ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 2, Issue – 5, September – October - 2019, Page No. : 174 - 182

New Scale for Assessment of Mandibular Fractures: Radiographic Union Scale for Mandible (RUSM)

Vikas Kunwar Singh[1], Ashish Chalana[2], Ruchika Tiwari [3], Rinki Aggarwal[4], Jay Kansara[5], Vandita Chaurasia[6]

[1]Professor, Master of Dental Surgery, Department of Oral & Maxillofacial Surgery, Mahatma Gandhi Dental College & Hospital, Jaipur, India

[2]Resident, Master of Dental Surgery, Department of Oral & Maxillofacial Surgery,Mahatma Gandhi Dental College & Hospital, Jaipur, India

[3]Professor, Master of Dental Surgery, Department of Oral & Maxillofacial Surgery, Mahatma Gandhi Dental College & Hospital, Jaipur, India

[4]Resident, Master of Dental Surgery, Department of Oral & Maxillofacial Surgery, Mahatma Gandhi Dental College & Hospital, Jaipur, India

[5]Resident, Master of Dental Surgery, Department of Oral & Maxillofacial Surgery, Mahatma Gandhi Dental College & Hospital, Jaipur, India

[6]Resident, Master of Dental Surgery, Department of Oral & Maxillofacial Surgery, Mahatma Gandhi Dental College & Hospital, Jaipur, India

Corresponding Author: Dr. Ashish Chalana, Department of Oral & Maxillofacial Surgery, Mahatma Gandhi Dental College & Hospital,Jaipur, India

Type of Publication: Original Research Paper

Conflicts of Interest: Nil

Abstract

Objective: The aim of this study was to radiographically assess the mandibular fractures and propose a new scale for the assessment of mandibular fractures and to give a **radiographic union scale for mandible (RUSM)**.

Methodology: This is a review of 60 patients who reported in trauma centre of Mahatma Gandhi Hospital, Jaipur for evaluation and management of mandibular fractures from **June 2017 to August 2019**. A cross sectional review of all the patients was adopted for assessment of fracture healing in accordance with two **orthogonal radiographs (orthopantomogram and occlusal radiograph)** in proposed assessment scale 3 months post-surgery.

Results: According to inference from the RUSM scale assessment of 60 patients, 5 patients were in category 1 - non-union, 8 patients were in the category 2 - not healed and 47 patients were in the category 3 - healed fracture post 3 month follow up.

Conclusion: RUSM's simple, systematic, and continuous gauge of the healing of mandibular fractures treated has been shown to result in excellent inter-observer agreement. Consequently, its use may standardize the monitoring of the treatment effect in routine practice and the outcome assessment in clinical trials.

Introduction

In Maxillofacial trauma, the mandible is the most common facial fracture after nasal bone. Mandible fractures are among the most common skeletal injuries in following

trauma due its anatomical location and less support from the cranium.[1] There are number of classifications given for mandibular fractures based on anatomic location, condition, and position of teeth relative to the fracture, favourableness, or type. In this study, mandibular fractures are classified according to its anatomical location i.e. symphysis, parasymphysis, angle, body and condyle fracture.[2]

Healing is a multifactorial phenomenon affected by various biological factors, injury characteristics and the mechanical environment. This complex system can be simplified into several stages of healing, beginning with hematoma formation, followed by inflammatory response, cell proliferation and differentiation and finally ossification with subsequent remodeling the new bone.

Treatment of mandibular fractures aimed at effecting healing of bone by anatomic reduction and fixation leading to complications and disability. Numerous techniques are there to achieve such results viz. external and internal rigid fixation and maxillomandibular fixation including intraosseous wiring. Although every method has a set of complications associated like infection, delayed union, malunion, non-union, malocclusion, facial deformity and paraesthesia. Development of such impairments may lead the patient to suffer from pain, infection resulting in trismus.[3]

The objectives in treating mandibular fractures are to effect rapid healing by anatomic reduction and fixation, with minimal infirmity and complications. Over the years a number of techniques have been developed to achieve these results. These have included maxillomandibular fixation with and without intraosseous wiring, external rigid fixation, and, more recently, rigid internal fixation. However, each method has its own complications like malunion, delayed union, non-union, disturbances of sensation, malocclusion, and facial deformity. Most of these unfortunate results can be prevented or corrected, but probably the most perplexing is the non-union. Patients developing non-union often suffer from infection, pain, and trismus sometime during their treatment. They are usually emotionally depressed and require multiple courses of medical treatment and surgery. Malnutrition, deformity, and permanent disability can also occur.[4]

A history of smoking, diabetes and NSAID use may also delay the healing process and increase the risk of post-operative complications.

The purpose of this study is to develop a new scale called RADIOGRAPHIC UNION SCALE FOR MANDIBLE (RUSM) to assess union in mandibular fractures after 3 months in different regions of mandible. With this proposed scale we can predict occurrences of complications like non-union which require careful and deliberate surgical management. The RUSM Score assess the presence of bridging callus and that of a fracture line on each of 4 cortices seen on 2 orthogonal radiographic views (Orthopantomogram and Occlusal Radiograph).

Existing Scales

Hammer et al[5] used a classification of the radiographic forms of fractures to compare the correctness of radiologic valuation of stage of union with mechanical stiffness (Table 1). Their classification, called as the Hammer scale, entailed of 5 groups, which are based on 5 different stages of callus development and 4 stages of fracture line annihilation, with group 1 and group 2 representing achieved union. Radiographic evaluation was found to correctly predict the mechanical stage of union in only 50% of the cases. Beside the fact that this scale poorly correlates with mechanical stability, the Hammer scale contains a group in which union is called ‘‘uncertain’’ (group 3), and indeed, the evaluators allocated a large proportion of radiologic valuations to this group. This has clinical insinuations, as the surgeon probably will prolong

treatment, assuming that the fracture has not healed yet. The inter-observer agreement of the Hammer scale has been found to be only moderate (k = 0.60; 95% CI 0.52–0.68) and even slightly less than the agreement of surgeons' general fracture healing assessment (k = 0.65; 95% CI 0.59–0.75).[6]

Table 1. Radiographic Scoring Method for Fractures by Hammer et al[5]

	Radiographic Assessment		
Group	Callus Formation	Fracture Line	Stage of Union
1	Homogeneous bone structure	Obliterated	Achieved
2	Massive. Bone trabeculae crossing fracture line	Barely discernible	Achieved
3	Apparent. Bridging of fracture line	Discernible	Uncertain
4	Trace. No bridging of fracture line	Distinct	Not achieved
5	No callus formation	Distinct	Not achieved

Tower et al[7] used a radiographic scoring scale ranging from 0 to 10, which included a assessment of the presence of periosteal callus (none, present, fair, or abundant), bridging callus (none, present, fair, abundant, maturing, or remodeled), and lucent lines (both planes, 1 plane, or none). The relationship between the resonant frequency of the healing and the fracture score, which was the sum of 11-point clinical score (comprising weight bearing, the presence of fracture motion, pain, and mobility status) and the cited radiographic score. Because a combined clinical and radiographic score was used in this correlation analysis, we cannot conclude from this study that the used radiographic scale is valid.

With the reliable measure of cortical bridging[6] and the frequently employed criterion of fracture line visibility[8] at its basis, the RUST score was hypothesized to be more valid and reliable than conventional assessments. Scored from 4 to 12, the RUST score provides an indication of the healing status of a tibial fracture on a continuous scale The RUST score is based on the presence or absence of callus and of a visible fracture line at the total of 4 cortices visible on the antero-posterior and lateral radiographs. Its minimum 4-point relates to a fracture that is not healed, whereas its 12-point extreme relates to a fracture that is healed with all cortices bridged with callus without a fracture line.

Development of the RUSM Score

Formerly devised healing assessment scales, such as those described above, have failed to provide simple systems, which still resemble the continuous process of fracture healing.[9,10] On the other hand, overly discrete systems involving only few categories may have a reduced informative content,[9] irrespective of their statistical correlation with the strength of the healing bone.[11] The surgeon's general impression and the number of cortices bridged by callus are examples of such measures.

Selected Criteria

Section 1. General Impression

- Healed
- Not-healed

Section 2. Scale

- Cortical index - bridging
- Cortical index – disappearance of the fracture line
- Trabecular index – consolidation
- Trabecular index – disappearance of the fractrure line
- Callus presence and fracture line visibility

Section 3. Quality of the callus

On the basis of selected criteria the RUSM score clearly signifies the healing status of fractures of mandible on an incessant scale. It is based on visible fracture line at 4 cortices and presence or absence of callus appreciated on the orthogonal radiographs (Orthopantomogram and Occlusal radiograph). Its minimum 7 point indicates a fracture that is not healed with non-union, whereas its maximum 21 point indicates a fracture that is completely healed with bridging of all cortices with callus and no fracture line is seen.

Singh V & Chalana A: New Proposed RUSM Scale for Mandibular Fracture Assessment Table 2. Assessment Scale

1. Radiographic Union Score for Mandible (RUSM)

Section 1: General Impression

Using your overall general impression, has the fracture healed?

☐ Healed ☐ Not Healed ☐ Non Union

Section 2:

1) Cortical Index – Bridging

Cortex	No Cortical Bridging Score = 1	Some Cortical Bridging Score = 2	Complete Cortical Bridging Score = 3	Total Score Range = 4 to 12
Labial Cortex				
Lingual Cortex				
Overall Score				

2) Cortical Index – Disappearance of the Fracture Line

Cortex	Fracture Line Fully Visible Score = 1	Some Evidence of Fracture Line Score = 2	No Evidence of Fracture Line Score = 3	Total Score Range = 4 to 12
Labial Cortex				
Lingual Cortex				
Overall Score				

3) Trabecular Index – Consolidation

	No Consolidation Score =1	Some Consolidation Score = 2	Complete Consolidation Score = 3	Total Score (Range : 1 to 3)
Amount of Consolidation				

4) **Trabecular Index – Disappearance of Fracture the Line**

	Fracture Line Fully Visible Score = 1	Some Evidence of Fracture Line Score = 2	No Evidence of Fracture Line Score = 3	Total Score Range = 4 to 12
Fracture Line				

2. Overview - Callus

Score per Cortex	Callus	Fracture Line
1	Absent	Visible
2	Present	Visible
3	Present	Invisible

Overall RUSM Score (Range: 07–21):

Quality of the Callus

1) What is the quality of the callus formation?

- **None**
- **Minimal Callus**
- **Moderate Callus**
- **ExuberantCallus**

None is defined as no callus formation being present.

Minimum callus is defined as slightly evident bridging across fracture ends.

Moderate callus is defined as clearly evident bridging callus across the fracture site.

Exuberant callus is defined as protuberant bridging across the fracture site

Quality of the Image

1) Is quality of the image acceptable?

- Yes
- No

2) Did the quality of the image inhibit your assessment?

- Yes
- No

3) Did the placement/position of the hardware inhibit your assessment by obscuring fracture visibility?

- Yes
- NO

INFERENCE

Score	**Status**
7-10	Non Union
11-14	Not Healed
15-21	Healed

The RUSM score is derived from the above-mentioned radiographic union scales in that they use similar criteria for fracture union. The scales designed by **Hammer et al**, **Tower et al and by Kooistra et al RUST** employ bridging callus and lucent fracture lines as part of their assessments. Moreover, all these scales provide a continuous approximation of the stage of the fracture

healing process. Still, RUST carries some unique advantages over these elaborate union scales.

Material & Method

This is a review of 60 patients who reported in trauma centre of Mahatma Gandhi Hospital for evaluation and management of mandibular fractures from June 2017 to August 2019. This study was approved by the institutional review board of institution and conducted in accordance with declaration of Helsinki.

Study considerations were demographic (age, gender), medical comorbidities (systemic diseases), behavioural risk factors (alcohol use, smoking), fracture characteristics. Follow up was done 3 months post-surgery for all the patients.

A cross sectional review of all the patients was adopted for assessment of fracture healing in accordance with two orthogonal radiographs (Fig.1) (orthopantomogram and occlusal radiograph) in proposed assessment scale 3 months post-surgery.

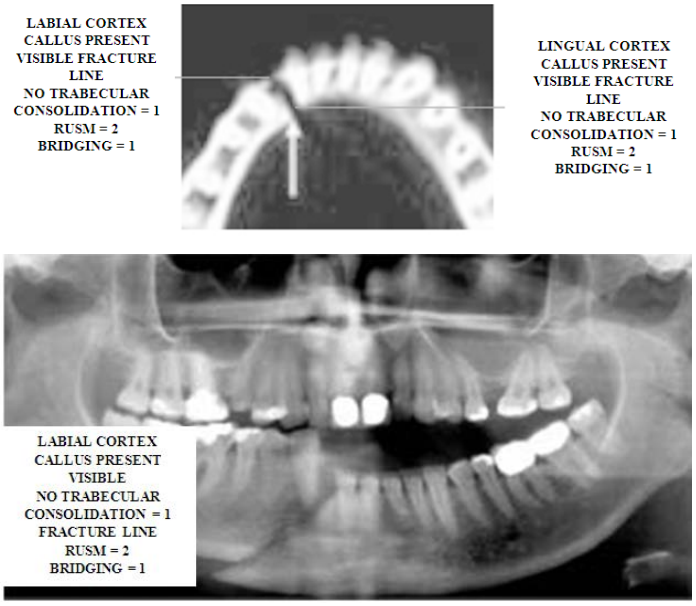
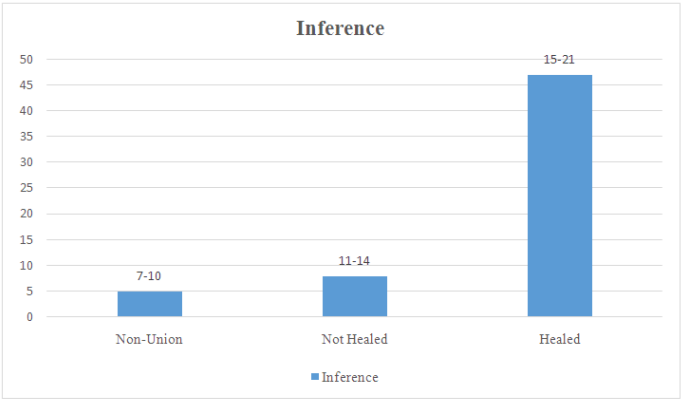


Fig.1: Example of the assignment of a RUSM score and the number of cortices bridged by callus to a radiograph of a mandibular fracture.

S.NO.	Location Of Fracture In Mandible	No. Of Cases
1.	Symphysis	19
2.	Parasymphysis	15
3.	Body	13
4.	Angle	10
5.	Ramus and Sub condyle Fracture	3



RUSM carries some unique advantages, First, the RUSM score examines the healing fracture in an unequivocal and complete manner. Although the abovementioned scales provide global assessments for 1 (set of) radiograph(s), a potential advantage of RUSM is that it evaluates each cortex separately through two orthogonal radiographs. Possibly, this addresses the unique healing pattern of each individual fracture more accurately. In addition, the assessment might be more reliable when individual cortices contribute to a final score. For example, the global assessment of the visibility of a fracture line could vary substantially across assessors if some cortices do and other cortices do not display a fracture line. The RUSM score would eliminate this problem as the assessments of all cortices add up to the final score (Fig. 1).

Second, the RUSM score also examines trabecular pattern of bone healing through consolidation and visibility of fracture line.

Panjabi et al[11] found that while cortical bridging was the single best predictor of fracture stiffness, increasing the number of radiographic criteria to 5 increased the ability to predict fracture stiffness based on a radiograph. Thus, the degree to which any radiographic union scale truly measures the state of union depends on the number of criteria's involved. This holds true solely for RUSM for radiographic assessments which included cortical bridging, fracture line visibility, trabecular consolidation, disappearance of fracture line and presence or absence of callus as criteria's.

Moreover, the accuracy of radiographs improve only slightly when more than 2 radiographic indices are examined (R2 = 0.71 for 2 indices vs. R2 = 0.75 for 5 indices).[12]

Validity and Reliability of the RUSM Score

To use an assessment of healing in routine practice, it should have been demonstrated to be reliable and valid.13 A maximally reliable radiographic assessment would be one on the basis of which different surgeons uniformly deem a certain fracture as healed or uniformly as not healed. For a test to be valid, it should be able to discriminate between cases that truly have the outcome of interest and cases who do not.14 In the situation of mandibular fracture healing, a radiographic measure that perfectly predicts whether fracture tissue has fully regenerated and has regained its former strength and is strongly correlated with patient-important measures, such as functional recovery, would be considered valid.Obviously, the importance of a valid radiographic assessment lies in its potential to guide decisions on interventions to promote healing.15,12 Excessively optimistic assessments would deny a useful intervention to patients suffering a nonunion, whereas systems that underestimate healing would lead to redundant operations. Additionally, a reliable assessment tool is essential for a consistently useful standardized integration in both routine fracture care and in clinical research.16Notably, limited work has been done on the reliability and especially on the validity of any radiographic assessment, whether it be commonly used or not.2

Table 3: Clinician Agreement With Expert Opinion As A Function Of Fracture Location[17]

	Agreement (%)		
Fracture Location	T1	T2	*P**
Symphysis	65.3	52.8	ns
Canine region	43.3	64	.067
Body	67.4	64.6	ns
Angle	77.2	97.2	.006
Ramus	77.8	79.2	ns
Coronoid	88.9	100	ns
Condyle	85.9	79.5	ns

Abbreviation: ns, not significant.
* Comparison of agreement between T1 and T2.

Table 4: Clinician Reliability As A Function Of Interfragmentary Displacement Measured In Millimeters (Icc And 95% Confidence Interval)[17]

Time Period	Traumatologist	Generalist	Overall	Clinical Significance
T1*	0.70 (0.55-0.83)	0.51 (0.36-0.71)	0.57 (0.43-0.74)	Moderate agreement
T2†	0.81 (0.63-0.93)	0.69 (0.47-0.88)	0.75 (0.57-0.90)	Substantial agreement
T1-T2	0.92 (0.65-0.99)	0.80 (0.37-0.96)	0.86 (0.68-0.96)	Substantial agreement

Although the need for the demonstration of a relationship of a radiographic scale and function has been expressed. The current lack of compelling validation evidence on any measure of radiographic healing, including RUSM scores, raises important questions regarding their use in treatment evaluation and outcome assessment18 and mandates continuing research in this area.19 As the RUSM score has been shown to be at least as reliable as conventional radiographic union assessments, it merits further specific validation in relation to its conventional alternatives. Future research on the RUSM score will be directed toward its ability to discriminate between a healed and a non-healed fracture and, in a longitudinal fashion, between a healing and a non-healing fracture with a larger

sample size. Eventually, this may increase our confidence in that it measures what it is supposed to measure and facilitates its implementation in clinical practice and research.However, different conducts create different mechanical environments, which regulate the fracture healing pattern, with more rigid fixation hindering callus formation.20 Therefore, the radiographic presence of a fracture depends on the way it is stabilized. For example, internal fixation aims for direct healing, in which the stability leads to intramembranous ossification with little external callus formation.8 The radiographic appearance differs between fractures treated with different methods of internal fixation.Patients treated by the same modality may show different radiographic healing patterns, as patients show different fracture patterns and are subjected to different physiological stresses. Therefore, using the same outcome for patients treated with the same modality might be just as unjustifiable as using the same outcome for differently treated fractures.

Conclusion

The common use of surgeon's general assessment of radiographic healing or assessment of the number of cortices bridged for mandibular fracture healing in maxillofacial practice and research is of questionable value. In response to findings of undesirably low validities and reliabilities in radiographic mandibular union assessments, the RUSM score was developed. Its simple, systematic, and continuous gauge of the healing of mandibular fractures treated has been shown to result in excellent interobserver agreement. Consequently, its use may standardize the monitoring of the treatment effect in routine practice and the outcome assessment in clinical trials. Further studies with RUSM score needs to be done with a larger sample size.

References

1. *Robert H. Mathog, MD,* Vincent Toma,† Lewis Clayman, MD, DDS,‡ and Steven Wolf, DDS§(2000)* Nonunion of the Mandible: An Analysis of Contributing Factors.
2. Kooistra BW, Sprague S, Bhandari M, et al. Outcomes assessment in fracture healing trials: a primer. J Orthop Trauma. 2010;23(Suppl):S71–S75.
3. Brian P. Cunninghama, Sloane Brazinab, Saam Morshedb, Theodore Miclau IIIb,*(2017) Fracture healing: A review of clinical, imaging and laboratory diagnostic options.
4. Deepak Passi*, Laxman Malkunje, Mansi Atri, Deepak Chahal, Tarun Kumar Singh and Jyoti Goyal(2017) Newer Proposed Classification of Mandibular Fractures: A Critical Review with Recent Updates.
5. Hammer RR, Hammerby S, Lindholm B. Accuracy of radiologic assessment of tibial shaft fracture union in humans. Clin Orthop Relat Res. 1985;199:233–238.
6. Whelan DB, Bhandari M, McKee MD, et al. Interobserver and intraobserver variation in the assessment of the healing of tibial fractures after intramedullary fixation. J Bone Joint Surg Br. 2002;84:15–18.
7. Tower SS, Beals RK, Duwelius PJ. Resonant frequency analysis of the tibia as a measure of fracture healing. J Orthop Trauma. 1993;7:552–557.
8. Morshed S, Corrales L, Genant H, et al. Outcome assessment in clinical trials of fracture-healing. J Bone Joint Surg Am. 2008;90:62–67.
9. Marsh D. Concepts of fracture union, delayed union, and nonunion. Clin Orthop Relat Res. 1998;355:S22–S30.
10. Postacchini F, Gumina S, Perugia D, et al. Early fracture callus in the diaphysis of human long bones.

Histologic and ultrastructural study. Clin Orthop Relat Res. 1995;310:218–228.

11. Panjabi MM, Walter SD, Karuda M, et al. Correlations of radiographic analysis of healing fractures with strength: a statistical analysis of experimental osteotomies. J Orthop Res. 1985;3:212–218.
12. Whelan DB, Bhandari M, Stephen D, et al. The development of the Radiographic Union Score for Tibial fractures (RUST) for the assessment of tibial fracture healing following intra-medullary fixation. J Orthop Trauma. In press.
13. Bhandari M, Joensson A. Clinical Research for Surgeons. Stuttgart, Germany: Thieme; 2009.
14. Bhandari M, Guyatt GH, Swiontkowski MF, et al. A lack of consensus in the assessment of fracture healing among orthopaedic surgeons. J Orthop Trauma. 2002;16:562–566.
15. Burstein AH. Fracture classification systems: do they work and are they useful? J Bone Joint Surg Am. 1993;75:1743–1744.
16. Kooistra BW, Busse JW, Walter SD, et al. The radiographic union scale for tibial (RUST): preliminary validation. J Bone Joint Surg Am. In press.
17. Shetty, V., Atchison, K., Belin, T. R., & Wang, J. (2001). *Clinician variability in characterizing mandible fractures. Journal of Oral and Maxillofacial Surgery, 59(3), 254–261*. doi:10.1053/joms.2001.20984
18. McClelland D, Thomas PB, Bancroft G, et al. Fracture healing assessment comparing stiffness measurements using radiographs. Clin Orthop Relat Res. 2007;457:214–219.
19. Guyatt GH, Feeny DH, Patrick DL. Measuring health-related quality of life. Ann Intern Med. 1993;118:622–629.
20. Chao EY, Aro HT, Lewallen DG, et al. The effect of rigidity on fracture healing in external fixation. Clin Orthop Relat Res. 1989;241:24–35.