Original Research Article

Comparative evaluation of ultrasonography with plain radiograph in maxillofacial fractures: A clinical study

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Abstract

Background: The three dimensional computed tomography, digital volume tomography and cone beam computed tomography are the "gold standard" for preoperative imaging in facial fractures.3 Whereas it has disadvantages of patient exposure to a high dose of radiation, the potential risk of development of cataract, problems with patient positioning especially in cervical spine injuries and delay in the extricating the patient from the machine during an emergency. Ultrasound imaging is a dynamic and readily available technique. Images are acquired quickly with few artifacts. The technique is non invasive hence it is highly accepted by most patients. **Objectives:** To evaluate the diagnostic accuracy of ultrasonography (usg) to determine facial fractures in comparison with conventional radiograph using intraoperative photographs. **Methodology:** The study includes 30 consecutive patients with maxillofacial trauma reporting to the Department of Oral and Maxillofacial Surgery of Navodaya Dental College and Hospital, Raichur, Karnataka. **Results:** In 29 of 30 patients there was agreement between plain radiograph, ultrasound and Intraoperative findings, where as in one case of frontozygomatic suture, plain radiograph created a suspicion of fracture. Ultrasound assessed 9 sites in the face with sensitivity, specificity, positive predictive value and negative predictive value being 100 % in agreement with the Intraoperative findings at all the sites , whereas plain radiograph showed 100 % in agreement at 8 sites except frontozygomatic region where the agreement was 96.67% with the Intraoperative findings based on the kappa statistics with $p<0.05$. Conclusion:there is a need to develop standard techniques in ultrasound specified for use in the maxillofacial region. Although it is not a replacement for conventional radiography, it can be used as an alternative in places where radiographs are not available

Key Word: Ultrasound, Radiograph, Fractures, Agreement, Maxiofacial

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INTRODUCTION

In the era of increasing auto mobilization, industrialization and technology, the treatment of maxillofacial injuries has attained prime importance. Traffic accidents, which are becoming more and more frequent, particularly have brought about an increase in maxillofacial injury, interpersonal violence, falls; sports injury and industrial trauma are among other causes.[1] Usual assessment of injured patients involves a structured clinical examination. When the signs and symptoms indicate the presence of a maxillofacial fracture, the clinician must select from a number of imaging methods for confirmation. The complexity of the facial skeleton has led to the development of many specialized views to visualize adequately.[2] The three dimensional computed tomography, digital volume tomography and cone beam computed tomography are the "gold standard" for preoperative imaging in facial fractures.[3]Whereas it has

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disadvantages of patient exposure to a high dose of radiation, the potential risk of development of cataract, problems with patient positioning specially in cervical spine injuries and delay in the extricating the patient from the machine during an emergency.[2,3] Ultrasound imaging is a dynamic and readily available technique. Images are acquired quickly with few artifacts. The technique is non invasive hence it is highly accepted by most patients. It can also be used to guide needle biopsies (fine needle and core biopsies).[4,5,6]As a versatile and dynamic test, the images obtained are best viewed live, after achieving they may bedifficult to orientate and to interpret unlike Computed tomography and Magnetic resonance imaging which are acquired in standard reproducible planes. This is the reason why ultrasound applications in the head and neck are understood less well than other imaging techniques. Recent developments in computing hardware and microelectronic technology have facilitated technological advancement in ultrasonography in the last three decades, making it applicable to both soft and hard tissues,[7,8] In ultrasonography the risk associated with radiation exposure is excluded, so imaging can be repeated several times without major concern. Hence, we consider it is noteworthy to investigate the sensitivity and specificity of ultrasonography in comparison with conventional radiographs, it could hold greater promise inmaxillofacial trauma care as a non invasive diagnostic tool.

AIMS AND OBJECTIVES

To evaluate the diagnostic accuracy of ultra sonography (usg) to determine facial fractures in comparison with conventional radiograph using intra operative photographs.

Ultrasound In Maxillofacial Trauma: Ultrasonography has shown very high accuracy for the detection of nasal bonefractures.[3,9,10] It was found to be better than CT in the studies of LEE and HONG *et al*[7] in which it was able to detect linear non depressed fractures of the nasal bridge and anterior septal cartilagedeviation, which were missed by CT scanning. Orbital fractures are the most extensively investigated maxillofacial fractures with the aid of ultrasonography.[11,12,13] Fractures of the inferiororbital rim are readily detected by ultrasonography respectively.[14] Infraorbital orbital rim fracture often occurs as part of zygomatico- maxillary or zygomatico-orbital fractures. Ultrasonography has been reported to readily detect fractures of the anterior wall of the maxilla.[2,15,16] The use of diagnostic ultrasonography in zygomatic arch fractures has been well investigated and it is found very accurate in all cases of displaced arch fractures.[16] Only a few authors have investigated the use of ultrasound in mandibular fractures. This is probably because mandibular fractures are easily diagnosed by clinical examination and conventional radiography. HIRAI *et al.*[17] in their case series demonstrated that ultrasound readily detects fractures of the mandibular symphysisand angle. Advanced radiological investigations are sometimes indicated in cases of subcondylar fractures of the mandible. This is one area where the use of ultrasound might be necessary in the management of mandibular fractures. KLEINHEINZ *et al.*[18] and FRIEDRICH *et al.*[19] reported ultrasonographic sensitivity and specificity of 100% and 100%, respectively, and 66% and 52%, respectively, in the detection of mandibular subcondylar/ ramus fractures. FRIEDRICH *et al.*[19] emphasized the limitation of ultrasound as failure to detect intracapsular condylar fractures due to the overlap of the zygomatic arch.[15] Although, the current findings are promising, further investigation is required to document strong evidence on the appropriateness of diagnostic ultrasonography inmaxillofacial fractures.

MATERIAL AND METHODS

Source of data: The study includes 30 consecutive patients with maxillofacial traumareporting to the Department of Oral and Maxillofacial Surgery of Navodaya Dental College and Hospital, Raichur, Karnataka.

Inclusion criterion: All the patients who reported to the Department Of Oral And Maxillofacial Surgery, Navodaya Dental College, Raichur with maxillofacial trauma, who were cooperative and willing to be included in the study.

Exclusion criterion: Patient having fracture more than two weeks old, not co-operative and unwilling for ultrasonography were excluded from the study.

MATERIALS

An ultrasound THOSHIBA ISTYLE (NEMIO XG) with a straight probe with frequency ranging between 7.5 MHz – 10 Mhz, Conventional radiographs, Intraoperative fracture photographs

METHODOLOGY

The patients with facial injuries were examined systematically for facial fractures, the patients with suspected facial fractures on clinical examination were considered for the study. After taking the informed consent, all patients who were diagnosed with facial fractures were examined with various plain radiographs depending on the clinical suspicion of the fracture site i.e., orthopantamogram for the mandibular fractures, paranasal sinus view and postero-anterior view if zygomatico-maxillary complex fractures were suspected

etc and ultrasonography was carried out with to evaluate for the fracture. The radiologist carrying out the ultrasound scan would not know the findings on the plain radiograph and be made to scan all facial bones to detect any discontinuity of the bone (fracture) to avoid the bias. Both the findings were compared with intra-operative findings. All the findings were recorded and tabulated for statistical analysis to find out the efficacy of ultrasound in detecting the maxillofacial fractures.

Figure 1:

Figure 2

Figure 3:

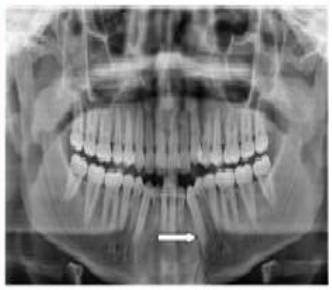

Figure 4

Figure 5:

Figure 6:

Figure 1: XRAY Machin**; Figure 2:** Toshiba Ultrasound Machin; **Figure 3:** Toshiba Ultrasound Probe

RESULTS

The patient age ranged from 18 to 56 years of age, the cause of injury was road traffic accident in 28 patients, in one patient it was assault and 1 patient fell from the roof, of these 30 patients there were 18 mandibular fractures and 11 mid face fractures where it was zygomaticomaxillary complex fractures in most of them, 1 patient had both mandibular and zygomaticomaxillary complex fracture.

Table 1: Comparison of Agreement between X ray, USG with Intra operative Findings

Diagnosis	Radiograph		USG		Intraoperative	
	Yes	No	Yes	No	Yes	No
Symphysis	1	29	1	29	1	29
Parasymphysis	14	16	14	16	14	16
Body	2	28	2	28	2	28
Angle	4	26	4	26	4	26
Infra orbital	8	22	8	22	8	22
Zygomatico maxillary buttress	7	23	7	23	7	23
Fz	6	24	5	25	5	25
Dentoalveolar	1	29	1	29	1	29
Ramus	3	27	3	27	3	27

In 29 of 30 patients there was agreement between plain radiograph ,ultrasound and Intraoperative findings, where as in one case of frontozygomatic suture, plain radiograph created a suspicion of fracture with clinical finding of depression and tenderness on palpation, ultrasound showed no fracture, based on the plain radiograph and clinical finding the site of fracture was opened for fixation and there was no fracture found in the frontozygomatic region. Ultrasound assessed 9 sites in the face with sensitivity, specificity, positive predictive value and negative predictive value being 100 % in agreement with the Intraoperative findings at all the sites , whereas plain radiograph showed 100 % in agreement at 8 sites except frontozygomatic region where the agreement was 96.67 % with the Intraoperative findings based on the kappa statistics with $p < 0.05$.

Table 2: Sensitivity, Specificity, PPV and NPV of X ray, USG with Intra operative Diagnostic Procedure

Diagnosis	X ray with intra operative diagnostic Procedures				USG with Intra Operative Diagnostic Procedures			
	Sensitivity	Specificity	PPV	NPV	Sensitivity	Specificity	PPV	NPV
Symphysis	100	100	100	100	100	100	100	100
Parasymphysis	100	100	100	100	100	100	100	100
Body	100	100	100	100	100	100	100	100
Angle	100	100	100	100	100	100	100	100
Infra Orbital	100	100	100	100	100	100	100	100
Zygomatico Maxillary Buttress	100	100	100	100	100	100	100	100
FZ	100	96	83.3	100	100	100	100	100
Dentoalveolar	100	100	100	100	100	100	100	100
Ramus	100	100	100	100	100	100	100	100

DISCUSSION

The facial skeleton is a three dimensional structure consisting of skeletal elements and sutures overlying one another which makes it rather difficult to detect fractures on plain films. Patient positioning is also important in getting good radiographic views for accurate diagnosis. The relative merits of ultrasonography are considerable. Ultrasound facilities are widely available, even at the lowest level of health care.[7,15,20] The cost of investigation is comparatively cheap, it is less dependent on patient cooperation and the technical sensitivity of patient positioning is minimal.[11,21] Ultrasonography has shown very high accuracy for the detection of nasal bone fractures with sensitivity ranging from 90% to 100%, specificity of 98–100% and high predictive values. These findings were found to correlate to some otherstudies100, 103, thus establishing that ultrasonography is an adequate investigation for clinically suspected nasal fractures, in our study there were no cases of nasal bone fractures as they were managed conservatively by closed reduction. The least sensitivity observed for detection of medial and lateral wall fractures was 56% and 88% respectively,[7,22] the least specificity was90% and 87%, respectively. Generally, accuracy for detection of orbital wall fractures was 90– 100% 6.In the case of the orbital floor, sensitivity and specificity ranged from85% to 100% and 57% to 100%, respectively, and accuracy was 86–98%.[15,20] It was consistently observed that orbital floor fractures beyond 4 cm posterior to the orbitalmargin is poorly detected by ultrasound.[14,16] Fractures of the inferior orbital rim are readily detected by ultrasonography with sensitivity and specificity up to 94% and92%, respectively.[11] Medial wall fractures were not included in our study, lateralorbital wall was considered as frontozygomatic suture in which ultrasound was more in agreement with the intraoperative finding and had a sensitivity and specificity of100% and 100% . The plain radiograph which was 96.67% in agreement with the intra operative findings according to kappa statistics had a sensitivity of 100% and specificity of 96%, as 1 patient out of 6 patients was suspected of frontozygomatic fracture based on the clinical and plain radiograph finding. The ultrasound and Intra operative finding showed no fracture, the rest of the other 5 patients were in100% in agreement with both plain radiograph and ultrasound when compared with the Intraoperative finding. Ultrasonography has been reported to detect fractures of the anterior wall of the maxilla.[15,20] In our case series 8 patients had Infraorbital fractures which were treated with open reduction and both the investigation modalities were in 100 % agreement with the Intra operative findings. The use of ultrasonography in zygomatic arch fractures has been well established and is found to be accurate in all cases of displaced arch fractures.[23] Our study did not include the arch as in all the cases it was managed by closed reduction. Only a few authors have investigated the use of ultrasound in mandibular fractures. This is probably because mandibular fractures are easily diagnosed by clinical examination and on orthomopantogram. HIRAI *et al*. 1999[17] in their case series demonstrated that ultrasound readily detects fractures of the mandible. This study coincides with the same study as 1 symphysis, 14 parasymphysis, 2 mandibular body and 4 angle fractures were investigated with plain radiograph and ultrasound and showed 100 % agreement with the Intraoperative findings. KLEINHEINZ *et al*. 1997[24] and FRIEDRICH *et al*. 2003[19] reported Ultrasonographic sensitivity and specificity of 100% and 100%, respectively, and66% and 52%, respectively, in the detection of mandibular sub condylar/ramus fractures. Our study had similar results as of KLEINHEINZ *et al*. as we had 3ramus/sub condylar fractures where we got 100% sensitivity and 100% specificitywith both plain radiograph and ultrasound.Our study has one maxillary Dentoalveolar fracture which showed 100 %sensitivity and 100 % specificity.

CONCLUSION

High level evidence is available to justify the use of ultrasonography in facial fractures. Ultrasound offers a safe, inexpensive, accurate diagnostic adjunct to conventional radiographs for suspected facial fractures and is well tolerated by recently injured patients. The ultrasound scan is difficult to interpret as there are noanatomic landmarks to identify the site. Therefore there is a need to develop standard techniques in ultrasound specified for use in the maxillofacial region. Although it is not a replacement for conventional radiography, it can be used as an alternative in places where radiographs are not available. It can still be helpful when it is done at point of care by the surgeon himself or in his presence by the radiologist. Its sensitivity and specificity according to our study is near to 100 % which suggests that with future advances ultrasound has a potential to play a significant role in diagnosis of facial fractures.

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