Review Article

Diagnostic Accuracy of Ultrasonography for the Assessment of Maxillofacial Fractures: A Meta-analysis

Srikanth Gadicherla[1], Kalyana-Chakravarthy Pentapati[2], Nasrullah Rustaqi[3], Anupam Singh[1], Komal Smriti[4]

[1]Oral and Maxillofacial Surgery, [2]Public Health Dentistry, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India, [3]Department of Oral and Maxillofacial Surgery, Dentistry Faculty of Kabul Medical University, Kabul, Afghanistan, [4]Oral Medicine and Radiology, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India

Received : 30-06-21
Revised : 15-07-21
Accepted : 21-07-21
Published : 21-09-21

ABSTRACT

Objective: To evaluate the pooled sensitivity and specificity of ultrasonography (USG) in maxillofacial fractures. **Materials and Methods:** A systematic search was performed in five databases (PubMed, Scopus, CINAHL, Web of Science, Dentistry and Oral Sciences Source) from inception to September 12, 2020. Studies that reported or from which sensitivity and specificity can be calculated and studies published in the English language were included. Conference proceedings, letter to editors, and case reports were excluded. Screening of studies, data extraction, and risk of bias assessment (QUADAS -2) were done separately by two review authors. A bivariate random-effects model was used to calculate the pooled estimates. **Results:** After the removal of duplicates, 1852 studies were included for screening of title and abstracts. Only 22 studies were included in the quantitative synthesis. The sample size ranged from 6 to 87. The majority of the studies assessed orbit and nasal bones fractures. Only two studies included a comprehensive assessment of facial fractures. The overall sensitivity and specificity values were 0.94 and 0.96, respectively. **Conclusion:** USG has good diagnostic accuracy for the assessment of fractures of orbit and nasal bones. Clinicians need to consider the advantages and limitations of USG before recommending advanced imaging modalities.

Keywords: *Computed tomography, diagnostic accuracy, fractures, maxillofacial, ultrasonography*

Introduction

Maxillofacial fractures are due to direct trauma to the face resulting in mandibular fracture, zygomaticomaxillary complex fracture, orbital floor fracture, nasal bone fracture, or a combination of any of these patterns. They are of great concern for the healthcare provider and the individual due to the complex care involved in the management. The most common causes of these fractures are road traffic accidents. The etiology and incidence of these fractures vary in different countries. The nasal bone being the most prominent bone is often prone to fracture (39% of maxillofacial fractures). The mandible and zygomaticomaxillary complex play an essential role in facial contour and mastication. A fracture in this area can affect facial appearance, function, and quality of life.[1] To restore aesthetics, function, and quality of life, it is essential to completely diagnose these fractures for effective management.

Various imaging modalities are available, ranging from simple "plain film radiography," "ultrasonography" (USG), and "computed tomography" (CT). In the past, plain film radiography was the norm for diagnosing facial fractures. It has many disadvantages like lack of details in imaging complex facial bones, superimposition of overlying structures, image distortion, and unavailability

Address for correspondence: Dr. Kalyana-Chakravarthy Pentapati, Public Health Dentistry, Manipal College of Dental Sciences, Manipal, Manipal Academy of Higher Education, Manipal 576104, Karnataka, India.
E-mail: drkalyan81@gmail.com

Access this article online

Quick Response Code:

Website: www.jispcd.org

DOI: 10.4103/jispcd.JISPCD_201_21

How to cite this article: Gadicherla S, Pentapati KC, Rustaqi N, Singh A, Smriti K. Diagnostic accuracy of ultrasonography for the assessment of maxillofacial fractures: A meta-analysis. J Int Soc Prevent Communit Dent 2021;11:503-9.

of real-time imaging. These disadvantages can be readily alleviated by the use of CT, which is considered as a gold standard in imaging for maxillofacial fractures due to its enhanced clarity and details. CT is an essential tool for clinicians in diagnosing and visualizing maxillofacial fractures. It enables the diagnosis of undisplaced fractures, which are overlooked in plain film radiography. However, CT is known to have few disadvantages such as high radiation exposure, routine unavailability, high cost, distortion due to artifacts, and inability to provide real-time imaging.[2]

USG is a safe, easy, and readily available imaging modality for soft tissues. The use of USG for fractures of skull, clavicle, foot and ankle, ribs, facial bones like zygomatic arch, orbit, nasal bone, mandible has been reported previously.[3-24] Many advantages like low cost, easy availability, lack of ionizing radiation, and real-time imaging have made it an attractive low-cost, safer, and reliable imaging modality for diagnosing fractures of the maxillofacial region. A previous systematic review had recommended USG owing to its high sensitivity and specificity.[2] Since then, there has been a substantial number of published studies on the use of USG for the diagnosis of maxillofacial fractures. Hence, our review aimed to evaluate the pooled sensitivity and specificity of USG in maxillofacial fractures.

Materials and Methods

The protocol for this systematic review was registered with INPLASY (2020120064; doi:10.37766/inplasy2020.12.0064). A systematic search was conducted in five databases (PubMed, Scopus, CINAHL, Web of Science, Dentistry and Oral Sciences Source) from inception to September 12, 2020. The references from the selected studies were searched manually. Search terms used were "Ultrasonography," "Ultrasound," "echography," "Tomography, X-Ray Computed," "CT Scan," "Computed Tomography," "CBCT," "Cone Beam Computed Tomography," "Mandible Fracture," "Mandibular Fracture," "Zygoma Fracture," "Facial Fracture," "Zygomatic Fracture," "Zygomatic arch Fracture," "Orbit Fracture," "Orbital Fracture," "Maxilla Fractures," "Maxillary Fractures," "Nasal fracture," "Nasal Bone/injuries," "Comparison," "Diagnosis," "Diagnostic," "Sensitivity," "Specificity," and "Accuracy." Appropriate filters specific for various databases were applied.

Eligibility criteria

Studies that reported or from which sensitivity and specificity can be calculated and studies published in the English language were included. We excluded conference proceedings, letter to editors, and case reports [Table 1].

Screening

Two review authors (K.-C. P. and K. S.) conducted title and abstract screening independently in web-based software (Rayyan).[25] Included studies were subjected to full-text screening and data extraction by two review authors separately (S. G. and A. S.). A third review author (K.-C. P.) resolved discrepancies. The reliability between the review authors was assessed using the Kappa coefficient.

Risk of bias (RoB) assessment

"Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2)" was used for RoB assessment. It has four domains ("patient selection," "index test," "reference standard," and "flow and timing").[26] The first three domains also have questions on concerns regarding the applicability (CRA). Included studies were rated as "low"/"high"/"unclear." The RoB assessment was performed by two review authors separately (K.-C. P. and A. S.).

Statistical analysis

Meta-analysis was performed on the data extracted from various studies (TP, FP, TN, and FN) using MetaDTA software (https://crsu.shinyapps.io/dta_ma/),[27,28] and "summary receiver operating characteristic" (SROC) curve was plotted. Sensitivity analysis was performed by excluding low-quality studies to evaluate the robustness of the model. Subgroup analysis would be performed based on the study characteristics (RoB) and patient characteristics (site, transducer, and operator).

Results

A search from five databases yielded 2171 studies [PubMed (1173), Scopus (688), CINAHL (90), Web of Science (49), Dentistry and Oral Sciences Source (171)]. Two additional studies were identified from reference lists. After duplicates removal, 1852 studies were screened for title and abstracts. Out of these, 28 studies were screened for full-text. Only 22 studies were eligible for qualitative and quantitative synthesis [Figure 1]. The sample size ranged from 6 to 87.

Table 1: PICOS

PICOS	
Participants	Patients (male or female) with suspected maxillofacial fractures
Intervention	Ultrasound imaging or ultrasonography
Comparison	Computed tomography scan or cone beam computed tomography (CBCT) scan
Outcome	True positive, true negative, false positive, false negative
Study design	Diagnostic accuracy studies (which report sensitivity and specificity)

Age and gender distribution

The age of the participants ranged from 10 to 85. Five studies have not specified the age range of the participants.[3,9,13,16,18] Also, three studies did not specify the sex distribution of the patients,[3,13,18] and data from 19 studies showed 544 males and 178 females.

Site

The majority of the included studies included patients with fractures of the orbit,[4,9,11,13,18-22] ZMC,[3,7,8,23,24] NB,[6,10,12,14] maxilla,[16] mandible,[7,15,16] and only two studies included a comprehensive assessment of facial fractures.[5,17] Majority of the studies used individual patients as a unit of the study. In contrast, only eight studies[4,5,10-14,21] have used the site as a unit to calculate sensitivity and specificity.

Ultrasound transducer

The ultrasound transducer used among the included publications had a range of 3–15 MHz. Three studies used a 5 MHz transducer,[9,18,19] and one study used an additional water bath with the 5 MHz transducers.[18] Eight studies used a 7.5 MHz transducer,[4,12,13,20-24] and two studies used a 10 MHz transducer[7,10] exclusively for all the patients.

Sensitivity and specificity

Among the included publications, the sensitivity values ranged from 83% to 100%,[3,5,6,8,10,18,21] whereas the specificity values ranged from 0 to 100%[3,7-9,11,12,15,17,19,23,24] [Table 2].

Assessment of RoB and CRA

The quality assessment was evaluated by the QUADAS-2 tool. The majority of the studies fall under low-risk category for the RoB assessment in various domains assessed viz., "patient selection" (*n*=17), "index test" (*n*=16), "reference standard" (*n*=15), and "flow and timing" (*n*=21). All the studies had low CRA in the domains of "patient selection," "index test," and "reference standard." Overall, 11 studies were categorized as low risk[4,5,8,11,12,15,16,20-23] and 11 as high risk[3,6,7,9,10,13,14,17-19,24] [Table 2].

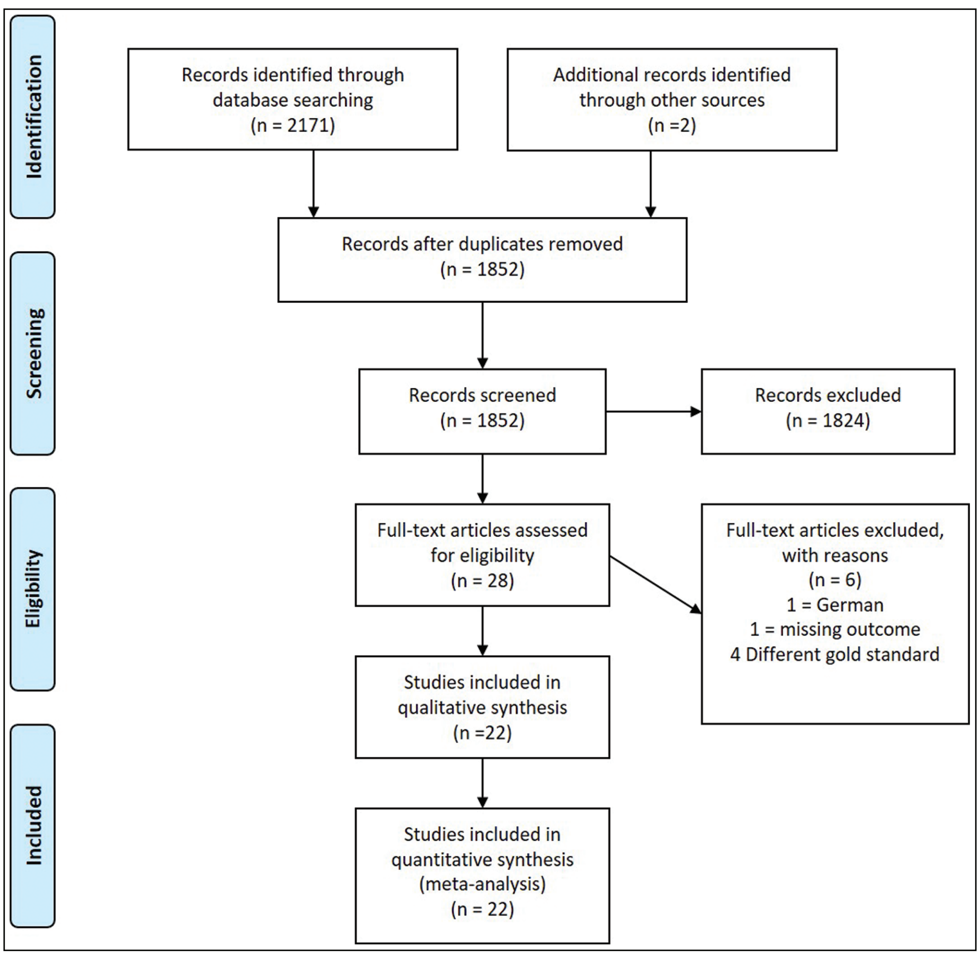

Figure 1: PRISMA flow chart

Table 2: Summary of the included studies

Author	TP	FN	FP	TN	*N*	Sens	Spec	RoB				AC		
								PS	IT	RS	FT	PS	IT	RS
Ord *et al.*[18]	7	0	2	3	12	1	0.6	☺	☹	☹	☺	☺	☺	☺
Lata *et al.*[9]	13	1	0	5	19	0.93	1	☺	☺	☹	☺	☺	☺	☺
Forrest *et al.*[19]	12	1	0	5	18	0.92	1	☹	☺	☺	☺	☺	☺	☺
Jenkins and Thuau[13]	11	2	1	7	21	0.85	0.88	☺	☹	☹	☹	☺	☺	☺
Jank *et al.*[20]	44	7	5	68	124	0.86	0.93	☺	☺	☺	☺	☺	☺	☺
Jank *et al.*[20]	83	4	3	30	120	0.95	0.91	☺	☺	☺	☺	☺	☺	☺
Siegfried *et al.*[4]	60	6	5	53	124	0.91	0.91	☺	☺	☺	☺	☺	☺	☺
Jank *et al.*[21]	14	0	3	35	52	1	0.92	☺	☺	☺	☺	☺	☺	☺
Sallam *et al.*[8]	10	0	0	0	10	1	0	☺	☺	☺	☺	☺	☺	☺
Nezafati *et al.*[24]	15	2	0	17	34	0.88	1	?	☺	☺	☺	☺	☺	☺
Javadrashid *et al.*[12]	37	2	0	41	80	0.95	1	☺	☺	☺	☺	☺	☺	☺
Mohammadi and Ghasemi-Rad[10]	90	0	15	156	261	1	0.91	☺	☹	☹	☺	☺	☺	☺
Lou *et al.*[6]	52	0	2	17	71	1	0.9	☺	☹	☹	☺	☺	☺	☺
Ogunmuyiwa *et al.*[23]	27	5	0	31	63	0.84	1	☺	☺	☺	☺	☺	☺	☺
Ardeshirpour *et al.*[14]	14	1	1	4	20	0.93	0.8	☺	☹	☹	☺	☺	☺	☺
Singh *et al.*[7]	37	1	0	2	40	0.97	1	?	☺	☺	☺	☺	☺	☺
Anand *et al.*[3]	6	0	0	0	6	1	0	?	☺	☺	☺	☺	☺	☺
Johari *et al.*[11]	34	5	0	81	120	0.87	1	☺	☺	☺	☺	☺	☺	☺
Sreeram *et al.*[17]	38	2	0	0	40	0.95	0	☹	☹	☹	☺	☺	☺	☺
Airan *et al.*[16]	38	2	1	9	50	0.95	0.9	☺	☺	☺	☺	☺	☺	☺
Rajeev *et al.*[5]	70	14	4	352	440	0.83	0.99	☺	☺	☺	☺	☺	☺	☺
Nezafati *et al.*[15]	20	3	0	19	42	0.87	1	☺	☺	☺	☺	☺	☺	☺

☺ = Low risk; ☹ = high risk; ? = unclear; RoB = risk of bias; AC = applicability concerns; TP = true positive; FN = false negative; FP = false positive; TN = true negative; *N* = sample size or number of sites; PS = patient selection; IT = index test; RS = reference standard; FT = flow and timing

Meta-analysis

The threshold effect was assessed using Spearman's correlation analysis between sensitivity and false positivity rate which was below the cut-off point of 0.6 (coefficient = 0.53), suggesting a low heterogeneity.[29] The overall pooled sensitivity and specificity were 0.94 and 0.96, respectively [Table 3 and Figures 2 and 3]. Three studies[3,8,17] showed null value for specificity. We conducted sensitivity analysis by excluding these studies, which showed minimal variation in the pooled estimates.

Subgroup analysis

The pooled sensitivity (0.91) and specificity (0.96) showed only minimal variation in low RoB studies when compared with overall estimates. Similarly, the pooled sensitivity (0.97) and specificity (0.92) also showed only minimal variation in high RoB studies. Studies conducted on orbit showed similar values to overall estimates, whereas studies conducted on nasal bone showed higher pooled sensitivity. The majority of the studies have used high-resolution transducers. Studies that used low- and high-resolution USG transducer have reported sensitivity and specificity estimates similar to overall estimates. In most of the studies, radiologists or sonologists have performed the USG.

Table 3: Meta-analysis of the sensitivity and specificity values for USG vs. CT scan

	Sensitivity	Specificity
Overall	0.94 (0.91–0.96)	0.96 (0.92–0.97)
Risk of bias		
Low (*n*=11)	0.91 (0.87–0.93)	0.96 (0.93–0.99)
High (*n*=11)	0.97 (0.93–0.99)	0.92 (0.85–0.96)
Site		
Orbit	0.92 (0.87–0.95)	0.94 (0.88–0.97)
Nasal bone	0.99 (0.92–1)	0.94 (0.86–0.98)
USG transducer		
<5 MHz (*n*=3)	0.94 (0.85–0.98)	0.95 (0.72–0.99)
≥5 MHz (*n*=17)	0.93 (0.89–0.95)	0.96 (0.93–0.98)
Operator		
Radiologist (*n*=15)	0.94 (0.9–0.97)	0.98 (0.95–0.99)
Surgeon (*n*=4)	0.93 (0.93–0.93)	0.92 (0.92–0.92)

No difference in the sensitivity and specificity estimates was observed between studies that used radiologists or surgeons to assess maxillofacial fractures [Table 3].

Discussion

The pooled sensitivity and specificity obtained in this meta-analysis were 94% and 96%, respectively. Subgroup analysis with respect to RoB, site, transducer, and operators showed no much variations when

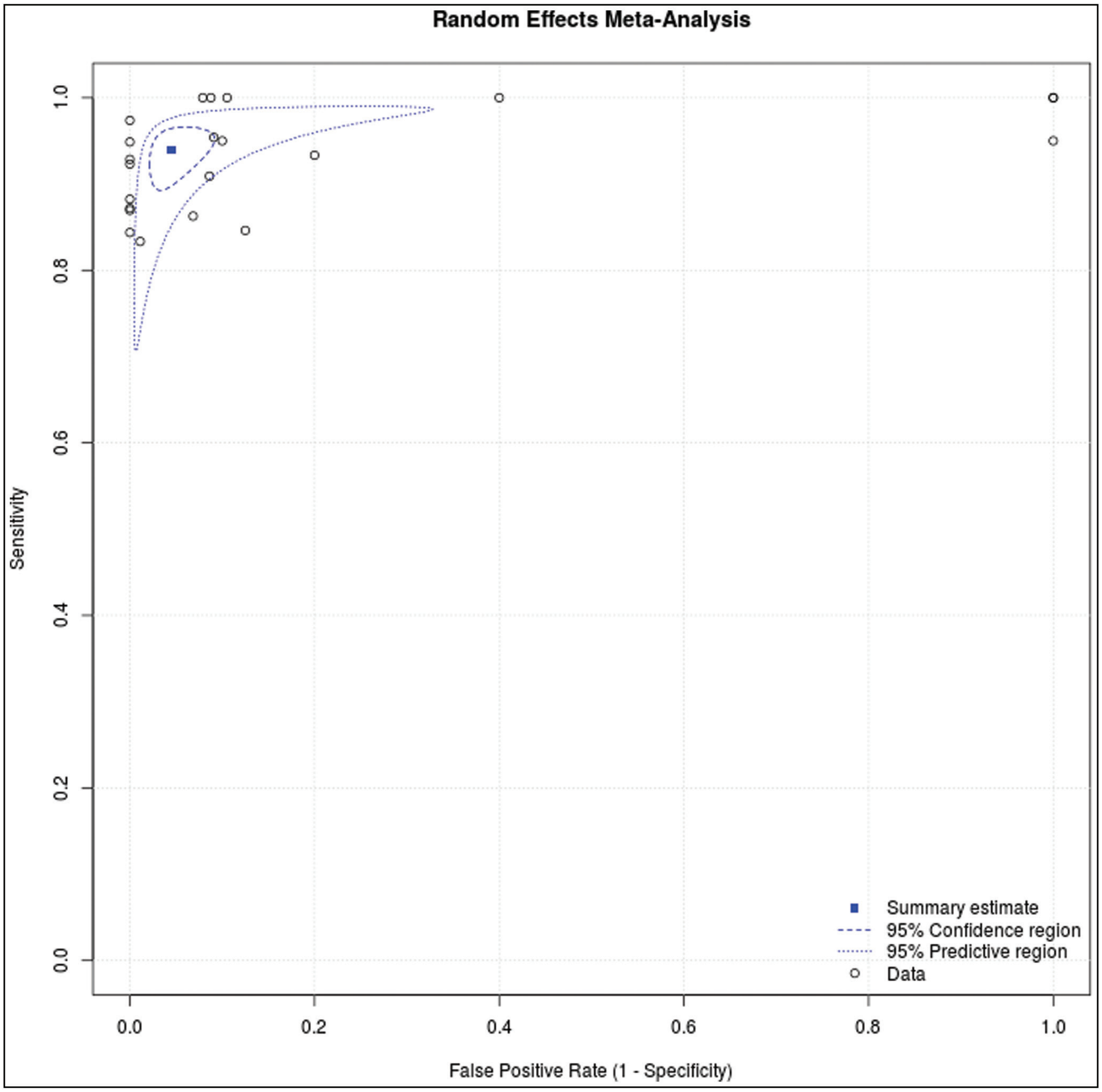

Figure 2: SROC curve

compared with overall estimates of sensitivity and specificity.

A previous systematic review highlighted that the factors such as the operator's experience, resolution of the transducer, standardized technique, real-time visualization, and USG investigation from the time of injury might influence the validity of USG.[30] The majority of the included studies have used experienced operators and a standardized technique. There were substantial variations in the transducer used in the included studies. Higher frequency transducers allow the evaluation of superficial characteristics as it has minimal depth penetration. Lower frequency transducers allow greater depth penetration with lowering image quality at more than 6 cm. However, in the maxillofacial region, deeper imaging may not be required with USG. Most of the studies used real-time visualization of the fracture. The USG investigation from the time of injury was not reported widely among the included studies.

The majority of studies have evaluated fractures in the orbital and nasal bone areas. Nasal bone fractures showed high sensitivity and specificity values followed by orbital fractures. This supports the use of USG as a diagnostic tool for orbital and nasal bone fractures. Good quality studies in other maxillofacial areas are required to endorse the diagnostic validity of USG. Future research should evaluate the influence of timing of USG from the time of injury, the time required for complete standardized USG, pain or discomfort due to the application of transducer on abrasions or wounds.

Many advantages of USG include availability even in low resource settings, portable, relatively cheap, minimal patient compliance and positioning,

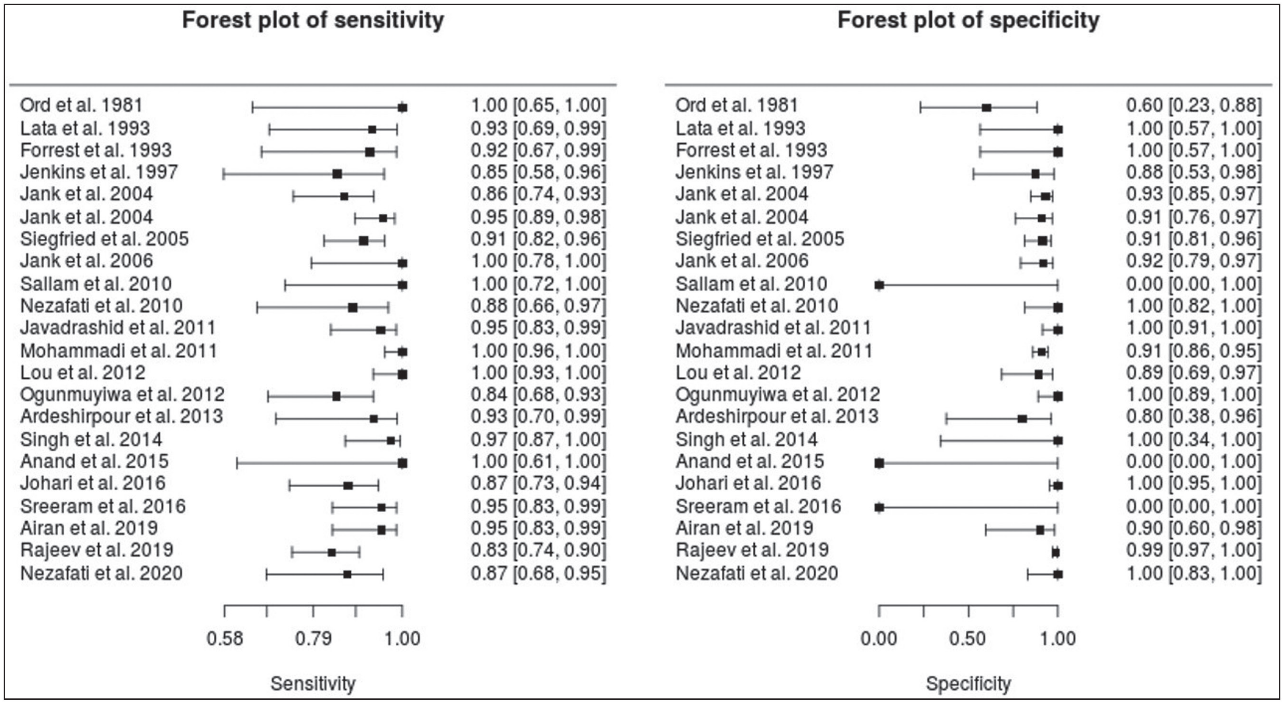

Figure 3: Forest plot of sensitivity and specificity

real-time imaging, repeatable, and minimal radiation.[30] However, there are certain limitations noted in earlier studies such as the inability to differentiate complex fractures,[31] identification of intracapsular fracture of the condyle,[32] new vs. old fractures,[33] anatomical vs. fractures,[33] inability in the detection of non-dislocated fractures,[20,31,32] poor visualization of the posterior orbital floor,[9,19,31] and limited coverage during acute situations.[31] Clinicians need to consider the above limitations and adapt to the advanced imaging modalities as per the trauma presentations.

Acknowledgements

Nil.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Authors contributions

Not applicable.

Ethical policy and institutional review board statement

Not applicable.

Patient declaration of consent

Not applicable.

Data availability statement

Not applicable.

References

1. Sikora M, Chlubek M, Grochans E, Jurczak A, Safranow K, Chlubek D. Analysis of factors affecting quality of life in patients treated for maxillofacial fractures. Int J Environ Res Public Health 2019;17:4.
2. McCann PJ, Brocklebank LM, Ayoub AF. Assessment of zygomatico-orbital complex fractures using ultrasonography. Br J Oral Maxillofac Surg 2000;38:525-9.
3. Anand D, Prasad K, Vineeth K, Ram AR, Patil SS. The use of ultrasonography in zygomatic arch fractures—A preliminary study. Res J Pharm Biol Chem Sci 2015;6:653-7.
4. Jank S, Deibl M, Strobl H, Oberrauch A, Nicasi A, Missmann M, Bodner G. Interrater reliability of sonographic examinations of orbital fractures. Eur J Radiol 2005 Jun;54(3):344-51.
5. Rajeev A, Pai KM, Smriti K, Kadavigere R, Kamath AT, Gadicherla S, *et al.* Diagnostic accuracy of ultrasonography in the assessment of facial fractures. Pesqui Bras Odontopediatria Clin Integr 2019;19:4832.
6. Lou YT, Lin HL, Lee SS, Lee WC, Kuo LC, Cheng YC, *et al.* Conductor-assisted nasal sonography: An innovative technique for rapid and accurate detection of nasal bone fracture. J Trauma Acute Care Surg 2012;72:306-11.
7. Singh KS, Jayachandran S. A comparative study on the diagnostic utility of ultrasonography with conventional radiography and computed tomography scan in detection of zygomatic arch and mandibular fractures. Contemp Clin Dent 2014;5:166-9.
8. Sallam M, Khalifa G, Ibrahim F, Taha M. Ultrasonography vs computed tomography in imaging of zygomatic complex fractures. J Am Sci 2010;6:524-33.
9. Lata AC, Marcuzzi DW, Forrest CR. Comparison of real-time ultrasonography and coronal computed tomography

in the diagnosis of orbital fractures. Can Assoc Radiol J 1993;44:371-6.
10. Mohammadi A, Ghasemi-Rad M. Nasal bone fracture—Ultrasonography or computed tomography? Med Ultrason 2011;13:292-5.
11. Johari M, Ghavimi MA, Mahmoudian H, Javadrashid R, Mirakhor Samani S, Fouladi DF. A comparable study of the diagnostic performance of orbital ultrasonography and CBCT in patients with suspected orbital floor fractures. Dentomaxillofac Radiol 2016;45:20150311.
12. Javadrashid R, Khatoonabad M, Shams N, Esmaeili F, Jabbari Khamnei H. Comparison of ultrasonography with computed tomography in the diagnosis of nasal bone fractures. Dentomaxillofac Radiol 2011;40:486-91.
13. Jenkins CNJ, Thuau H. Ultrasound imaging in assessment of fractures of the orbital floor. Brain Lang 1997;52:708-11.
14. Ardeshirpour F, Ladner KM, Shores CG, Shockley WW. A preliminary study of the use of ultrasound in defining nasal fractures: Criteria for a confident diagnosis. Ear Nose Throat J 2013;92:508-12.
15. Nezafati S, Ghavimi M, Javadrashid R, Farhadi S, Dehnad V. Comparison of accuracy of computed tomography scan and ultrasonography in the diagnosis of mandibular fractures. Dent Res J (Isfahan) 2020;17:225-30.
16. Airan L, Baliga M, Sarkar S, Chakraborty S, Tusharbhai DM. Comparison of the efficacy of ultrasonography with computed tomography in the diagnosis of maxillomandibular fractures. World J Dent 2019;10:181-5.
17. Sreeram MP, Mandava R, Ravindran C. Use of ultrasound as a screening tool in the maxillofacial fractures. MedPulse-Int Med J 2016;3:573-7.
18. Ord RA, Le May M, Duncan JG, Moos KF. Computerized tomography and B-scan ultrasonography in the diagnosis of fractures of the medial orbital wall. Plast Reconstr Surg 1981;67:281-8.
19. Forrest CR, Lata AC, Marcuzzi DW, Bailey MH. The role of orbital ultrasound in the diagnosis of orbital fractures. Plast Reconstr Surg 1993;92:28-34.
20. Jank S, Emshoff R, Etzelsdorfer M, Strobl H, Nicasi A, Norer B. The diagnostic value of ultrasonography in the detection of orbital floor fractures with a curved array transducer. Int J Oral Maxillofac Surg 2004;33:13-8.
21. Jank S, Deibl M, Strobl H, Oberrauch A, Nicasi A, Missmann M, *et al*. Intrarater reliability in the ultrasound diagnosis of medial and lateral orbital wall fractures with a curved array transducer. J Oral Maxillofac Surg 2006;64:68-73.
22. Jank S, Emshoff R, Strobl H, Etzelsdorfer M, Nicasi A, Norer B. Effectiveness of ultrasonography in determining medial and lateral orbital wall fractures with a curved-array scanner. J Oral Maxillofac Surg 2004;62:451-5.
23. Ogunmuyiwa SA, Fatusi OA, Ugboko VI, Ayoola OO, Maaji SM. The validity of ultrasonography in the diagnosis of zygomaticomaxillary complex fractures. Int J Oral Maxillofac Surg 2012;41:500-5.
24. Nezafati S, Javadrashid R, Rad S, Akrami S. Comparison of ultrasonography with submentovertex films and computed tomography scan in the diagnosis of zygomatic arch fractures. Dentomaxillofac Radiol 2010;39:11-6.
25. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—A web and mobile app for systematic reviews. Syst Rev 2016;5:210.
26. QUADAS-2 | Bristol Medical School: Population Health Sciences | University of Bristol. Available from: http://www.bristol.ac.uk/population-health-sciences/projects/quadas/quadas-2/.
27. Freeman SC, Kerby CR, Patel A, Cooper NJ, Quinn T, Sutton AJ. Development of an interactive web-based tool to conduct and interrogate meta-analysis of diagnostic test accuracy studies: MetaDTA. BMC Med Res Methodol 2019;19:81.
28. Patel A, Cooper N, Freeman S, Sutton A. Graphical enhancements to summary receiver operating characteristic plots to facilitate the analysis and reporting of meta-analysis of diagnostic test accuracy data. Res Synth Methods 2021;12:34-44.
29. Devillé WL, Buntinx F, Bouter LM, Montori VM, de Vet HC, van der Windt DA, *et al*. Conducting systematic reviews of diagnostic studies: Didactic guidelines. BMC Med Res Methodol 2002;2:9.
30. Adeyemo WL, Akadiri OA. A systematic review of the diagnostic role of ultrasonography in maxillofacial fractures. Int J Oral Maxillofac Surg 2011;40:655-61.
31. Friedrich RE, Heiland M, Bartel-Friedrich S. Potentials of ultrasound in the diagnosis of midfacial fractures*. Clin Oral Investig 2003;7:226-9.
32. Friedrich RE, Plambeck K, Bartel-Friedrich S, Giese M, Schmelzle R. Limitations of B-scan ultrasound for diagnosing fractures of the mandibular condyle and ramus. Clin Oral Investig 2001;5:11-6.
33. Hong HS, Cha JG, Paik SH, Park SJ, Park JS, Kim DH, *et al*. High-resolution sonography for nasal fracture in children. Am J Roentgenol 2007;188:W86-92.