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BACKGROUND AND PURPOSE: Conventional thinking among radiologists is that the mandible acts as a closed "ring" that needs to fracture at 2 points, though the frequency of multiple mandible fractures has been reported to be only as high as 67%. However, many of these studies did not use CT to confirm the presence of suggested fractures and excluded nondisplaced fractures. The purpose of this study was to determine the incidence of unifocal mandibular fractures on the basis of detection with dedicated facial bone CT scans and to characterize these fractures.

MATERIALS AND METHODS: We retrospectively reviewed the imaging reports of patients during a 3-year period to identify those who had mandible fractures documented on dedicated facial bone CT scans. The incidence of unifocal fractures was determined, the unifocal fractures were further subcategorized, and any derangements of the temporomandibular joints were also evaluated.

RESULTS: One hundred two patients met the inclusion criteria. The incidence of unifocal mandible fractures was 42% (43/102). Three unifocal fracture patterns identified were the following: simple fractures (25/42, 58%), comminuted fractures (11/42, 26%), and fractures associated with condylar subluxations (7/42, 16%). Most fractures had none to mild displacement or distraction.

CONCLUSION: Unifocal mandible fractures occur with greater frequency than anticipated by most radiologists. This may be due to the somewhat dynamic nature of the mandibular "ring," which includes the temporomandibular joints, though joint derangements evident on CT occur in the minority of cases.

Fractures of the mandible are a common cause of morbidity from trauma. The mandible is the second most frequently fractured bone in the facial skeleton, and in the setting of motor vehicle crashes, mandible fractures are the most frequent.[1,2] Fractures of the mandible at multiple sites are common and should always be sought radiographically.[1] Conventional thinking among radiologists holds that the mandible, when considered along with the central skull base, is a closed ring that needs to fracture at 2 points. In patients being evaluated for facial fracture in emergency department settings, however, multiple sites of fracture have been reported in up to only 67.9% of patients.[1] A slightly higher percentage (69.8%) has been reported with a selection bias of only patients admitted to the hospital.[1,3] In other series, the incidence of multifocal mandible fractures has been as low as 40%.[4] Unfortunately, many of these studies did not use CT to confirm the presence of suggested fractures and excluded additional nondisplaced fractures. Helical CT has been reported to be more accurate, sensitive, and specific for the diagnosis of mandibular fractures (particularly in the posterior portions of the mandible) and to have better interobserver agreement and fracture characterization than panoramic tomography.[2,5] Thus, the true incidence of multifocality might be higher than that reported in the literature, which is based on studies in which all patients did not receive dedicated facial bone CT scans. The purpose of this study was to determine the incidence of unifocal mandible fractures on the basis of detection with dedicated facial bone CT scans and to characterize these fractures.

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Methods

Subjects: Inclusion Criteria

This study complied with institutional guidelines and was approved by our institutional review board. Using an "honest broker," we searched our electronic medical records and retrospectively reviewed anonymized imaging reports from multiple hospitals within our institutional system, to identify patients who had mandible fractures documented on a dedicated facial bone CT scan over the 3-year interval from October 28, 2002 through October 28, 2005. Imaging reports of all cases, images of all unifocal fractures, and images of select multifocal fractures in which there was any ambiguity in the report were reviewed. Images of patients with multifocal fractures were reviewed if the description in the report did not explicitly state that more than 1 fracture was present and included wording such as: "The mandibular fracture is seen just to the right of midline and extends posteriorly within the right mandible. The second fracture line is seen near the right angle of the mandible," and "A fracture is seen extending from the body of the right side of the mandible to the angle on the left." Patients were excluded if any of the following criteria were present:

- The dedicated facial bone CT did not include the entire mandible.
- Fractures occurred in a previously fractured mandible with prior open reduction—internal fixation.
- Only postoperative studies were available.
- The CT scan was nondiagnostic due to motion or technical factors.
- An underlying bone disorder or a pathologic fracture (eg, osteogenesis imperfecta, ameloblastoma) was present.
- On retrospective review, no fracture could be identified.
- The fracture was surgical (osteotomy).
- The patient was younger than 18 years of age.

Image Review

The CT scans on all patients with unifocal fractures meeting the inclusion criteria were reviewed independently by the authors, both of whom are Certificate of Added Qualification–certified fellowship-trained neuroradiologists who are dedicated to head and neck imaging. One CT scan was not available for review because the films had been lost. Discrepancies between the observers were clarified by consensus review.

Scanning Protocols

Facial bone CT protocols varied considerably because protocols and CT scanners changed during the time period spanned, and protocols also varied within our institutional system because it is comprised of multiple hospitals. Imaging protocols included the following: 1.25-mm axial images, reformatted in the coronal and optionally sagittal planes; 2.5-, 3-, or 4-mm true coronal images; 3-mm axial images and coronal images; 4-mm true coronal and axial images; 4-mm axial images; 2.5-mm axial images with 1-mm overlap and sagittal reformats. All were reconstructed on bone algorithms. Oblique sagittal reformatted images were included in 2 patients who were excluded due to their age being younger than 18 years.

Injury Classification

Each observer classified the fractures as either unifocal or multifocal. Furthermore, each fracture was classified by location and if it was comminuted and/or associated with condylar subluxation or dislocation. Condylar subluxation was defined as any side-to-side asymmetry between the positions of the condylar heads with respect to the glenoid fossa and was described as ipsilateral or contralateral to the fracture. "Subluxation" will be used synonymously with "dislocation" for the purposes of this review because generally these 2 conditions are distinguished by being spontaneously reducible (subluxation) or not reducible (dislocation), a distinction made clinically. Subluxation was evaluated on sagittal and coronal reformatted images, when available, or by a combined review of any available reformatted images and axial images if sagittal reformatted images were not available, with the best approximation of position made. Condylar position was described in the sagittal plane with respect to the articular eminence on the basis of the face of a clock, with the normal closed position (the condylar head seated in the glenoid fossa) being 3 o'clock and the near-full open position, with the condylar head sitting below the articular eminence, being 6 o'clock. Any condylar angulation was also noted. Degree and direction of fracture fragment displacement and distraction were also evaluated. Displacement/distraction was measured on either the axial or reformatted images (whichever was thought to show the fracture best) and graded as none to mild ($\leq$3 mm) or moderate or greater ($>$3 mm).

Fracture Location Classification

Fractures were classified on the basis of a modification of the classification systems proposed by Dingman and Natvig[6] and Sinn et al.[7] These are classification systems based on fracture location with the former consisting of regions of the symphysis, body, angle, ramus, condylar process, coronoid process, and alveolar process; and the latter consisting of condylar (intracapsular), subcondylar, coronoid, ramus, angle, body, and symphysis.[6,7] If fractures involved more than 1 site, they were named on the basis of their dominant site of involvement, as suggested by Dingman and Natvig.[6]

The Fracture Location Classification System used for this study was as follows:

Parasymphyseal. A fracture that occurs in the central mandible with the lateral extent not past the gap between the lateral incisors and canines.

Body. A fracture of the mandibular body, of which the anterior margin is the interspace between the lateral incisor and the canine and the posterior margin is the interspace between the second and third molars.

Angle. A fracture that involves the angle and can include extent into the third molar socket.

Condylar. A fracture that involves the condylar head or neck.

Ramus. A fracture that involves the mandibular ramus, excluding subcondylar fractures and including those that are oriented vertically in the ramus.

Coronoid Process. A fracture that involves only the coronoid process.

Subcondylar. An oblique fracture of the superior ramus at the base of the condylar neck, from the sigmoid notch to the posterior ramus.

Alveolar Ridge. A fracture confined to the alveolar ridge and not extending through the inferior aspect of the mandible.

Statistics

The proportion of unifocal fractures was tabulated, and a 95% confidence interval (CI) was calculated by using the Wilson method.[8] The classification and comminution of the fractures, along with the presence of condylar subluxation or dislocation, were tabulated with descriptive statistics for the unifocal fractures only.

Results

After reviewing the radiology reports and images of unifocal fractures (except the single case in which only a report was available) and multifocal fractures when reports were ambiguous, 41 patients were excluded, and a total of 102 patients were left in the study. Most were excluded for not having a dedicated face CT scan and/or having the fracture diagnosed only on conventional radiographs or panoramic tomographs (14 cases). After the images were reviewed, additional fractures were identified on the scans of 4 patients initially reported as having unifocal fractures.

Of all 102 eligible patients, 43 fractures were unifocal (42%; 95% CI, 33%–52%) and 59 were multifocal (58%). Of the unifocal fractures, 25 (58%) were simple unifocal, 11 (26%) were comminuted, and 7 (16%) were associated with a condylar subluxation (these fractures might be either simple or comminuted). If the number of fractures that were comminuted was evaluated without regard to whether there was associated condylar subluxation, 16 (37%) of the unifocal fractures were comminuted (Table). Most of the fractures had minimal or no displacement or distraction, though this varied with fracture location (Table). The angle was the most frequently involved site, and many of these fractures involved the sockets of the posterior molars (Fig 1). The body was the next most frequent site.

Condylar subluxation occurred in 7 cases (16%), predominantly with condylar fractures (5 out of the 7 cases with subluxation), and all of the condylar fractures (5/5) had associated subluxation. All subluxations associated with condylar fractures were of the ipsilateral condyle. All except 1 of the condylar fractures with subluxation were associated with a characteristic anterior-inferior and medial displacement of the

Location and displacement/distraction of mandible fractures

Location	No.	Percentage	Displ/Distr (none/mild [≤3 mm])	Displ/Distr Mod or Greater	Comminuted* (% of all unifocal fractures in same location)
Parasymphyseal	7	16%	2	5	4 (57)
Body†	11	26%	4	6	8 (73)
Angle	13	30%	12	1	1 (8)
Condyle or neck	5	12%	0	5	3 (60)
Ramus	2	5%	2	0	0
Coronoid process	1	2%	1	0	0
Subcondylar	2	5%	2	0	0
Alveolar ridge	2	5%	2	0	0
Total	43	100%	26/43	17/43	16 (37)

Note:—Displ/Distr indicates displacement and/or distraction; Mod, moderate.
* Comminuted includes fractures that may or may not be associated with condylar subluxation; 5/7 fractures with condylar subluxations were comminuted.
† The films for 1 of the body fractures were not available, so Displ/Distr could not be quantified.

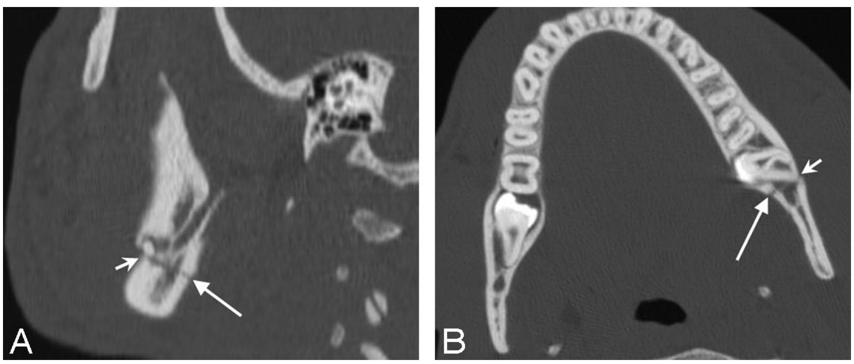

Fig 1. *A*, Sagittal reformatted image through the mandibular angle shows a nondisplaced very minimally distracted left mandibular angle fracture (*long arrow*), extending mildly obliquely anteriorly. Note that the fracture just enters the socket of the left third molar (*short arrow*). *B*, Axial CT scan shows the left mandibular angle fracture (*long arrow*) entering the socket of the third molar (*short arrow*).

Fig 2. *A*, Axial CT scan at the level of the glenoid fossa shows a right condylar fracture, with typical displacement. Note that the condylar head (*solid arrow*) is dislocated and displaced anteriorly and inferiorly from the glenoid fossa (*asterisk*) and that the ramus/neck component of the fracture (*dashed arrow*) is "telescoped" with respect to the condylar head component and displaced superiorly toward the glenoid fossa. Note the overlapping of the fracture fragments, with the condylar head component lying medial to the ramus/neck component. *B* and *C*, Coronal reformatted images through the mandibular condyle show the "telescoping," with upward retraction of the ramus/neck component (*dashed arrow*) and anterior inferior medial displacement of the condylar head component (*solid arrow*) and resultant overlap of fracture fragments. This is the typical pattern of dislocation/displacement seen in this type of fracture and was present in all but 1 of the fractures that involved the condylar head or condylar neck. (The asterisk in *C* indicates the glenoid fossa.)

condylar head and "telescoping" with upward displacement of the ramus or condylar neck component of the fracture (Fig 2). The remaining condylar fracture was associated with rotation of the condylar head, with mild widening of the joint space, as well as telescoping with upward displacement of the ramus component. The other 2 fractures associated with condylar subluxation were a mildly comminuted fracture of the posterior body, with a contralateral lateral subluxation, and a comminuted right parasymphyseal fracture with contralateral inferior, lateral, and anterior subluxation. Five other cases had mild temporomandibular joint asymmetries, but these were likely due to factors other than trauma and included the following: the appearance of slight ipsilateral joint space narrowing likely due to patient rotation, a likely degenerative joint space narrowing of the contralateral side, a contralateral joint space widening likely due to the effects of a large osteophyte, ipsilateral joint space narrowing likely due to degenerative changes, and ipsilateral joint space widening likely due to a developmentally small hemimandible and associated degenerative changes. The remaining joints did not demonstrate any additional derangements, asymmetries, or rotation.

Most comminuted fractures involved the body, with a similar percentage of the parasymphyseal and condylar fractures being comminuted, and proportionally fewer of the angle fractures were comminuted.

Discussion

As prior studies have shown, mandibular fractures are more frequently multifocal but occur as unifocal fractures a substantial proportion of the time.[1,3,4] Mandibular fractures have been classified in a variety of ways, and because there is no definitive classification system used in all publications, we chose to use modifications of 2 of these systems, those of Dingman and Natvig[6] and Sinn et al.[7] These 2 classification systems are based on anatomy, and we chose to modify these systems on the basis of the patterns of fracture that we most commonly observed. Thus, our modifications consisted of using "subcondylar" from the Sinn et al classification to refer to a fracture that extends through the condylar base at the sigmoid notch, rather than classifying this fracture as "region of the condyle" as in the Dingman and Natvig system. Likewise, we have reclassified the "region of the symphysis" and "symphysis" to "parasymphyseal," because this term is more accurate. The Dingman and Natvig system describes the "region of the angle" fracture as "a triangular region bounded by the anterior border of the masseter muscle and an oblique line extending from the mandibular third molar to the posterior superior attachment of the masseter muscle," and the Sinn et al classification, though not as specific with respect to the relationship to the masseter or exact boundaries, includes the extent into the socket of the third molar. We have noted this to be a common extension of angle fractures, so we have included the socket of the third molar as our anterior boundary.

We have not been as rigid with respect to the overlying masseter muscle, similar to Sinn et al,[7] and consider the angle to be the general region of curvature. Otherwise our system is quite similar to that of Dingman and Natvig.[6] Few of the current articles have described in detail their classification schemes, other than to list the sites without explicitly defining them, particularly with respect to regions that may include the ramus.[1,3,9] In some of the larger series describing mandibular fractures, Greene et al[3] do not include ramus at all in their categorization scheme (but do include subcondylar, angle, and coronoid process). King et al[1] include ramus, subcondyle, and angle but do not specifically mention coronoid process; and Rhea et al[9] include ramus, coronoid process, and angle. In studies in which the ramus is considered a separate site, it has a low incidence of fracture (Stacey et al,[10] 3%; King et al,[1] 5.7%). Likewise, there is discrepancy in the literature in the separate classification of condylar from condylar neck fractures. We chose to group these together, as did Lindahl,[11] (though he included subcondylar fractures as well), though there was a difference in the pattern between fractures that involved the condylar head (tendency for anterior-inferior dislocation of the head from the glenoid fossa and upward retraction of the neck component) versus isolated fractures of the neck (less likely to be have significant displacement and dislocation).

There have been few published studies comparing CT with panoramic tomography in the evaluation of mandibular fractures. Wilson et al[5] compared panoramic tomography and CT and found that 7 fractures in 6 patients (of 42 patients with 73 fractures) were seen only on CT. Six of the 7 missed fractures were in the posterior mandible (angle, ramus, or condyle/subcondyle), and 1 was symphyseal/parasymphyseal. Because CT was the gold standard in this study, its false-negative rate was unknown. Rhea et al[9] state that the sagittal condylar fracture cannot be seen by radiographs and that condylar fractures are the most frequently missed facial fracture. Roth et al[2] evaluated CT-versus-panoramic tomography for fracture detection, characterization, and physician agreement and found that all fractures not seen by panoramic tomography but seen on high-resolution CT were in the angle, ramus, or subcondylar region and that there was greater interobserver agreement with CT than with panoramic tomography. Therefore, from these few studies, it would seem that CT is more sensitive than panoramic tomography, particularly for fractures of the angle, ramus, or condyle. The incidence of unifocal fractures in our study was concordant with the existing plain film, panoramic tomography, and mixed-technique literature, despite the assumed higher sensitivity of CT that might be expected to yield a lower incidence of unifocal fractures.

Presumably, unifocal mandibular fractures can be explained by the temporomandibular joints absorbing force, transiently (or permanently) subluxing or rotating to allow this higher than anticipated incidence of unifocal fractures. Although one might expect that there would be CT evidence of either ipsilateral or contralateral mandibular condylar subluxation (referred to as displacement by some authors) or dislocation in most unifocal fractures, this was not the case. Subluxations were seen in only 7 cases, whereas slight asymmetry in the joints was seen in a slightly smaller number; however, in most of these latter cases, this finding could be potentially explained by other etiologies, such as degenerative changes, patient rotation, congenital anomalies, and intubation. It is possible that these other factors lead to some laxity of the joint as well, though future studies would be necessary to evaluate this. There is the possibility that internal derangement or ligamentous or capsular injury to the temporomandibular joints may occur in many of these cases but without a malalignment of the mandibular condyle within the condylar fossa, CT would be insensitive to this. MR imaging could potentially reveal injuries such as these. Also, because we do not have clinical correlation or follow-up for our cases in which the temporomandibular joints appeared normal or for those in which mild asymmetries were ascribed to causes other than the acute trauma, we cannot exclude the possibility that some of these joints may have been injured. A study evaluating all of these joints with follow-up MR imaging and clinical evaluation would be necessary to definitively evaluate this question.

Lindahl[11] found, in a study of mandibular condylar fractures (this includes head, neck, and subcondylar fractures), that in unilateral fractures in adults (older than 20 years), 17 (27%) patients did not have any condylar subluxation or dislocation, 32 (52%) had mild-to-moderate subluxation (which they refer to as displacement), and 13 (21%) had condylar dislocation.[11] Most interesting, he also found that the incidence of isolated unilateral condylar (or subcondylar) fractures (no additional mandibular fracture present) was 73 of 108 (68%). Unfortunately, it is not possible to tell from his data the relationship between isolated condylar fractures and condylar subluxation/dislocation, so direct comparison with our data cannot be performed, though the incidence in our study may be lower. His data are based entirely on radiographs, including orthopantomograms, and no CT scans were used.

One of the more evident limitations to our study is the diversity of imaging protocols used. This reflects the studies being performed at multiple hospitals within our institutional system, which includes both community hospitals and a large academic hospital, each with its own imaging protocols and CT scanners. Although axial images were available in most cases, a few studies consisted of coronal images alone. There was also variability in the creating of coronal and/or sagittal reformatted images. There is the potential that this variability could lead to a subtle additional fracture not being detected, potentially decreasing the incidence of unifocal fractures, but this is probably unlikely because all scans included were considered of diagnostic quality and considered "dedicated facial bone CT scans" by the radiology departments obtaining them. However, the lack of the availability of both sagittal and coronal reformatted images in all cases probably does limit the detection of subtle temporomandibular joint widening. A study using standardized protocols on a multisection scanner with both sagittal and coronal reformatted images performed in all cases would be a more ideal situation and could be the basis for future studies.

There is also the possibility that subtle mandibular fractures, either single or multiple, were missed on trauma facial bone CT scans, causing mandibular fractures that may have occurred during the inclusion period to be omitted from our data because only those fractures that were reported were included. It would have been ideal to have been able to review all the trauma facial bone CT scans obtained during the 3-year interval; however, due to the sheer number of scans obtained at our institutions (thousands over the 3-year interval), review of all of these scans would be logistically difficult and impractical. Because our study evaluated the incidence of unifocal mandibular fractures with respect to all mandibular fractures (rather than the incidence of unifocal mandibular fractures in all trauma facial bone CT scans), one could assume that if all the trauma facial CT scans were reviewed, there would likely be a higher incidence of unifocal mandibular fractures because it is probably more likely that a unifocal fracture would not be reported than a multifocal fracture, and thus it would be unifocal fractures that would be omitted from our data. In fact, this supposition is supported by the fact that 4 of our "unifocal fractures" were reclassified as multifocal fractures on further review.

Conclusion

Unifocal mandible fractures occur with greater frequency than anticipated by many radiologists. This may be due to the complex somewhat dynamic nature of the mandibular "ring," which includes the temporomandibular joints, though radiographic subluxation is present in only a minority of cases and occurs most commonly with condylar fractures. Although radiologists should always seek out a second site of mandibular fracture, in a significant percentage of patients, a second fracture site will not be identified.

References

1. King RE, Scianna JM, Petruzzelli GJ. **Mandible fracture patterns: a suburban trauma center experience.** *Am J Otolaryngol* 2004;25:301–07
2. Roth FS, Kokoska MS, Awwad EE, et al. **The identification of mandible fractures by helical computed tomography and panorex tomography.** *J Craniofac Surg* 2005;16:3940–49
3. Greene D, Raven R, Carvalho G, et al. **Epidemiology of facial injury in blunt assault: determinants of incidence and outcome in 802 patients.** *Arch Otolaryngol Head Neck Surg* 1997;123:923–28
4. Sakr K, Farag IA, Zeitoun IM. **Review of 509 mandibular fractures treated at the University Hospital, Alexandria, Egypt.** *Br J Oral Maxillofac Surg* 2006;44:107–11
5. Wilson IF, Lokeh A, Benjamin CI, et al. **Prospective comparison of panoramic tomography (zonography) and helical computed tomography in the diagnosis and operative management of mandibular fractures.** *Plast Reconstr Surg* 2001;107:1369–75
6. Dingman RO, Natvig P. *Surgery of Facial Fractures.* Philadelphia: WB Saunders; 1964:142–45
7. Sinn CA, Hill SC, Watson SW. **Mandibular fractures.** In: Foster CA, Sherman JE, eds. *Surgery of Facial Bone Fractures.* New York: Churchill Livingstone; 1987:177–78
8. Newcombe RG. **Statistical applications in orthodontics. Part II. Confidence intervals for proportions and their differences.** *J Orthod* 2000;27:339–40
9. Rhea JT, Rao PM, Novelline RA. **Helical CT and three-dimensional CT of facial and orbital injury.** *Radiol Clin North Am* 1999;37:489–513
10. Stacey DH, Doyle JF, Mount DL, et al. **Management of mandible fractures.** *Plast Reconstr Surg* 2006;117:48e–60e
11. Lindahl L. **Condylar fractures of the mandible. I. Classification and relation to age, occlusion, and concomitant injuries of teeth and teeth-supporting structures, and fractures of the mandibular body.** *Int J Oral Surg* 1977;6:12–21