A New Classification of Mandibular Fractures.

James S Brown

Ayesha Khan

Sam Wareing

Andrew G Schache

Liverpool Head and Neck Centre

Aintree University Hospital NHS Foundation Trust

Lower Lane

Liverpool L9 7AL

Tel +44(0)1515295280

Fax +44(0)1515295288

Mobile +44(0)7788136229

brownjs202@me.com

Abstract

There is no accepted method of reporting mandibular fracture that reflects incidence, treatment and outcome for individual cases. As most series include anatomical site only for all fractures, we sought to establish a new method to report fractures based on a systematic review of the literature and an internal audit.

Classification proposed:   
Class I; condyle, II; angle, IIc; II + condyle, III; body/symphysis, IIIc; III + condyle, IV; multiple fractures not including condyle, IVc; IV + condyle, V; bilateral condyle +/- other fracture(s).

10971 adult and 914 paediatric cases were analysed through systematic review, and 833 from the regional audit. Only 32%(14/44) of reported series could be reclassified which when added to the audit data showed Class IV was commonest (29%), with similar proportions of Class III, Class IIIc and Class II (18-23%). External validation (literature review) in terms of treatment and outcome was non-informative, but the internal validation (audit) demonstrated an increasing requirement for adding maxillomandibular fixation (MMF) to open reduction and internal fixation (ORIF) as class increased.

The heterogeneity of data reporting found in the systematic review confirms the need for a classification such as this, likely to enhance comparison of varying management protocols.

196 words

Introduction

The fractured mandible is a common facial injury and yet there is no generally accepted format or classification into which the fractures can be placed indicating their incidence, management and outcome or risk of complication. Initial reading of the standard text in Oral and Maxillofacial Surgery1 does not recommend a format for reporting a series of fractures, which is surprising for such a common injury frequently requiring surgical intervention. Review of all previously proposed classifications highlights their descriptive nature; relying on the anatomical position of the fracture and then including simple and compound, associated soft tissue injuries and the risk of displacement based on the muscle pull on the fragments2-4 .

The main therapeutic contention reported was with regards to the management of condylar, sub-condylar and condylar head (diacapitular)5 fractures and whether these should be treated open or closed5-7. Also contended was the management of the angle fracture; whether to use 1 or 2 plates8-9, and whether plate placement should be via a buccal or intraoral approach10.

At present the anatomical location of the fractures is most commonly reported, but there is no indication of the type and number of fractures occurring in an individual patient. This ignores any combination of the fractures which occurred and how that may influence treatment and outcome. In some series the number of patients is not stated 11,12 whilst in others a distinction is made between the single and multiple fractures, with a clear indication of the site of the single fractures,13 yet only limited data on those with multiple injuries13,14.

The lack of a viable and useable method to classify and report these fractures as they occur in an individual patient has meant that no consensus exists with regards to incidence, treatment or complications. We propose a novel classification and aim to assess its capability to describe increasing complexity of presentation and management. It is our objective to propose a new method of recording mandibular fractures capable of ascribing increasing complexity of presentation and management and outcome, through a systematic review of the literature and our own experience, with a planned audit. With this data we hope to confirm the value of such a proposal, use the data to suggest the current classification and through internal and external validation assess its quality and potential value.

Method

A systematic search of the literature was undertaken to examine the methods used to report

mandibular fracture series, and to utilise these data to derive a classification that would ensure a more accurate and comparable method of fracture documentation. The search included series reported after 1990; a date after which the method of open reduction and internal fixation (ORIF) was generally considered to have become universally accepted and applied for mandibular fractures.

The PubMed database was searched with the key words mandible and fracture in either the title or the abstract. This yielded a total of 2259 publications and the inclusion and exclusion criteria are listed below.

Inclusion criteria:

1. Retrospective mandibular series with no exclusions of a site.
2. Prospective series were included as long as all sites of the mandible were being reported on or treated.
3. Papers including a new proposal for classification
4. Isolated mandibular injury

Exclusion criteria: are numbered in figure 1 but we also excluded those papers in the search that were clearly non-contributory as follows.

1. Series including other maxillofacial injuries
2. Series with exclusion criteria based on site of fracture (excluding other sites)
3. Small Case reports and series reporting (<21 cases)
4. Other topics from the PubMed search were excluded as not relevant such as orthognathic surgery and distraction series.

Having examined the titles and abstracts, 2143 papers were excluded and a total of 91 full papers made up of the 19 additional records identified through cross referencing and the 72 downloaded from the PubMed search for full reading and assessment (Figure 1). After due analysis we were able to include 30 adult and 5 paediatric series with data that could be assessed through the site of the fractures (Table 111-40,241-45). There were 14 adult and 3 paediatric series reported with sufficient data for them to be classified into the new proposal (Table 346-59, 460-62). The search was carried out to establish primary outcomes which were the incidence of each fracture, multiple fractures, site of mandibular fracture and the number of patients. Treatment and complications/outcome were analysed including frequency of return to the operating room under general anaesthesia (GA) within 90 days. Secondary outcomes were the method of treatment and other outcome criteria such as malocclusion and infection rates.

Quality assessment of the included studies was based on the Newcastle-Ottawa Scale (NOS) for cohort studies63. The assessment is based on the following criteria:

1. Selectability (5 stars)
   1. Truly or broadly representative
   2. Including all patients attending with fractured mandibles
   3. No other maxillofacial injuries
   4. Secure attainment of data
   5. Prospective study
2. Comparability (3 stars)
   1. Classification system for mandibular fractures utilised in addition to anatomical site
   2. Data able to be classified into the current proposal
   3. Treatment recorded
3. Outcome (2 stars)
   1. Adequate follow-up method utilised
   2. Complications recorded

The proposed classification was determined following analysis of the mandible fracture series from the systematic review (Tables 1-4), and the approved audit of adult patients with an isolated fractured mandible treated under GA at the Liverpool Head & Neck Centre, Aintree University Hospital (also referred to as the Regional audit), from 3rd July 2016 to 31st December 2019 (Table 5). The aim was to utilize increasing Classification grade as an indicator of increasing fracture complexity and to indicate potential treatment, and risk of complication.

Having established a putative classification from published cohorts it was possible to validate the proposal with adjustments as appropriate, through the current internal audit data. Once this process was complete, and informed by the incidence, treatment and complications demonstrated in the internal validation (audit data), the published data from the systematic review was analysed to provide external validation.

Results

Following analysis of 255 papers 52 series were included (presented in Tables 1-4). Table 1 includes those 30 papers11-41 reporting adult mandibular series but without any indication as to the fracture pattern for multiply injured patients. In some cases, the number of patients with single or multiple fractures was stated as shown but how those fractures were distributed between cases was not discernable. Table 2 shows the 5 paediatric reports41-45, demonstrating a similar incidence of the anatomical site of the fractures to the adult series. Tables 3 and 4 include 14 adult46-59 and 3 paediatric60-62 series in which there was sufficient detail to be able to re-classify the fractures as proposed. Included in Table 3 is the summary data of the Liverpool Regional audit with more detailed presentation of this data in Table 5 also classified as proposed. Assessment of quality and applicability of included studies utilising the Newcastle-Ottawa scale63, is reported in table 6. Using this system adds credibility to the method and we have made some adjustments related to the specific reasons for this review. A score has been added for each publication to aid comparison of the contributions made.

Justification for Proposed Classification groups (Table 7)

A condyle fracture including condylar head or subcondylar site (Figure 2) represented 24%(3961/16238) of adult fractures reporting anatomical site only, (Table 1), compared to 8%(305/3710) for isolated fractured condyles in the classifiable group (Table 3). The paediatric results report a condyle involved in the injury in 36%(465/1285, Table 2) compared to 25%(49/195Table 4) when isolated. Similarly for an angle fracture occurring as either an isolated or combined fracture occurred in 31%(5029/16238) of adults (Table 1) but in 19%(694/3710) as an isolated fracture (Table 3). Paediatric angle fractures occurring as either isolated or combined was reported in 24%(312/1285, Table 2) compared to only 9%(18/195, Table 4) as an isolated injury. Combining body and symphysis fractures reveal this part of the mandible is fractured in 45%(7256/16238) of adults (Table 1) compared to only 23%(854/3710) arising as an isolated injury (Table 3). In the paediatric series any fracture of the body or parasymphysis occurred in 40%(508/1285 Table 2) compared to 29%(57/195) as an isolated injury (Table 4).

Angle fractures (Class II) were separated from the body and symphysis site as a fracture in this site is relatively common (Table 1-4) and there was some controversy over the best way to manage this fracture alluded to above8-10. Ramus and coronoid fractures are included in this class, as they are few in number and are unlikely to contribute to any change in proposed treatment. In a similar way we combined body, parasymphysis and symphysis into Class III (45%, 7256/16238, Table 1) which are fractures anterior to the angles in the horizontal part of the jaw, since displacement and/or instability are more likely and ORIF a standard treatment. Class IV is a multiple fracture but not involving either condyle (Figure 2). These cases are common and often require ORIF at both sites. In recognition of condylar fractures occurring as part of multiple fractures, Class IIc, IIIc and IVc were added as separate classes. The relevance of the condylar element in these double fractures is illustrated by Ellis64 who suggests deciding on ORIF of the condylar fracture per-operatively based on the mandibular movement and occlusion once the angle, body, or symphyseal fracture has been fixed. It was considered important to place bilateral fractures of the condyles into a separate Class (V), due to the complexity of this form of injury, the controversy over its management, and the reported poor outcomes6, 64.

Incidence

A comparative classification performance between internal (Regional audit) and external (Systematic review) validation cases is reported in Table 3. Having analysed the 14 studies46-59 that provided sufficient detail to be classified as proposed, and adding the data from the regional audit, we can now report that the commonest fracture involves 2 sites of the mandible excluding the condyle (Class IV, 29%(1096/3710)), followed by the anterior or horizontal part of the mandible (Class III, 23%(854/3710)). The commonest multiple fracture (>=2 sites) involving a single condyle is Class IIIc with 18% (650/3710)), which is a similar incidence to the classic angle fracture (Class II, 19%(694/3710)).

A comparison of the incidence of classifiable adult fractures in the literature and the regional audit showed comparable results. Both reported Class IV as the commonest fracture; 26%(751/2877) in the literature and 38%(318/833) in the audit of practice. Class III was more common in the literature at 25%(742/2877) compared to 13%(112/833) in the regional audit. The results were similar for Class II with 18%(522/2877) from the literature compared to 21%(172/833) from the audit and Class IIIc with 17%(498/2877) v. 18%(152/833) respectively.

The number of isolated condyle adult fractures (Class I) was 9.4%(270/2877) in the literature compared to 4.2%(35/833) in the regional audit (Table 3). An aggregation of any mandibular fracture involving the condyle was found in 30%(862/2877) of cases in the literature and 28%(231/833) in the audit (Table 1). Less common fractures were similarly distributed in both the literature and the Regional audit; class IIc (1.0%(30/2877) v. 1.9%(16/833), Class IVc at 1.3%(36/2877) v. 1.7%(14/833) and Class V, 0.98%(28/2877) v. 1.7%(14/833) respectively.

The results from those series reporting paediatric fractures demonstrated contrasting findings to the adult literature in that Class I occurred in 25%(49/195) of cases compared to 4.2-9.4% in the adults (Table 4), and the commonest injury was Class III at 29%(57/195) comparing to 13-25% in adults. Class IV was less common for paediatric cases with 14%(27/195) comparing to 26-38% in adults although the incidence of Class IIIc was similar at 19%(38/195) compared to 17-18%. The less common fracture sites are confirmed in the paediatric series with Class IIc at 1.0%(2/195), Class IVc with none reported and Class V at 2.1%(4/195.

When considering the incidence of fractures per patient with data useable from the anatomical site only reports (Table 1,2), the number of patients was included in most studies, as well as those reclassified (Table 3,4). For those studies reporting only the anatomical site but including the number of patients there were 1.45 fractures per patient in adults compared to 1.41 in paediatric series. For those classifiable studies the fractures per patient was 1.48 from the review, 1.63 from the Regional audit and 1.51 for the total adult group. There were 1.36 fractures per patient in the classifiable paediatric series inferring a lower rate of multiple injury in both paediatric cohorts.

Treatment

Although different methods of treatment for fractured mandibles were reported, variability in the format of data presentation did not allow the management of individual patients to be discerned, hence there was minimal validation for this aspect of care possible (Tables 1-4). For the 10971 adult fractured mandibles (Table 1,3) and 914 paediatric cases whose management could be ascertained (Table 2,4), the methods of treatment have been recorded as far as possible and included in a column in the Tables. If the data from Table 1 and 3 (adults) are consolidated in terms of treatment intent to conservative, closed reduction, or open reduction and internal fixation (ORIF); which may have included MMR or a combination, an analysis of results can be made as follows. Conservative treatment was provided for 15%(705/4567), closed reduction for 31%(1415/4567) and ORIF with or without MMR for 54%(2484/4567). In the paediatric series (Tables 2 and 4) conservative treatment was provided for 14%(167/1172), closed reduction for 63%(731/1172) and ORIF with or without MMR for 23%(274/1172).

There were individual reports, however, which do show validation, and an increasing tendency for operative intervention as the Classes increase. Adi15 reported on 378 patients of which 19%(72/378) were treated conservatively with 76%(55/72) of this group having single fractures, 18%(13/72) with doubles and 5.6%(4/72) with triple fractures. Hence the use of fixation techniques increases with increasing complexity of injury. In the study by Lee29 more detail of the sites of single fractures was shown with condyles (Class I) managed conservatively in 79%(166/211, angles (Class II) 41%(111/269), body/parasymphysis/ symphysis (Class III) 24%(29/123), and for fractures involving more than one site (Classes IIc, IIIc, IV, IVc and V) only 13%(55/406) could be treated conservatively. Valuable validation was also available from the paediatric series with Feriera41 showing increasing use of ORIF from condylar fractures at 1%(2/213), angles/ramus/coronoid at 21%(41/194), and body/parasymphysis/symphysis at 36%(116/322), although this included multiple fractures as reported by site rather than patient. In the same way closed reduction decreased in frequency from 87%(185/213) for condyles to 71%(137/194) for angles, and 60%(192/322) of body/symphysis/parasymphysis fractures. The difference was less striking for conservative management at 12%(26/213) for condyles, 8.2%(16/194) for angles and 4.3%(14/322) for the body/parasymphysis/symphysis group. Smith43reported a difference of 50.7% ORIF for multiple fractures compared to 11.8% of single fractures which was significant at p<0.05. The difference was similar for adverse outcomes with 54.6% in multiple fractures compared to 17.4% in single fracture cases (p<0.05). Kao45 had similar results in that 25%(38/250) of patients were treated conservatively and these were very likely to be single fractures showed statistically (p=0.007).

The data from the Regional audit was also non-informative as far as validation of treatment intent is concerned as the vast majority of patients (98%, 815/833) were treated by ORIF (Table 5). We can report, however, that MMF alone was most commonly used for Class I (34%, 12/35), but for only 3 other cases in Class III, IIIc and IV (1.7%,3/172). The combination of additional MMF for ORIF cases was used 50% (116/231) of the time if a condyle was included compared to 8.3% (50/602) when not part of the injury. In order to further validate the treatment of condylar fractures the current series demonstrated the use of ORIF for a single condyle (Class I) in 66% (23/35) of cases compared to 22% (44/196) when another fracture was present. In the literature search there was one study that reported fractured condyles treated by ORIF in 66% (14/21) cases and although not distinguishing between single and multiple fractures there was only 1 case of a single condyle indicating that 95% (20/21) were multiple fractures52.

Complications

Complications were not always included in the literature but there were 5271 adult patients that could be analysed and 830 from the paediatric series. In a similar way to the treatment there was no useful data from the Literature (external validation) matching the rate of complication to a type of fracture and how it was treated. Prospective ramdomised studies did report specific complications and treatment but this was always in a single fracture site such as the angle8-10, and so did not fulfil the inclusion criteria. As can be seen from the way that complication data is presented in most mandibular series (Table 1-4), we are unable to discern either the most likely treatment or outcome relating to the site and number of fractures per patient. The major complication (requiring a second operation under GA in the Regional audit data was evident in 3.4% (28/833) of cases (Table 5). It was also apparent that the risk of a major complication increased from 1.5% (3/207) in Classes I and II to 4.0% (17/430) in Classes III and IV (Table 5).

Discussion

This proposed classification (Table 6, Fig 2) provides a method of reporting mandibular fractures accurately, including isolated and multiple injuries per patient and offering the potential to increase our knowledge and understanding of the management and outcome. In Tables 1 and 2 we have shown that simply reporting the site of each fracture without indicating a single or multiple fracture for each patient is too simplistic and belies the complexity of the injury. In particular it is not possible to know how individual types of fracture were treated nor their outcome. By introducing the classification as proposed, the accurate reporting of several critical elements of mandibular fractures is possible; frequency of multiple mandibular fractures, fracture location, and individual patient’s management and outcome.

Incidence

An isolated condyle or subcondylar fracture was less common in this series of patients (8.2%(305/3710)) and although it is considered important to include Class IIc, IVc and certainly Class V, these cases are infrequent. Although the classifiable paediatric case series is small (3 publications60-62), it shows that a multiple fracture not involving either condyle (Class IV) is less likely at 14%(27/195), but there is a higher incidence of fractures involving the anterior or horizontal part of the mandible with 29%(57/195) in Class III, and 19%(38/195) in Class IIIc.

Evidence derived from the 8 paediatric mandibular series41-45, 60-62 demonstrate that this classification can work well in this age group and the differences in management and incidence we hope can be more accurately assessed. There was only one study reporting an edentulous mandible series38 so a comparative analysis was not worthwhile, although we feel that these cases can be incorporated into this proposal.

The non-classifiable studies identified in the systematic review (Table 1,2) confirm a high number of multiple fractures involving the mandible, The number of fractures per patient was reported in most of these series and hence we can summarise that in the non-classifiable data there were 1.45 fractures per patient in adults and 1.41 in the paediatric series. This contrasts with 1.51 fractures per patient in both the adult and paediatric classifiable series (Table 3,4). This similarity in the results provides a degree of assurance that this proposed classification can be accurately applied.

Treatment

Many of the studies in the literature reported the treatment of the fractures as a frequency of treatment intervention types rather than which type of fracture (single or multiple), was treated by any particular technique. By analysing the literature in detail, we have tried to show the management options reported. The results do show that single fractures (Class I, II and III) are more frequently treated conservatively15,29,41,45, but apart from Class I we have no data showing Class II are treated more conservatively than Class III. The data from the Regional audit (internal validation) series shows a preference for ORIF in all fractures with Class II 95%(165/172), Class III 94%(106/111) and Class IV 87%(276/318), but there are some differences in the choice of treatment related to multiple fractures including the condyle. If a condylar fracture is part of a multiple injury the regional audit data demonstrated that a combination of ORIF and MMF was required more frequently; Class II using this technique in 2%(4/172) v. IIc 75%(12/16), Class III at 5%(5/112) v. IIIc at 54%(83/152) and Class IV at 13%(41/318) v. IVc 43%(6/14). Also within these data was confirmation of a preference for ORIF alone for the condyle when this fracture is isolated (Class I) at 66% (23/35) compared to 25%(4/16) in Class IIc, 24%(36/152) in Class IIIc, and 14%(2/14) in both Class IVc and V.

Complications

The incorporation of deranged occlusion, fracture displacement, fracture mobility, comminution, compound or simple and associated soft tissue injuries for inclusion into the proposed classification was considered. These additional points would have to be qualified adding a further complexity to the system and reducing its chances of routine clinical use. We also considered the use of a severity score system described for facial and skull fractures66. Although it is acknowledged that the presence of other fractures will have an impact on the decision for the treatment of the mandibular fracture their inclusion would complicate the classification into a scoring system of which none have been widely adopted.

Reporting of outcomes was not evident in the majority of series analysed, and in others the incidence and type of complication could not be explored within the context of the classification as fracture sites only were included. Even within Table 3 and 4 showing series that could be classified, the complications could not be ascertained from the point of view of each Class. In the Regional audit dataset (Table 5) we have only included patients that had a further operation within 90 days. We can report, however, that this complication increases from 1.5% (3/207) in Class I and II to 4.0% (17/430) in Class III, IV.

The difficulty in finding appropriate validation data for this proposal in terms of treatment and complications from the literature emphasises the importance of adopting a more standardised approach to reporting.

Limitations

There was demonstrable heterogeneity in the quality of data from the systematic review as would be expected from retrospective case series (Table 6). It could be considered a limitation of the proposal not to include more complex fractures in class I involving the temporomandibular joint itself or the condylar head, but it was our view that adding these additional factors5,67,68 would make this basic reporting tool too cumbersome. Hence if these forms of fractured condyle were to be reported, the Loukota-type classification(s) could then be utilized separately5,67,68. This proposal could be used so that Class I cases could be fully assessed and then re-classified for specific study purposes. As with any form of data presentation there is a need for simplicity and functionality which we hope to have addressed. The retrospective nature of most data sets, and indeed the Regional audit data utilised for internal validation, is a clear limitation. In particular, virtually all the patients in the Regional audit received ORIF either with or without MMF and so variability in treatment related to the classification proposed cannot be confirmed. Complications such as malocclusion, prolonged trismus, infection and/or plate removal, non-union and fibrous union have only been noted if a further GA was required. More importantly we have not reported on those fractures that did not require surgical intervention. This point is emphasised by the results of the treatment from the literature search indicating a relatively high rate for conservative treatment at 15%, closed reduction 31% and open reduction 54%. This compares to 14%, 63%, and 23% for conservative closed and open reduction respectively for paediatric cases (Tables 1-4). In the Regional audit we were concerned that retrospective data for these patients may be unreliable given the complexities of data acquisition from a broad geographical service with multiple contributing spoke hospitals. Hence, we would welcome a prospective multicentre study including all patients presenting with a mandible fracture so that the management and outcome can be fully analysed and appropriate validation and/or alteration of this proposal undertaken.

Summary and Conclusion

This report presents a robust classification system capable of emphasising the complexity of mandibular fractures and suitable for integration into clinical practice. We have effected an initial validation, however a planned external multicentre prospective study, is necessary to assess suitability for conservative treatment, closed and open surgical intervention, complications and longer-term outcomes.

In the modern era with electronic medical records becoming standard, this classification is timely. It is hoped that by providing an improved method of reporting mandibular fracture series, this will allow useful comparison in a more meaningful and appropriate academic format.

Author contribution

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| --- | --- | --- | --- | --- |
| Name of author | Data collection | Literature search | Text preparation | Conflict of Interest |
| James Brown | - | Most of the literature review | Majority of text preparation | Nil |
| Ayesha Khan | Contributed to all the data collection and method | -Minimal literature review | Contributions to text preparation methods and tables | Nil |
| Sam Wareing | Data collection including the complications | Literature review of the reported complications | Contributions to text preparation methods and tables | Nil |
| Andrew Schache | - | - | Major contribution to principle of the study and text preparation | Nil |

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Figures

Figure 1

Flow diagram of the systematic review through the PubMed database using the keywords mandible and fracture in the title or abstract after 1990

Figure 2

The Classes of fracture in diagrammatic form. Class I, II and III include single fractures +/- those also involving the condyle with Class IV and V being multiple fractures and Class V involving both condyles.

Table 1

Results of systematic review of the literature for adult series classified by anatomical site of fracture only

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Author | Year | Condyle | Angle  Ramus  Coronoid | Body | Symphysis Para symphysis | Total fractures | Total patients single fracture | Patients >= 2 fractures  (%) | Total patients | Treatment (Rx) (%) | Complications (%) | Type of study / Comment |
| Adi M15 | 1990 | 165 | 158 | 166 | 121 | 610 | 178 | 200 | 378 | Co 72(19) 55/(76) single 13(18)double4(5.6) triple Closed 296(78) ORIF 10(2.6) | NR | R (9 yrs) audit |
| Hall FC16 | 1991 | 21 | 44 | 81 | 25 | 171 | 68 | 48 | 116 | Co 0  Cl 74(64)  ORIF 42(36) | Non-U2 (4.3) | R (3yrs) Treated patients |
| Edwards TJ17 | 1994 | 99 | 194 | 81 | 116 | 491 | 164 | 160 | 324 | NR | NR | R (3 yrs) Aetiology |
| Valentino J18 | 1994 | 113 | 107 | 69 | 143 | 432 | NR | NR | 246 | NA | Inf 4(1.6) Non-U 4(1.6) | R (5 yrs) ORIF treatment |
| Terris DJ19 | 1994 | 32 | 74 | 19 | 51 | 176 | 70 | 42 | 112 | Cl 37(33)  ORIF 75(67) | Re-op 16(14) | R (4 yrs) on treatment |
| Vartanian J20 | 2000 | 5 | 10 | 11 | 14 | 40 | 9 | 14 | 23 | NA | 0 | R using bone screw fixation |
| Boole JJR21 | 2001 | 716 | 1266 | 392 | 620 | 2994 | 1655 | 689 | 2344 | NR | NR | P database (18yrs) audit |
| Wilson IF22 | 2001 | 16 | 28 | 9 | 20 | 73 | NR | NR | 42 | Co 10(24) ORIF 32(76) | NR | R OPG and CT compared |
| David LR23 | 2003 | 12 | 13 | 2 | 8 | 35 | NR | NR | 25 | Cl 13(52)  ORIF 12(48) | Minor | R comparing delayed and immediate Rx |
| Lamphier J24 | 2003 | 101 | 196 | 146 | 145 | 588 | NR | NR | 358 | Cl 112(31)  ORIF 246(69) | Non-U 26  (7.3) | R(4yrs) comparing open and closed Rx |
| Sakr K25 | 2006 | 142 | 183 | 157 | 221 | 703 | NR | NR | 509 | Cl 170(33)  ORIF 339(67) | NR | R (9yrs) Pattern of injury |
| Simsek S26 | 2007 | 287 | 356 | 313 | 325 | 1281 | 568 | 257 | 825 | NR | NR | R(9yrs) USA and Turkish cities compared |
| Adayemu WL27 | 2008 | 50 | 121 | 137 | 135 | 443 | 175 | 139 | 314 | Co 12(3.8)  Cl 261(83)  ORIF 41(13) | Inf 12(2.7)Mal 12(2.7) Non-U 8(1.8) | R (6-8yrs) Management in a developing country |
| Czerwinski M28 | 2008 | 75 | 88 | 42 | 95 | 300 | 72 | 109 | 181 | NR | NR | R (5yrs) Aetiology |
| Lee KH29 | 2008 | 358 | 552 | 221 | 326 | 1457 | 590 | 405 | 995\* | Co 361(36), Cl 65(6.5)  ORIF 569(57) | NR | P database (11yrs) |
| de Matos FP30 | 2010 | 57 | 49 | 50 | 45 | 201 | NR | NR | 126 | Co 17(13)  Cl 0  ORIF 109(87) | Inf 10(5) | R(3.4yrs) Aetiology and management |
| Martins MMS31 | 2011 | 33 | 29 | 22 | 59 | 143 | 50 | 45 | 95 | NR | NR | R (1.8yrs) Aetiology |
| Ramadhan A32 | 2014 | 176 | 93 | 42 | 95 | 406 | NR | NR | 266 | NR | NR | R audit (10yrs) |
| Boffano P33 | 2015 | 590 | 387 | 207 | 307 | 1491 | NR | NR | 997 | Cl 125(13)  ORIF 872(87) | Re-op 8(0.5) Inf 12(0.8) | P database comparing 2 centres (10yrs) all treated) |
| @Tay AB11 | 2015 | 16 | 32 | 29 | 46 | 123 | NR | NR | 81 | Co 1(1.3)  Cl 27(22)  ORIF 95(77) | AOB 1(0.8)  Non-U 1(0.8) | P Inferior alveolar nerve outcome |
| @Verma S34 | 2015 | 63 | 56 | 13 | 27 | 159 | NR | NR | 111 | Co 50(32)  Cl 9(5.7)  ORIF 99(63) | NR | R audit (3yrs) |
| Gadicherla S35 | 2016 | 133 | 187 | 102 | 429 | 851 | 459 | 194 | 653 | NR | NR | R audit (3.4yrs) |
| @Oruc M13 | 2016 | 90 | 120 | 43 | 162 | 415 | 157 | 126 | 283 | Co 14(3.4)  Cl 74(18)  ORIF 327(79) | PR 68(16) | R audit of operated fractures (5yrs) |
| Lin K-C12 | 2017 | 161 | 88 | 47 | 207 | 503 | NR | NR | 312 | NR | NR | R audit (5yrs) |
| Diaconu SC14 | 2018 | 21 | 154 | 53 | 101 | 329 | 64 | 137 | 201 | NA | Re-op 29(14) | R (3yrs) (MMF) after ORIF. |
| Samman J36 | 2018 | 103 | 63 | 23 | 49 | 238 | NR | NR | 175 | NR | NR | R (3yrs) audit for incidence and pattern of injury |
| Batbayer E-O37 | 2019 | 61 | 70 | 54 | 67 | 252 | NR | NR | 131 | NA | Re-op 8(3.2) | R Use of repositioning forceps |
| Brucoli M38 | 2019 | 105 | 42 | 114 | 24 | 285 | NR | NR | 197 | Co 56(28)  Cl 6(3.0)  ORIF 135(69) | NR | R (10yrs) Edentulous cases |
| Srinavasan B39 | 2019 | 37 | 43 | 13 | 69 | 162 | 51 | 43 | 94 | NA | Re-op 4(2.5) for PR | R audit of surgically treated cases (6 yrs) |
| Balasundran S40 | 2020 | 123 | 216 | 148 | 399 | 886 | NR | NR | 593 | NA | NR | R (4yrs) Audit of ORIF |
| Totals (%) | - | 3961  (24) | 5019  (31) | 2806  (17) | 4450  (28) | 16238 |  |  | 10289 | #Co 644/3671  (17)  Cl 1110/3671(30)  ORIF  1954/3671(53) |  | F/P 1.45  (14947/10289) |

NR: Not Reported

NA: Not applicable

R: Retrospective

P: Prospective

Rx: Treatment

Co: Conservative Soft diet and close review

Closed: MMF or External pin fixation

ORIF: Open reduction and usually plated

Re-op: Further surgery within 90 days

Inf: Infection

Mal: Malocclusion

Non-U: Non-union

PR: Plate removal

MMF: Maxillomandibular fixation

OPG: Orthopantomogram

CT: Computerised tomography scan

AOB: Anterior open bite

@: Treatment reported by fracture site rather than by patient

\*: Data on treatment includes 995 patients although total patients was recorded as 1045

#: Inclusions in this total had to have reported Conservative, Closed and ORIF techniques

Table 2

Results of systematic review of the literature for paediatric series classified by anatomical site of fracture only

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Author | Year | Condyle  Subcondyle  Condylar head | Angle  Ramus  Coronoid | Body | Symphysis Para symphysis | Total fractures | Total patients single fracture | Patients >= 2 fractures (multiple) | Total patients | Treatment (%) | Complications (%) | Type of study / Comment |
| @Ferriera PC41 | 2004 | 211 | 161 | 90 | 143 | 605  (719 by treatment) | 385 | 136 | 521 | Co 56(7.8)  Cl 504(70)  ORIF 159(22) | Reop 13(2.1) | R (9yrs) Incidence |
| Glazier M42 | 2011 | 38 | 18 | 7 | 22 | 85 | 33 | 28 | 61 | Co 0  Cl 53(87)  ORIF 8(13) | NR | R (17yrs) audit for treated patients |
| Smith DM43 | 2013 | 113 | 31 | 13 | 58 | 215 | NR | NR | 120 | Co 34(28)  Cl 45(38)  ORIF 41(34) | 54.6% multiple v 17.4% single p<0.05 | R (10yrs) audit |
| Namdev R44 | 2015 | 25 | 17 | 15 | 13 | 70 | 54 | 8 | 62 | Co 31(50)  Cl 23(37)  ORIF 8(13) | NR | R(2.5 yrs) Incidence and management |
| Kao R45 | 2019 | 78 | 85 | 69 | 78 | 310 | 41 | 109 | 150 | Co 38(25) Cl 67(45)  ORIF 45(30) | Mal/Non-U 4(1.3) Inf(1.0)  PR 2(0.7) Trismus 2(0.7), Deformity 1(0.3) | R (6yrs) audit NB >=2 fracture patients had complications (p=0.005) and 11/13 body (p=0.02) |
| Totals | - | 465  (36) | 312  (24) | 194  (15) | 314  (25) | 1285 | 513 | 281 | 914 | Co 159/1112  (14)  Cl 692/1112  (62)  ORIF 261/1112  (24) | - | F/P (1.41)  (1285/914) |

NR: Not Reported

R: Retrospective

Co: Conservative Soft diet and close review

Closed: MMF or External pin fixation

ORIF: Open reduction and usually plated

Re-op: Further surgery within 90 days

Inf: Infection

Mal: Malocclusion

Non-U: Non-union

PR: Plate removal

F/P: Fractures per patient

@: Treatment reported by fracture site rather than by patient

NB: The final total of fractures treated is 1112 rather than 914 as Ferriera42 recorded treatment by fracture rather than by patient adding 198 to the total.

Table 3

Results of systematic review of the literature for adult series classified by anatomical site but also including sufficient data to be able to re-classify into the current proposal. Including the audit results of the Head and Neck Centre Liverpool.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Author | Year | Classes | | | | | | | | Total | Treatment (%) | Complications  (%) | Type of study / Comment |
| I | II | IIc | III | IIIc | IV | IVc | V |
| Fordyce AM46 | 1999 | - | 26 | 5 | 23 | 20 | 37 | - | 2 | 113 | NA | NR | R (1yr) MMF v ORIF |
| Bolourian R47 | 2002 | - | 19 | - |  | - | 12 | - | - | 31 | NA | 0 | P ORIF and MMF |
| Dongas P48 | 2002 | 29 | 65 | - | 30 | 26 | 38 | - | - | 188 | Co 36(19)  Cl 25(14)  ORIF 127(67) | NR | R (6yrs) audit Tasmania |
| Kim Y-K49 | 2002 | 1 | 7 | - | 22 | 5 | 14 | - | - | 49 | NA | Re-op 1(2) | P biodegradable plates |
| Yerit KC50 | 2002 |  | 2 |  | 12 |  | 5 | 2 | 1 | 22 | NA | Re-op 1(4.5) | P (1.5yrs). biodegradable plates |
| Burm JS51 | 2010 | 1 | 4 | - | 4 | 14 | 12 | - | 1 | 36 | NA | PR 1(2.8) | P microplates |
| Singh V52 | 2011 | - | 11 | - | 16 | 3 | 18 | 1 | 1 | 50 | NA | 7(14) (no details) | P miniplates |
| Natu SS53 | 2012 | 7 | 6 | - | 23 | 13 | 16 | - | 1 | 66 | NR | NR | R audit |
| Eskitascioglu T54 | 2013 | 82 | 81 | 11 | 309 | 86 | 155 | 8 | 12 | 708 | Co 25(3.5)  Cl 280(40)  ORIF 403(57) | 61(7.9) (no details) | R (10yrs) audit |
| Mittal G55 | 2013 | 12 | 27 | - | 63 | 5 | 12 | - | 2 | 121 | NR | NR | R (3yrs) audit |
| Gutta R56 | 2014 | 26 | 69 | 10 | 45 | 76 | 131 | 2 | - | 359 | NA | Inf 85(8.1)  Mal 44(8.0)  Non-U 32(5.8)  Re-op 45(8.1) | R (5yrs) audit of ORIF |
| Jung H-W57 | 2014 | 67 | 155 | 3 | 127 | 168 | 206 | 9 | - | 735 | NA | NR | R (10yrs) audit of ORIF |
| Buch K58 | 2016 | 29 | 51 | 2 | 15 | 22 | 68 | 12 | 8 | 207 | NR | NR | R (4yrs) CT scans |
| Rashid S59 | 2019 | 16 | 12 | - | 60 | 22 | 17 | - | - | 127 | NR | NR | R (1yr) co-morbidities |
| Totals  (review) | - | 270  (9.4) | 522  (18) | 30  (1.0) | 742  (25) | 498  (17) | 751  (26) | 36  (1.3) | 28  (0.98) | 2877 | Co 61/896  (6.8)  Cl 305/896  (34)  ORIF 530/896  (59) | - | F/P 1.48  (4256/2877) |
| Present study | - | 35  (4.2) | 172  (21) | 16  (1.9) | 112  (13) | 152  (18) | 318  (38) | 14  (1.7) | 14  (1.7) | 833 | Cl 18(2.2)  ORIF 814(98) | Table 3 | F/P 1.63  (1361/833) |
| Totals (%) | - | 305  (8.2) | 694  (19) | 46  (1.2) | 854  (23) | 650  (18) | 1069  (29) | 50  (1.4) | 42  (1.1) | 3710 | NA | - | F/P 1.51  (5617/3710) |

NR: Not Reported

NA: Not applicable

Co: Conservative Soft diet and close review

Closed: MMF or External pin fixation

ORIF: Open reduction and usually plated

R: Retrospective

P: Prospective

Inf: Infection

Mal: Malocclusion

Non-U: Non-union

PR: Plate removal

Re-op: Further surgery within 90 days

F/P: Fractures per patient

Table 4

Results of systematic review of the literature for paediatric series classified by anatomical site but also including sufficient data to be able to re-classify into the current proposal.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Author | Year | Classes | | | | | | | | Totals | Treatment (%) | Comps related to class (%) | Comment |
| I | II | IIc | III | IIIc | IV | IVc | V |
| Munante-Cardenas JL60 | 2010 | 46 | 13 | - | 26 | 14 | 13 | - | - | 112 | Co 57(51)\*  ORIF 55(49) | Inf 2(1.8) | R (10yrs) audit |
| Naran S61 | 2014 | 3 | - | 2 | - | 10 | 7 | - | 1 | 23 | NA | NR | R (10yrs) Arch bar treatment only |
| Andrade NN62 | 2014 | - | 5 | - | 31 | 14 | 7 |  | 3 | 60 | Co 8(13)  Cl 39(65)  ORIF 13(22) | Minor only | R (5yrs) audit of closed or open reduction |
| Totals (%) | - | 49  (25) | 18  (9.2) | 2  (1.0) | 57  (29) | 38  (19) | 27  (14) | - | 4  (2.1) | 195 | Co 8(13)  Cl 39(65)  ORIF 13(22) | - | F/P 1.51  (266/195) |

NR: Not Reported

NA: not applicable

R: Retrospective

P: Prospective

Co: Conservative Soft diet and close review

Closed: MMF or External pin fixation

ORIF: Open reduction and usually plated

Inf: Infection

F/P: Fractures per patient

\*: Some patients had 7-10 days immobilization with MMF

Table 5

Audit results of the Head and Neck Centre Liverpool (Regional audit).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Classes(%) | | | | | | | | Totals (%) |
| I | II | IIc | III | IIIc | IV | IVc | V |
| No cases | 35(4) | 172  (21) | 16(2) | 112  (13) | 152  (18) | 318  (38) | 14(2) | 14(2) | 833 |
| Treatment | | | | | | | | | |
| ORIF | 19 (54) | 165 (96) | 4(25) | 106(94) | 68(45) | 276(87) | 8(57) | 3(21) | 649(78) |
| MMF only | 12(34) | 3(1.7) | - | 1(0.9) | 1(0.66) | 1(0.31) | - | - | 18(2.2) |
| ORIF & MMF | 4(11) | 4(2) | 12(75) | 5(5) | 83(54) | 41(13) | 6(43) | 11(79) | 166(20) |
| ORIF Condyle (%) | 23(34) | - | 4(5.9) | - | 36(54) | - | 2 (3.0) | 2 (3.0) | 67/231(29) |
| Complications | | | | | | | | | |
| Malocclusion | 1 | 1 | 2 | 1 | 4 | 9 | - | - | 18(2.2) |
| Non-Union |  | 1 |  | 4 | 1 | 2 | - | - | 8(0.96) |
| Infection | - | - | - | - | 1 | 1 | - | - | 2(0.24) |
| Totals(%) | 1(2.9) | 2(1.2)  2\* | 2(13) | 5(4.5) | 6(3.9) | 12(3.8)  1# | - | - | 28(3.4) |

NB \* - 2 patients refractured due to Dystonia

# - Further assault and new fracture

These 3 cases not included in totals or percentages

Table 6

Quality assessment based on the Newcastle – Ottawa assessment scale (NOS)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Author | Date | Selection | Comparability | Outcome | Score /10 |
| Table 1 | | | | |  |
| Adi M15 | 1990 | \*\*\* | \* | \*\* | 6 |
| Hall FC16 | 1991 | \*\*\* | \* | \*\* | 6 |
| Edwards TJ17 | 1994 | \*\*\*\* |  | \*\* | 6 |
| Valentino J19 | 1994 | \*\* | \* | \*\* | 5 |
| Terris DJ20 | 1994 | \*\*\* | \* | \*\* | 6 |
| Vartanian J21 | 2000 | \*\*\* | \* | \*\* | 6 |
| Boole JJR21 | 2001 | \*\* | \* |  | 3 |
| Wilson IF23 | 2001 | \*\*\* |  |  | 3 |
| David LR24 | 2003 | \*\*\* | \* | \*\* | 6 |
| Lamphier J25 | 2003 | \*\*\* | \* | \*\* | 6 |
| Sakr K26 | 2006 | \*\* | \* |  | 3 |
| Simsek S27 | 2007 | \*\* |  |  | 2 |
| Adayemu W28 | 2008 | \*\*\* | \* | \*\* | 6 |
| Czerwinski M29 | 2008 | \*\*\* |  |  | 3 |
| Lee KH30 | 2008 | \*\*\* |  | \*\* | 5 |
| de Matos FP31 | 2010 | \*\*\* | \* | \*\* | 6 |
| Martins MMS32 | 2011 | \*\*\* | \* |  | 4 |
| Ramadhan A33 | 2014 | \*\*\* |  |  | 3 |
| Boffano P34 | 2014 | \*\*\* | \* | \*\* | 6 |
| Tay AB11 | 2015 | \*\*\* | \*\* | \*\* | 7 |
| Verma S35 | 2015 | \*\*\*\* | \* |  | 5 |
| Gadicherla S36 | 2016 | \*\*\* |  |  | 3 |
| Oruc M13 | 2016 | \*\*\* | \* | \*\* | 6 |
| Lin K12 | 2017 | \*\* |  |  | 2 |
| Diaconu SC14 | 2018 | \*\*\* | \* | \*\* | 6 |
| Samman J37 | 2018 | \*\*\* |  |  | 3 |
| Batbayer E-O38 | 2019 | \*\*\* | \* | \*\* | 6 |
| Brucoli M39 | 2019 | \*\*\* | \*\* | \*\* | 7 |
| Srinavasan B40 | 2019 | \*\*\* | \* | \*\* | 6 |
| Balasundran S41 | 2020 | \*\*\* | \* | \*\* | 6 |
| Table 2 | | | | |  |
| Ferriera PC42 | 2004 | \*\* | \* | \*\* | 5 |
| Glazier M43 | 2011 | \*\* | \* | \* | 4 |
| Smith DM44 | 2013 | \*\*\*\* | \* | \*\* | 7 |
| Namdev R45 | 2015 | \*\*\*\* | \* |  | 5 |
| Kao R46 | 2019 | \*\*\*\* | \*\* | \*\* | 8 |
| Table 3 | | | | |  |
| Fordyce AM47 | 1999 | \*\*\* | \*\* | \* | 6 |
| Bolourian R48 | 2002 | \*\*\* | \*\* | \*\* | 7 |
| Dongas P49 | 2002 | \*\* | \*\* |  | 4 |
| Kim Y-K50 | 2002 | \*\*\* | \*\* | \* | 6 |
| Yerit KC51 | 2002 | \*\*\* | \*\* | \*\* | 7 |
| Burm JS52 | 2010 | \*\*\*\* | \*\* | \*\* | 8 |
| Singh V53 | 2011 | \*\*\*\* | \*\* | \*\* | 8 |
| Natu SS54 | 2012 | \*\*\* | \* |  | 4 |
| Eskitascioglu T55 | 2013 | \*\* | \*\* | \*\* | 6 |
| Mittal G56 | 2013 | \*\*\* | \* |  | 4 |
| Gutta R57 | 2014 | \*\* | \*\* | \*\* | 6 |
| Jung H-W58 | 2014 | \*\* | \*\* |  | 4 |
| Buch K59 | 2016 | \* | \*\* |  | 3 |
| Rashid S60 | 2019 | \*\* | \* |  | 3 |
| Table 4 | | | | |  |
| Munate-Cardinas JL61 | 2010 | \*\*\* | \*\* | \*\* | 7 |
| Naran S62 | 2014 | \*\* | \*\* |  | 4 |
| Andrade NN63 | 2014 | \*\*\* | \*\* | \*\* | 7 |
| Table 5 | | | | |  |
| Current audit | - | \*\*\* | \*\* | \*\* | 7 |

Table 7

Proposed classification

|  |  |
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| Class I | Condyle/subcondyle and/or condylar head |
| Class II | Angle / Ramus / Coronoid |
| Class IIc | Class II and Condyle |
| Class III | Body / Parasymphysis / Symphysis |
| Class IIIc | Class III and Condyle |
| Class IV | >1 fracture not including a Condyle |
| Class IVc | Class IV and Condyle |
| Class V | Bilateral Condyles +- other fracture(s) |