table 1). Results were limited to manuscripts published in the English language. Duplicate manuscripts were removed.

Results underwent screening sequentially by keyword, title and then abstract. Articles that passed abstract screening had full text articles retrieved. The reference list of each full-text article was then reviewed for additional studies that may be eligible for inclusion. Screening and article appraisal were critiqued against the predetermined inclusion and exclusion criteria and performed by two authors (UA, EW). Any disagreement between the two authors was resolved by input from a third, senior, author (WH). Collaborative agreement of all four authors was necessary prior to inclusion of any paper.

Details of each study was recorded, including level of evidence (according to the NHMRC guidelines of statistical analysis), statistical data, case presentation, sport, fracture type, intervention, time to return to sport, complications, rehabilitation protocol, and expert opinion recommendations.

This study received no funding and has no conflicts of interest.

3. Results

Our search strategy returned a total of 229 articles across all 6 databases, including repeated articles (Fig. 1). 17 papers met our inclusion criteria, including 1 prospective (Fowell and Earl, 2013) and 2 retrospective reviews (Roccia et al., 2008; Murphy et al., 2015), 3 cases series (Procacci et al., 2009; Morita et al., 2007; Tanaka et al., 1996), 4 case reports (Walsh and Cooper, 2008; Karsteter and Yunker, 2006; Koloskie and Orr, 1992; Cascone et al., 2008), 6 review articles (Patel et al., 2017; Marston et al., 2017; Viozzi, 2017; Reehal, 2010; Malanga and Chimes, 2006; Romeo et al., 2005; Petrigliano and Williams, 2003) and 1 survey (Mahmood et al., 2002, Table 2). There was a single level 3 evidence paper, and the remaining papers were level 4 or 5. The range of fractures included nasal, orbital, zygomatic, mandibular, and maxillofacial fractures. Author recommendations were almost entirely expert opinion. Most articles acknowledged a lack of evidence and clinical guidelines.

2 prospective papers were excluded. Approximately half of the patients in the first paper were less than 18 years of age (Suggs and Cannon, 2012). The second paper had an average age of 18, however a range that extended well below our inclusion criteria (7–60, Cannon et al., 2011).

1 prospective (level 3) and 2 retrospective papers (level 4) covered a broad range of fractures in large numbers undergoing conservative and operative treatments (Table 3).

Fowell and Earl's (2013) prospective study included 19 professional and semi-professional athletes sustaining twenty fracture cases in the contact sport of football (n = 12) and rugby union (n-8s). 18 athletes returned successfully to sport without complication after 3 weeks. 2 cases (both in football) had an extended absence by factors unrelated to recovery times.

The two retrospective papers by Murphy et al. (2015) and Roccia et al. (2008) included all hospital admissions due to sporting injuries (without noting the grade of sport). The age range of the two papers included athletes below our inclusion criteria (16–67 and 11–72 years respectively). However, this data was included as the mean age met our inclusion criteria (mean age 27 and 28.5 years respectively). These papers had the highest number of cases (138 and 140 patients respectively) in both low and high impact sports. The average return to sport was approximately 7 weeks in each paper, with return to combat sport being 3 months in one paper (Roccia et al., 2008). Each paper noted no complications post return to sport. Neither paper presented return to sport data based upon fracture type, treatment or sport.

Table 1
Search strategy.

Database	Search Strategy
	Subject
Medline	facial injuries, maxillofacial injuries, exp skull fractures, zygomatic Fractures, orbital fractures, mandibular fracture, exp Facial Bones/in [Injuries), Nose in [injuries], maxillary fractures
Cochrane Databases[a]	Sports/, Athletes/, sports/or baseball/or basketball/or bicycling/or boxing/or football/or golf/or gymnastics/or hockey/or exp martial arts/or mountaineering/or exp racquet sports/or exp running/or skating/or exp snow sports/or soccer/or "track and field"/or volleyball/or walking/or exp water sports/or weight lifting/or wrestling/or youth sports/return to sport, recovery of function, rehabilitation, convalescence
Embase	face injury, face fracture, maxillofacial injury, zygomatic arch fracture, orbit fracture, mandible fracture, maxilla fracture, nose fracture Sport, athlete, sports/or baseball/or basketball/or bicycling/or boxing/or football/or golf/or gymnastics/or hockey/or exp martial arts/or mountaineering/or exp racquet sports/or exp running/or skating/or exp snow sports/or soccer/or "track and field"/or volleyball/or walking/or exp water sports/or weight lifting/or wrestling/or youth sports/ convalescence, return to sport, return to work, work resumption, rehabilitation
Sportdiscus	facial injuries, facial bone fractures, Le Fort fractures athlete discipline, athletes, elite athletes, professional athletes, African American professional athletes, professional sports, Olympic athletes recovery training, rehabilitation
	Keywords
All above databases[b]	((face or facial or maxillofacial or maxillo-facial or craniofacial or cranio-facial or zygoma or cheek bone[a] or orbit[a] or mandib[a] or maxilla[a] or jaw or nose or nasal) adj4 (fractur[a] or break[a] or broken or trauma[a] or injur[a])).mp (athlet[a] or sport[a] or olympian[a]).mp. ((return[a] or resum[a] or commence[a] or recommence[a]) adj4 (sport[a] or train[a] or play[a] or compet[a])).mp
Scopus (keywords only)	athlet[a] or sport[a] or olympian[a] or baseball or basketball or bicycling or boxing or football or rugby or golf or gymnastics or hockey or "martial art"* or mountaineering or racquet or running or skating or snow sport[a] or soccer or "track and field"* or volleyball or walking or "water sport"* or "weight lifting"or wrestling or "youth sport"* (return[a] or resum[a] or commence[a] or recommence[a]) W/4 (sport[a] or train[a] or play[a] or compet[a]) (face or facial or maxillofacial or maxillo-facial or craniofacial or cranio-facial or zygoma or "cheek bone"* or orbit[a] or mandib[a] or maxilla[a] or jaw or nose or nasal) W/4 (fractur[a] or break[a] or broken or trauma[a] or injur[a])

[a] Cochrane Database of Systematic Reviews and Cochrane Central Register of Controlled Trials.
[b] Medline, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled trials, Embase, and Sportdiscus.

13 cases were included across 3 cases series (Procacci et al., 2009; Morita et al., 2007; Tanaka et al., 1996) and 4 case reports (Walsh and Cooper, 2008; Koloskie and Orr, 1992; Karsteter and Yunker, 2006; Cascone et al., 2008, Table 3). All cases involved impact sports, with one case involving a combat sport (boxing, Karsteter and Yunker, 2006). The case selection included nasal, zygomatic, mandibular and orbital blowout fractures.

All 3 acute nasal bone fractures returned to sport in 7–8 days (Procacci et al., 2009; Morita et al., 2007), including one operatively treated case who wore a face guard for 1 month post-surgery (Morita et al., 2007). 1 old nasal fracture, treated with nasal osteotomy, returned to sport after 14 days, also with a face guard worn for 1 month post-surgery (Morita et al., 2007).

3 zygomatic fractures treated operatively return to sport in 7–10 days (Procacci et al., 2009; Cascone et al., 2008).

There were 4 mandibular fractures in total. The 3 conservatively treated cases returned to sport between 10 and 14 weeks, with a malocclusion complication noted in a female wrestler upon an early return to sport 3 weeks post injury (Tanaka et al., 1996). The single operatively treated mandibular fracture returned to sport in 3 days using nasal mask protection during competition basketball games and hockey helmets during practice (Koloskie and Orr, 1992).

There were 2 orbital blowout fractures. The first case was treated operatively, and returned to sport in 11 weeks with the use of facial protection for up to one year (Walsh and Cooper, 2008). The second case was involved in a combat sport (boxing) and treated non operatively (Karsteter and Yunker, 2006). This paper did not specify a time upon return to sport, however did specify a return to fitness tests at day 7, and completed a marathon at day 47.

Clinical recommendations are summarized in Table 4.

The protocol in the prospective study by Fowell and Earl (2013) has perhaps the strongest evidence base. For both operative and non-operatively treated cases across a range of maxillofacial fractures, he proposed a step wise increase of exercises from day 3 aerobic, to day 8 fitness and day 15 sport specific, with return to sport after day 21. There was no recommendation on a return to combat sport. This was the only study to recommend against using protective facemasks citing a lack of evidence, and also suggesting players do not favour its use as facemasks can be uncomfortable and may create a feeling of being 'targeted' during competition.

Roccia et al. (2008), in a large retrospective study, also recommended a graded increase in exercise activity. However, this protocol extended over a longer period of time, including an initial rest period until day 20 and a return to sport at day 41. This study also supported the use of protective facemask post nasal injury for an earlier return to sport. It finally included a recommendation of 3 months of rehabilitation before returning to combat sports. The second large retrospective study by Murphy et al. (2015) offered no clinical recommendations.

Whilst not recommending a specific rehabilitation protocol, case-based studies detailed return to sport pathways in selected maxillofacial fracture cases (Table 3). Tanaka et al. (1996) presented 3 conservatively treated mandibular fracture cases successfully rehabilitated by a graded increase in exercise activity after 2–3 weeks (including light exercises, swimming and running) and then a return to sport after 8–12 weeks. Morita et al. (2007), Procacci et al. (2009), Walsh and Cooper (2008) and Cascone et al. (2008) recommended protective facemasks to facilitate an early return to sport. Their cases returned to sport after 7 to 14, 7 to 10, 77, and 10 days respectively. Walsh and Cooper (2008) presented a single case who's rehabilitation included walking from 0 to 3 weeks post operatively, stationary biking from 3 to 5 weeks, running, sprinting and weight lifting 5–11 weeks, and return to sport after 11 weeks after a CT scan had confirmed healing and a custom fitted facemask manufactured. Koloskie and Orr (1992) presented a single case

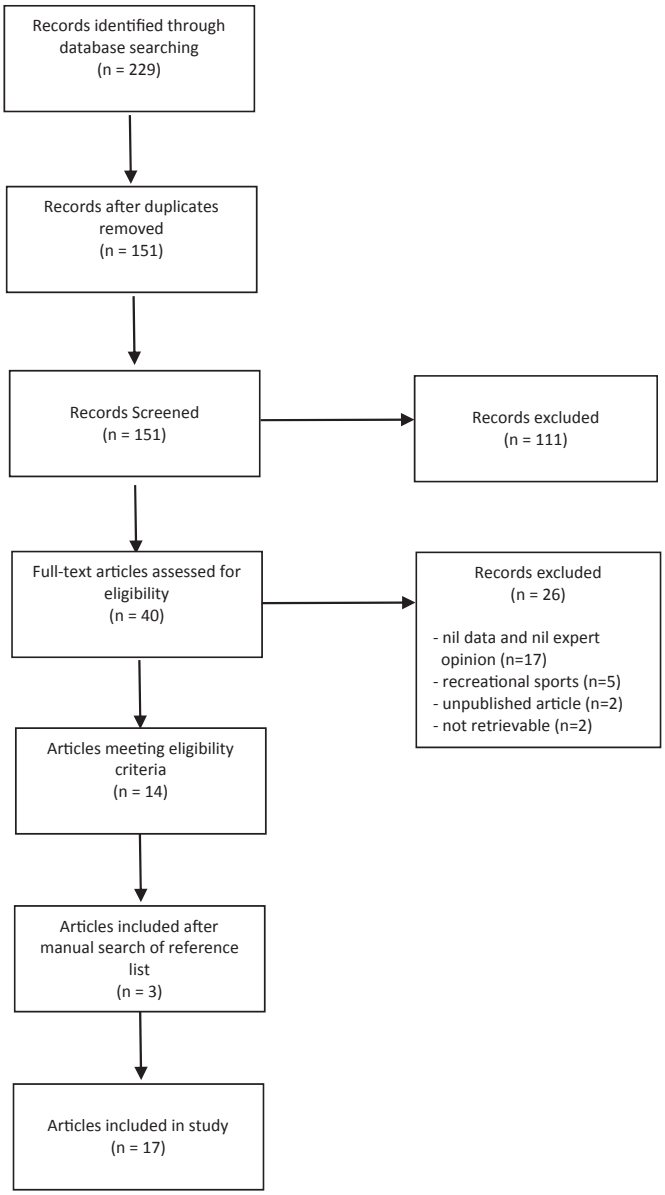

Fig. 1. PRISMA flow diagram of literature search results.

involving a college basketball player sustaining a mandibular fracture, and suggested its management pathway as a potential model for similar presentations. Both Koloskie and Orr (1992) and Karsteter and Yunker (2006) also recommended the use of face-masks for an early return to sport.

The 6 review articles (Patel et al., 2017; Marston et al., 2017; Viozzi, 2017; Reehal, 2010; Malanga and Chimes, 2006; Romeo et al., 2005; Petrigliano and Williams, 2003) and the single survey (Mahmood et al., 2002) varied widely on their return to sport recommendations (Table 4). However, the articles did generally support a graded increase in exercise activities during rehabilitation (Petrigliano and Williams, 2003; Viozzi, 2017; Patel et al., 2017; Romeo et al., 2005), and the use of protective facemasks (Petrigliano and Williams, 2003; Reehal, 2010; Viozzi, 2017; Marston et al., 2017; Patel et al., 2017; Romeo et al., 2005; Cascone et al., 2008) in certain circumstances to allow an earlier return to competition.

4. Discussion

Professional sport has grown to assume an important cultural role in modern times (Crawford, 2004). The association between maxillofacial fracture injuries and popular world sports is well established (Roccia et al., 2008; Murphy et al., 2015; Reehal, 2010). Given the increasing contractual and performance pressures faced by professional athletes (Jordet, 2009), the potential for an early return to sport post injury is an important management consideration for the maxillofacial surgeon. However, there is currently no consensus on early return to sport protocols, resulting in practice variation (Mahmood et al., 2002) and the potential for suboptimal patient outcomes (Dieppe et al., 1999).

A research challenge lies in the difficulty in comparing forces sustained during sporting collisions with the strength of bone healing of a maxillofacial skeleton fracture. Studies that quantify impact force vectors sustained during sporting collisions have been performed (Wu et al., 2007; Stidwill et al., 2009; Pellman et al., 2003). However, experimental mechanical studies that quantify the strength of bone healing at different stages would be ethically impossible. Furthermore, the judgement of union and non-union can still vary amongst clinicians (Bhandari et al., 2002; Dias et al., 1988), and healing bone strength can vary according level energy level of trauma and soft tissue condition (Karladani et al., 2001), the strength of operative repair, blood supply (Trueta, 1974), medical comorbidities (Macey et al., 1989), and smoking status (Sloan et al.,

Table 2
Summary of included studies and interventions.

Author	Location	Design	Participants	Study Subject	Level of Evidence
Fowell and Earl (2013)	Coventry, UK	Prospective	19	Facial Fractures and time in convalescence	3
Murphy et al. (2015)	Dublin, Ireland	Retrospective review	140	Maxillofacial Injuries	4
Roccia et al. (2008)	Turin, Italy	Retrospective Review	138	Maxillofacial Injuries	4
Procacci et al. (2009)	Verona, Italy	Case Series	4	Maxillofacial Fractures	4
Morita et al. (2007)	Ishikawa, Japan	Case Series	2	Nasal Bone Fracture	4
Tanaka et al. (1996)	Sapporo, Japan	Case Series	3	Mandible Fractures	4
Walsh and Cooper (2008)	Greenville, USA	Case Report	1	Orbital Blow-out Fracture	4
Cascone et al. (2008)	Rome, Italy	Case Report	1	Zygomatic and Orbital Floor Fracture	4
Karsteter and Yunker (2006)	New York, USA	Case Report	1	Orbital Blowout Fracture	4
Koloskie and Orr (1992)	Las Vegas, USA	Case Report	1	Parasymphyseal Mandible fracture	4
Patel et al. (2017)	New Jersey, USA	Review	Nil	Nasal Fractures	5
Marston et al. (2017)	Rochester, USA	Review	Nil	Nasal Injuries	5
Viozzi (2017)	Rochester, USA	Review	nil	Maxillofacial and Mandibular fractures	5
Reehal (2010)	Indianapolis, USA	Review	Nil	Facial Injury	5
Romeo et al. (2005)	Turlock, USA	Review	Nil	Facial Injuries	5
Petrigliano and Williams (2003)	New York, USA	Review	Nil	Orbital Fractures	5
Mahmood et al. (2002)	Glasgow, Scotland	Survey	Nil	Zygomatic fractures and time in convalescence	5

Table 3
Summary of participants, sport, fracture type, intervention, return to sport, and outcome measures.

Study	Participants and Selection	Sport	Fracture Cases	Intervention	Time to Return to sport	Outcomes
Fowell and Earl (2013)	19 professional and semi-professional sportsmen	Ruby union, football	12 Zygomatic complex 4 orbital 3 mandible	8 ORIF 2 elevation 9 conservative	18 cases[a] 3 weeks 2 cases >3 weeks	All players returning at 3 weeks suffered no complications 1 Player was injured in the final season game (hence leave > 3 weeks) 1 player retired from sport for factors unrelated to the fracture
Murphy et al. (2015)	140 facial Fracture	Gaelic football, soccer, rugby, equine sports, biking, hockey	59 zygomatic complex 33 Mandible 23 Orbit 20 Nasal 3 Maxillary Sinus 2 Frontal Bone 1 Le Fort	70% surgical management 41% osteosynthesis 10% closed reduction of mandibular fracture 10% manipulation of nasal bone 4.3% gillies lift Operation	7.3 weeks mean (1–18 weeks)	Return to chosen sport
Roccia et al. (2008)	138 sporting injury admissions	Soccer, skiing, horseback riding, motocross, rugby, cycling, mountain biking, swimming, baseball, basketball, bobsledding, golf, free climbing, karate, kickboxing, skating, high jump, water skiing, tennis	42 Mandible 42 Maxillo-Zygomatic/Orbital Complex 39 Orbital Walls 15 Zygomatic Arch 9 Nose 8 Le Fort 2 Frontal Sinus 2 Dentoalveolar Maxilla 1 Dentoalveolar Mandible 1 Palatal Bone	102 ORIF 9 conservative 27 closed reduction	2 patients in contact sports (Karate and Kickboxing) 3 months 136 patients in Non-contact sports 40 days	No complication 3 months post hospitalization
Procacci et al. (2009)	4 sport fractures	Soccer	Right Orbit-maxillary-zygomatic complex Zygomatic arch and orbital floor 2 × Nasal Bone	Open Reduction ORIF Closed Reduction	7 days 10 days 7 & 8 days	Nil refractures.
Morita et al. (2007)	2 sport fractures	Soccer Rugby	Nasal Bone Old Nasal Bone Fracture	Closed reduction and internal fixation with K-wire Nasal Osteotomy	7 days 14 days	Facial guards worn for 1 month after surgery, nil re-fractures
Tanaka et al. (1996)	3 Professional and amateur sportspeople	Baseball Rugby Wrestling	Right Mandible Bilateral Mandible Right Condyle and Symphysis of Mandible	Conservative 5 weeks Conservative 6 weeks Conservative 5 weeks	10 weeks 14 weeks 12 weeks	A malocclusion resulted after the professional female wrestler returned to sport 3 weeks post initial therapy
Walsh and Cooper (2008)	1 sport Fracture	Basketball	Orbital blowout	ORIF	11 weeks + time to manufacture and approve custom made face mask	The athlete returned to full sport Face shield to be worn for 1 year post injury
Cascone et al. (2008)	1 facial fracture	Soccer	Zygomatic and Orbital Floor	Operative fixation	3 days swimming 7 days training and friendly matches 10 days international competition	Customized protective face shield worn for professional matches
Karsteter and Yunker (2006)	1 facial Fracture	Boxing	Orbital Blowout	Non operative	Unspecified	Return to fitness test 7 days, marathon 47 days
Koloskie and Orr (1992)	1 sport Fracture	Basketball	Parasymphyseal Mandibular	Closed Reduction with intraoral maxillomandibular fixation and arch bars	3 days, nasal mask for games, and hockey helmet for training	Return to sport in 3 days

[a] Including 1 player with 2 case presentations.

Table 4
Summary of study recommendations in systematic review.

Paper	Level of Evidence	Conclusion and Recommendations	
		Day/s	Recommendation
Fowell and Earl (2013)	3	0–2	Complete rest post surgery
		3–7	Moderate aerobic exercise
		8–14	Full fitness (nil contact or ball work)
		15–21	Sport-specific work, build to full training
		>21	Return to sport
			Use of facemasks may be unpopular with players
Procacci et al. (2009)	4	0–30	Customized facial protection to be worn post surgery.
Roccia et al. (2008)	4	0–20	Abstention from activity post surgery
		21–30	Light aerobic exercise
		31–40	Noncontact training drills
		>41	Resumption of noncombat sporting activities
		>90	Resumption of combat sporting activities
Walsh and Cooper (2008)	4	-	Multiple facial fractures require custom fitted face shield
Karsteter and Yunker (2006)	4	-	Face shield may allow earlier return to sport
Morita et al. (2007)	4	-	Custom fitted facial guards may facilitate an early return to sport and should be worn for 1 month post surgery
			It may be useful is craniofacial surgeons themselves produce facial guards
Koloskie and Orr (1992)	4	0	Surgery
		1–3	Shooting Free throws
		>3	Return to Competitive sport
		28	Hockey Helmet for training, face masks for games
			Fitted mouthpiece
Patel et al. (2017)	5	0	Possible immediate return to the game if there is haemostasis, no airway blockage, no concomitant facial fracture, no suspicion
		0–7	of cerebral injury.
		70–84	Return to sport post minimally displaced nasal fracture (nonoperative treatment) with facemask worn for 4 weeks.
			Postoperative fixation, facemask to be worn for 6 weeks.
			Post operative fixation return to sport for patient's participating in combat sports
Marston et al. (2017)	5	0–42	No competitive sports post reduction of nasal fracture
		>42	Earlier return possible with protective facemasks
			Return to competitive sports
Viozzi (2017)	5	10–14	Aerobic and strength training post mandibular fracture, avoid contact or training that could induce clenching teeth vigorously
		>56, ideally >84	Return to sport that may impact face, including soccer or hockey
			Use protective headgear, and custom made mouth guard for mandibular teeth
			Associated ocular injury may extend recovery periods.
Romeo et al. (2005)	5	0–28	Return to sport post nasal fracture with protective device in contact sports
		0	Return to sport post nasal fracture if haemostasis is maintained
Reehal (2010)	5	-	Protective facemask is a possible option for sooner return
Cascone et al. (2008)	5	-	Protective facemask can shorten recovery period.
Petrigliano and Williams (2003)	5	0–21	Nil activity post orbital fracture surgery
		21–42	Light Lifting
		>42	Return to sport with protective eyewear
Mahmood et al. (2002)	5	21–84	Range of surgeon recommendation on resumption of contact sport post zygomatic fracture
		42	Most common recommendation to resume contact sports post zygomatic fracture

2010). A useful research approach to this niche field of study may be to summarize the reported cases published in the literature and their clinical contexts. This could highlight key clinical factors for consideration when assessing a healing fracture's ability to absorb the impact forces of sport during an early return to competition.

The studies retrieved in this systematic review indicate that professional athletes post maxillofacial fracture injury can potentially return to sport earlier that the conventional 6 week recovery period. Although these studies are insufficient evidence to formulate clinical practice guidelines, they underline important management considerations for the surgeon, including treatment modality, sporting type, and the potential utility of protective facemasks.

The retrieved studies demonstrated that an early return to sport can be exercised safely and successfully (Table 3). In the single prospective study, 18 patients suffering a variety of maxillofacial fracture injuries returned to playing ruby union or soccer at 3 weeks without complication. From case based studies, excluding the single case report that did not specify a return to sport time, 64% (n = 7) of patients returned to sport from 3 to 14 days. 27% (n = 3) of cases returned to sport from 10 to 14 weeks, however of note, they all were non-operatively treated mandibular fractures. This subset of patients included the single and only complication reported after a return to sport across all studies in the review. The two large retrospective papers (total n = 278) reported return to sport at approximately 7 weeks. However, one paper adopted a pre-set rehabilitation protocol (Roccia et al., 2008), and the both papers lacked detail for individual cases, such as what sports, fracture configurations and treatments correlated to exact return to sport times.

The literature also indicated that a sport's probability to occasion an impact collision upon a healing maxillofacial fracture could be graded, as this can influence return to sport times. Non-contact sports (such as running or swimming) often formed part of early rehabilitation exercises (Fowell and Earl, 2013; Tanaka et al., 1996; Walsh and Cooper, 2008; Koloskie and Orr, 1992) and would likely also entail an earlier return to sport. The term 'combat' was used to describe sports that involved direct high energy martial forces to the maxillofacial skeleton (such as boxing), and studies assigned protracted recovery periods (Roccia et al., 2008; Patel et al., 2017). The final category was a 'contact' sport (Tanaka et al., 1996; Walsh and Cooper, 2008; Viozzi, 2017) wherein an impact force is a potential event, although not a direct outcome or objective of the sporting activity. Combining cases from the case based studies, 6 out of 8 athletes playing low grade contact sport returned to competition in 3–10 days. The cases from Fowell and Earl's (2013) prospective study undertook predetermined rehabilitation protocols, so sport specific data could not be retrieved. Nevertheless, 19 athletes from low grade and high grade contact sports returned to competition at 3 weeks post injury.

The studies in this review also used protective facemasks in order to facilitate an earlier return to sport in nasal (Morita et al., 2007; Procacci et al., 2009) and maxillofacial fracture cases (Walsh and Cooper, 2008; Procacci et al., 2009; Koloskie and Orr, 1992). Multiple authors endorsed the use of facemasks in their recommended rehabilitation protocols (Table 4). However, athletes also reported a lack of comfort and the sense of being 'targeted' during competition (Fowell and Earl, 2013). Contrary reports indicate that facemasks allowed players to concentrate on sport participation and ironically resulted in opposing teams avoiding impact collisions (Morita et al., 2007). Cost, the availability of custom fitting services (Walsh and Cooper, 2008) and treating surgeon to provide design input (Morita et al., 2007), are factors that may limit accessibility of protective facemasks.

Based upon the trends derived from the available evidence in this systematic review, the authors of this study would support surgeons broaching the possibility of an early return to sport with patients. However, in order to incorporate the existing evidence base into a clinical context, several steps would be recommended. The surgeon would firstly need to discuss the risks of refracture and its operative implications with the patient, and most commonly prescribed healing period of 6 weeks. The patient's sport would also be classified as either noncontact, low or high grade contact, or combat, as this may directly influence return to sport times. The surgeon would ideally directly reference the available case base in the literature (Table 3) to the patient from which an early return to sport is being broached. Finally, a discussion would be required evaluating the suitability of a facemasks that factors fracture configuration, sport classification, expert opinion (Table 4) and patient amenability via discussions regarding on field comfort and visibility.

The limitations in the design of this systematic review includes its search of only 6 databases, published studies, and articles in the English language. Articles matching the eligibility criteria included only a single level 3 evidence paper, 2 retrospective papers, and case based studies including a sum total of 12 cases. Thus, the clear lack of high powered and detailed articles means that the trends and author recommendations, despite being a reflection of the best current available evidence, are quite weak. The two large retrospective studies unfortunately lacked clinical detail in the management of individual cases in order to facilitate a meaningful comparison with other studies retrieved in this review. A number of rehabilitation of protocol recommendations were also purely expert opinion (Table 4). Finally, the paucity of evidence necessitated a broad focus, and the conclusions are generalizations across different fracture configurations. In a clinical context however, different fracture configurations would entail different management considerations.

This study highlighted deficits in the available literature on return to sport post maxillofacial fracture injury. The results have demonstrated significant heterogeneity in treatment protocols, low powered study designs, and a lack of data, including outcomes on long term follow-up. Due to the porous nature of the published literature, the conclusions and clinical recommendations are weak. Future research efforts could focus on early return to sport based upon fracture configuration, operative and non-operative treatment, sport impact grade, the utility of facemasks, athlete amenability to facemasks, rehabilitation protocols, complications and patient satisfaction. This may be undertaken prospectively or retrospectively, however data would ideally be published for each individual patient case. This would allow for comparison of the various factors involved in management, and a more powerful meta-analysis in the near future.

5. Conclusion

In summary, the evidence retrieved in this systematic review demonstrates that an early return to sport in the professional athlete post maxillofacial fracture injury is achievable in the setting of multiple fracture configurations and sports. The optimal clinical approach may be to categorize the patient's sport according to level of impact forces during play, broaching the possibility of an earlier return to sport with reference to the available literature, and finally discussing the potential utility of facemasks. This would directly address the professional athlete patient's priority of an early return to sport, incorporate the available evidence, risks of refracture, and his or her own circumstances and preferences into the decision making process. Further research efforts are required for this niche

area of study, addressing each step in this management process, and this may form the basis of future fracture and sport specific clinical practice guidelines on early return to elite competition for the professional athlete.

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