“DIAGNOSTIC ACCURACY OF ULTRASONOGRAGHY VERIFIED WITH COMPUTED TOMOGRAPHY FOR THE DIAGNOSIS OF MAXILLOFACIAL FRACTURES- A PROSPECTIVE STUDY.”

By

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KAHER’s V K INSTITUTE OF DENTAL SCIENCES
BELAGAVI, KARNATAKA

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I dedicate my work to

my family

Mr. Shailesh M Shah,

Mrs. Ranjan S Shah,

&

Mrs. Eshita Shah

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DR. ABHISHEK SHAH

LIST OF ABBREVIATIONS

Pre-op	:	Preoperative
Post-op	:	Postoperative
CT	:	Computed Tomography
US	:	Ultrasound
USG	:	Ultrasonography
HRUS	:	High Resolution Ultrasonography
Se	:	Sensitivity
Sp	:	Specificity
PPV	:	Positive Predictive Value
NPV	:	Negative Predictive Value
SMV	:	Submentovertex
TP	:	True-Positive
TN	:	True-Negative
FP	:	False-Positive
FN	:	False- Negative

ABSTRACT

Introduction

Maxillofacial injuries are quite common following road traffic accident, falls, assaults. For a long time, Computed Tomography is considered as gold standard for maxillofacial fracture diagnosis and is used as first modality. But it has certain limitations such as access to facility, high cost and radiation exposure. Over the last decade, ultrasonography has been widely used in medical fields due to its remarkable features such as non-radiation, quick and painless technique. . The assessment of maxillo-facial fractures with the help of ultrasound for is emerging concept.

Aim

To determine the diagnostic "accuracy" of ultrasound verified with computed tomography for the detection of maxillofacial fractures.

Materials and Methods

Patients reported to Trauma Care and Emergency centre of KLES Dr.PrabhakarKore Hospital with maxillofacial trauma were included based on the inclusion criteria. The patients suspected of any fractures underwent CT Scan to rule out any neurological disorder and diagnosis of the fractures was made. Ultrasonography was done after taking consent from the patient. CT scan and USG results were analysed by two different radiologists. Here, CT scans diagnostic result was considered as gold standard for identifying fractures and results of USG was verified with CT scan results.

Results

A total of 32 patients were selected in the study. All the patients who underwent CT scan were taken up for Ultrasonography. Out of all the fourteen anatomical landmark, nine were able detect all the fracture on USG with 100% sensitivity and specificity. Intracapsular condyle fracture were not seen on USG. The region where all fractures were not identified were medial wall and floor of orbit, one nondisplaced ramus fracture.

Conclusion

In conclusion, ultrasonography can be a handy, diagnostic, additional, non-invasive and inexpensive tool in the detection of maxillofacial fractures when compared to computed tomography in primary healthcare center.

Keyword: 'Ultrasonography' 'ultrasound' 'computed tomography' 'maxillofacial fractures'

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF IMAGES

INTRODUCTION

Maxillofacial injuries are quite common following road traffic accident, fall, assault. Standard evaluation of trauma patients in the maxillofacial area includes structured clinical review, including history, inspection, palpation and percussion. If a clinical examination reveals the existence of a fracture of the facial skeleton, various imaging techniques are used to validate the diagnosis[5].For a long time, Computed Tomography is considered as gold standard for maxillofacial fracture diagnosis and is used as first modality. But it has certain limitations such as access to facility, high cost and radiation exposure. Another diagnostic tool used is plain radiography which has its own limitations.

Over the last decade, ultrasonography has been widely used in medical fields due to its remarkable features such as non-radiation, quick and painless technique[1]. Ultrasound imaging is used mainly in head and neck region for identification of pathology in association of soft tissue.[23] Ultrasound has historically been used in the identification of soft tissue lesions such as salivary gland evaluation, orbital diagnosis such as presence of foreign body, any underlying neoplasms. The role of ultrasonography in maxillofacial trauma is less widely recognized. Ultrasound uses frequency of 3-15 MHz in medical fields.Ultrasonography uses high-frequency ultrasonic waves, which are transmitted to the body and dispersed through the tissues by a transducer, and echoes are reflected on the screen for the diagnostic purpose[1]. With recent technical advancements, ultrasonography, unlike before, can transmit ultrasound waves to bony lesions and fractures of the head and neck apart from soft tissues. The use of ultrasound for the assessment of maxillo-facial fractures is therefore emerging[1]. The use of sonography has already been reported in the region of orbit, zygomatic arch, nasal bone, mandibular condyle and ramus in the literature[11].As this is a cost-effective, non-invasive and cheaply available imaging technique, it can be used as a primary investigative imaging method. [1]. Due to its marked features, ultrasound can be made available at primary health care centre, as it is widely used by the gynaecologists, ENT surgeons and General Surgeons.

The aim of this study is to evaluate the diagnostic accuracy of ultrasound verified with computed tomography for the diagnosis of the maxillofacial fractures.

AIMS & OBJECTIVES

Aim of the Study:

To determine the diagnostic accuracy of ultrasound verified with computed tomography for the detection of maxillofacial fractures.

Objectives of the Study:

1. To evaluate the diagnostic accuracy of ultrasonography if it can be used as a primary diagnostic method for maxillofacial trauma.

2. To evaluate the sensitivity and specificity of ultrasonography verified with CT Scan.

REVIEW OF LITERATURE

Ord et al used ultrasound for the first time in 1981. A 5 MHz probe was used to check patients with medial orbital wall fracture. A total of 17 patients were included in the study. U.S.G. had been found to have 95% sensitivity to facial fracture screening. In this analysis, all the fracture of mandible was diagnosed by USG. The USG was not able to diagnose high condylar fractures.[27]

Beck et al investigated 21 patients suspicious with nasal bone fractures using 5-7.5MHz linear probe and showed that all the fractures lines diagnosed by radiography were also diagnosed by sonography[29]. Oliver et al evaluated 63 patients and reported that when diagnosing fracture lines, the precision of sonography had been more than radiography.

Jenkins et al performed a prospective blinded analysis evaluating the use of al floor fractures to CT. It was summarized that USG could be used in case of zygomatic fractures with co-existing floor of the orbit fractures. The study also showed that in cases of absolute blowout fracture, ultrasonography was inconclusive.[26]

Forrest et al, (1993) This study involved application of high resolution, real time ultrasound in case of orbital trauma. It involved eighteen patients (16 males, 2 females) who had trauma to the orbito zygomatic area that had been evaluated over a 6-month period at a regional trauma centre.All patients underwent for ultrasound analysis of both the orbits. The results of the study showed a strong correlation between ultrasound and CT findings in 17 (94 per cent) of patients. Ultrasound showed adequate sensitivity (92 percent) and specificity (100 percent) and positive predictive value (100 percent) when compared with CT scanning.[3]

Hirai et al (1996) conducted a case series of 5 patients which concluded that limited use of ultrasound has been documented for orbital and zygomatic arch fractures and for detection of mandibular condyles. All these inspection were performed using a 10 MHz or less frequency probe. The findings are always uncertain without the use of 15 MHz or higher frequency. In some cases, traditional probes are too wide to map the face three-dimensionally. Ultrasound could be used to diagnose even minimal fractures, particularly in cases where only the reverse view of Waters is available, and the image is unclear. The results are always unsure without the use of 15 MHz or higher frequencies. Traditional probes in some cases were too large to map the face three-dimensionally. Even slightest of fractures could be diagnosed by ultrasound.[4]

McCann et al (2000) investigated the sensitivity and specificity of ultrasound to detect zygomatic-orbital complex fractures. Ultrasound imaging took place in five landmarks: infraorbital margin; anterior wall of the maxillary sinus; zygomatic arch; frontozygomatic process; and the floor of orbit. Ultrasound imaging was most effective at the lateral wall of the maxillary sinus, with a sensitivity of 94 per cent and accuracy of 100 per cent. In this area the positive predictive value was 100 per cent compared to the radiographic findings. It concluded that ultrasound as an initial examination is a valuable method in imaging facial injuries and minimize the use of radiographs required for diagnosis of fractures.[5]

Jank et al (2004); The study included a sample size of total of 58 patients with clinical ophtalmological or radiological diagnosis of orbital trauma. They were prospectively studied by the Ultrasound and CT. An alternative to computed tomography (CT) imaging system for detecting orbital wall and infraorbital rim fractures could be done with a curved array transducer. The USG of infraorbital rim investigation provided 77 percent sensitivity, 89 percent specificity, and 97 percent accuracy. The U.S.G of orbital floor obtained a sensitivity of 94 per cent, a specificity of 57 per cent and an accuracy of 96 per cent. In the analysis of the infraorbital surface (P = 0.809) and the orbital floor (P = 0.729), there was no major difference between US and CT. They concluded that further experiments have to be performed to reduce the existence of false negative outcomes.[6]

Friedrich et al (2001); This research examined the uses and drawbacks of B-scan ultrasound for the diagnosis of mandibular condyle and ramus fractures. Thirty-two consecutive patients (age: 11–70 years, mean 34.5 years) with 39 mandibular condyle and ramus fractures were clinically investigated using X-ray and B-scan ultrasound. Radiographs have been used as the standard diagnostic tool. Ultrasonography detected 26 fractures out of 39 fractures. The Sp of ultrasonographic fracture diagnosis was 52% and the Se was 66%.[7]

In another study by **Friedrich et al;(2003)** evaluated the uses and drawbacks of ultrasound in the diagnosis of midfacial fractures. The study included 81 patients with radiologically proven facial skeleton fractures. For examination a small-part 7.5-MHz applicator was used. The conclusion made was ultrasound was not effective for non dislocated fractures. Ultrasound is also applicable in visualization of the zygomatic arch and the frontal sinus- anterior wall and it could also be used to check closed reduction post-op. But its use is limited in fractures of the orbital margin and the nasal bone.[8]

Jank et al (2004) examined the diagnostic utility of ultrasonography (US) in fractures of the orbital floor and fractures of the orbital rim. Sixty patients with an orbital fracture were examined over a 10month period. The US investigation was conducted with a curved array transducer of 7.5MHz. The US infraorbital rim investigation showed 94 percent sensitivity and 92 percent specificity with 92 percent diagnostic accuracy. The U.S. orbital floor examination showed 95% sensitivity and 100% specificity with 98% diagnostic accuracy. The study results indicated that ultrasonography could be used as an another option in the detection of fractures in orbital floors.[9]

In 2005**, Siegfried et al** conducted a study to determine if statistically relevant differences occur between the various observers while analyzing orbital wall fractures. It included twenty-eight patients with clinically suspected orbital fractures which were prospectively tested with ultrasound. Two diffrent investigator re-checked the US of the infra-orbital margins, the orbital floors, medial and lateral wall of the orbit. US examination of the infra-orbital margins had 12 TP, 16 TN, 1 FP and 2 FN results. The value obtained for sensitivity, specificity and accuracy were 86%, 94% and 90%. The US examination of the orbital floors gave 26 true positive, 3 true negative, 1 false negative and no false positive results. The sensitivity was of 90%, specificity was of 100% and accuracy was of 94%. There was no significant discrepancies among investigators. In conclusion, Ultrasound examination of the orbit in patients with clinical evidence of a fracture of the infra-orbital margin and/or the medial and/or lateral orbital walls has a very good result. The reliability of the ultrasound was unsatisfactory in orbital floor fractures.[10]

Hong et al (2007) described the ultrasound findings in case of nasal bone fractures in children and diagnostic value of sonography was evaluated as compared with conventional radiography. 26 children with nasal trauma underwent conventional radiographs and sonographic scans. Conventional radiographs showed 14 of 26 fractures while Sonographic scans detected all the fractures. **They concluded that** Sonography could be as used as prime technique for evaluating nasal bone fractures.[28]

Blessmann et al (2007); This study was conducted to test if an ultrasound could be used as primary training tool.10 patients who were diagnosed with mid-facial fractures on CT, a navigated sonography was executed on them. Through displaying fused images of CT and US, the results were tallied with CT findings. 7 patients had fracture in at least in one spot on sonography. The examiner was unable to assess whether or not a fracture was present in three patients.[11]

Mohammadi et al (2009) conducted a cross-sectional analysis that measured the diagnostic accuracy of ultrasonography and traditional radiography. They also compared USG to clinical examination which was considered gold standard technique to decide if it could be used as primary diagnostic method. 103 fracture were confirmed clinically having nasal bone fractures. On radiograph 80 were identified, while 90 were detected by ultrasonography. The Sensitivity of USG and conventinal X-ray were 90.2 per cent and 77.6 per cent, respectively. The specificity obtained was 98.5 per cent and 82% respectively. The result was that high resolution ultrasound could be the replacement for conventional radiography as primary diagnostic method.[12]

Lee et al (2009) performed a retrospective study comparing the significance of high-resolution ultrasonography (HRUS) and computed tomography (CT) in the detection of nasal bone fractures. CT and HRUS tests were conducted on 140 patients. Sonograms were obtained using a hockey stick (15–7 MHz) probe. Nasal bone fractures were graded by severity into high-and low-grade categories. HRUS findings were used as a reference standard to compare all the CT findings. The accuracy ratings for HRUS, CT and standard radiography for nasal fracture detection were 100 percent, 92.1 percent and 78.6 percent, respectively. They concluded that CT had lower accuracy compared to HRUS, particularly in low-grade nasal fractures.[13]

Sallam et al (2009) compared ultrasound and CT results in the diagnosis and treatment of ZMC fractures. This prospective research included 10 consecutive patients. Ultrasound results revealed significant variations in the ability to achieve accurate estimate of the identified anatomical landmarks. The zygomatic arch, the lateral orbital wall and the infraorbital margin could be easily seen by ultrasound. The evaluation of the orbital floor and medial wall proved to be very uncertain. In conclusion, ultrasound is more effective in post-op follow-up, having reduced costs and lower sensitivity to radiation.[30]

Javadrashid et al (2011); The purpose of this research was to compare USG with CT in the identification of nasal bone fractures. The study included 40 patients of nasal bone fractures. Ultrasonography with a 7.5 MHz transducer was used to test the fractures. Sonograms were compared with CT findings and it obtained Se, Sp and predictive values. In 24 of the 40 patients CT scans diagnosed nasal bone fractures and in 23 patients ultrasonography identified the fractures. Ultrasonography sensitivity and accuracy were 94.9 percent and 100 percent respectively when measuring nasal bone fracture compared to CT. The ultrasound evaluation gave a PPV and NPV of 100% and 95.3%. There was no significant difference between CT and ultrasonography in the identification of nasal bone fractures. They concluded Ultrasonography could be used as a primary imaging technique for detecting nasal bone fractures.[15]

Nezafati et al (2010); The goal of this research was to compare ultrasound in the visualization of zygomatic arch fractures with CT scan and submentovertex film. 17 patients were studied with possible zygomatic arch fracture. The ultrasonographic results were compared with the data from CT and plain films. The probe was positioned over the fractured arch transversely to evaluate its entire length. Ultrasound detected the fractured arches with Se of 88.2% (two false negatives) and Sp of 100% (no false positives). In conclusion, ultrasound was successful in the depiction of arch fractures and could be used as an alternative to radiograph to minimize exposure to radiation.[16]

Ogunmuyiwa et al 2012; The study established the Se, Sp, PPV and NPV ultrasound values for the identification of zygomatomaxillary complex fractures. 21 patients with zygomatomaxillary complex fractures were included in this prospective analysis. Ultrasound showed a sensitivity of 100 per cent for zygomatic arch fractures, 90 per cent for infraorbital margin fractures and 25 per cent for frontozygomatic process fracture. The specificity was 100 percent at all these three landmarks. There was no significant difference in ability of the CT scan and ultrasonography to detect fractures of zygomatic complex.[17]

Jank et al, (2006) documented the usefulness of ultrasound (US) in detection of orbital wall fractures when compared CT and also measured the intra observer reliability of US using a curved array transducer. The research involved 13 patients with orbital trauma as their clinical diagnosis who were prospectively examined by CT (reference) and 2 U.S. investigators. Statistical tests based on true-positive, true-negative, false positive and false-negative results were measured. The comparison of the results of the 2 US investigators by the chi-square test showed P values of 0.385

for the medial orbital wall and 0.638 for the lateral orbital wall, which shows no significant difference. The results of the study implied that US has the potential to reach the same diagnostic quality as CT in the future, but further studies must be performed to improve the diagnostic quality of the method.[18]

Atigechi et al (2014); This analysis determined the diagnostic value of USG and radiography. It was compared with clinical examinations which was considered gold standard technique to confirm whether ultrasound could be used for the diagnosis of nasal bone fracture. The prospective research was performed in 128 patients with clinical symptoms of nasal bone fractures. Waters view and lateral view radiograph was taken by two independent and USG was performed with a 10-MHz ultrasound probe. In ultrasound fracture evaluation, the sensitivity was 84%, the specificity was 75%, the accuracy was 82%. In the assessment of fracture on lateral view radiography, sensitivity, specificity and accuracy was 50%, 72%, 55% respectively. On Waters view radiography, sensitivity, specificity and accuracy was 53%, 65%, 56% respectively. They concluded that diagnosis of nasal bone fracture by ultrasound was significantly better as compared with radiography (P = 0.04).[19]

Johari et al (2016); In this study, ultrasonography (USG) and cone beam computed tomography (CBCT) against computed tomography (CT) in identifying orbital floor fractures was performed and compared. A total of 120 patients with isolated orbital floor fractures underwent CT scanning, orbital USG with a 7-10 MHz linear transducer, and CBCT. According to CT findings, 39 orbital floor fractures were present. The sensitivity, specificity, PPV and NPV value obtained for US in detecting orbital floor fractures were 87.2%, 100%, 100% and 94.2%, respectively. The values of Se, SP, PPV and NPV obtained for CBCT were 97.4%, 97.5%, 95.0%, and 98.8%, respectively. They concluded that CBCT could be superior in detecting orbital floor fractures. The use of USG in such cases is limited because of its lower sensitivity value.[20]

Sreeram M P (2016); The study was conducted to discover the efficiency of ultrasound in screening maxillofacial fractures compared to Computed Tomography as gold standard. The study included fifty patients; 40 with maxillofacial trauma and 10 subjects were of control. Linear ultrasound probe with a frequency of 5 to 10 MHz was used. Ultrasound identified the fracture with 95 % sensitivity. The undisplaced high condylar fracture and pure blowout fracture were not detected by ultrasound.[1]

Reddy et al (2016); This study evaluated ultrasonography as a diagnostic aid for zygomatic arch fractures. A prospective research was performed in 10 patients with ZMC fractures. Ultrasonography was conducted bilaterally along with the conventional SMV radiographic view. Ultrasonography was successful in the assessment of zygomatic arch fractures. Ultrasonography provides a safe, readily available, inexpensive and precise adjunct to conventional x-rays for the diagnosis of zygomatic arch fractures.[23]

Singh et al (2014); The research measured the use of ultrasonography (USG) in conjunction with traditional radiography and computed tomography (CT) scan for the detection of mandibular fractures and zygomatic arches. A total of 40 patients suspected of either fractures were included. Ultrasonographic procedures have been conducted using small linear probe with 10 MHz frequency. Se and Sp of USG in evaluating zygomatic arch fractures were 100% and 100%, respectively; and that of mandibular fractures were 94.74% and 100%, respectively.In summary, USG is a very accurate method for the identification of zygomatic arch and mandible fractures.[22]

Nemati S (2015); The purpose of this study was to show the importance of High Resolution Ultrasonography (HRUS) in determining the time of fracture of the nasal bone. In 45 patients with clinical symptoms of unilateral nasal bone fracture, a longitudinal, descriptive-analytical analysis was performed. For all the patients, the follow-up period was 6 months. HRUS was carried out by an experienced consultant who was blinded to the clinical data of the patients. In each session, the ultrasonographic findings were recorded. Thirty-six cases completed the study course successfully.In HRUS, for the diagnosis of nasal bone fracture after trauma, subperiosteal hematoma with a mean thickness of 1.14 mm (0.79-1.31 mm) was extremely sensitive (100%). In conclusion, HRUS is a effective diagnostic technique for estimating the time of nasal bone fracture.[24]

Nezafati et al (2020); This research compared the effectiveness of USG and computed tomography (CT) scans in the diagnosis of mandibular fractures. In this prospective analysis, a CT scan was performed in 42 patients suspected of mandibular fractures. The CT scans were analyzed by two radiologists. Another radiologist evaluated all patients with USG at a frequency of 7-12 MHz. The Sp and Se of USG was 100 percent and 91.1 percent respectively. The sensitivity of USG in angle region, condyle, condylar neck and symphysis fractures was 100 per cent, 91.6 per cent, 85.7 per cent and 80 per cent respectively, and the specificity was 100 per cent in all these regions. Among the astonishing factors, in the presence of hematoma the USG had sensitivity of (84.6%) which was the lowest.

While sensitivity, specificity and diagnostic accuracy of USG were high, there were some limitations which made it difficult to replace USG unequivocally with CT scans, particularly in the case of condylar fractures.[25]

MATERIALS AND METHODS

Patients reporting to Trauma Care & Emergency centre to KLES Dr. Prabhakar Kore Hospital suspected of maxillofacial trauma to maxillofacial region were included in the study. As first line imaging, a Computed tomography of the facial skeleton was carried out and examined to establish a diagnosis. Later the patient underwent ultrasound examination of the affected region. The results of CT and USG were summarized by two different radiologists. The radiologist conducting the USG investigation will be blinded to the findings of the CT Scan examination.

STUDY DESIGN:

This study was a comparative prospective study which consisted total of 32 patients. The patients were selected based on inclusion criteria.

SOURCE OF DATA:

All data required was collected from the patients reporting with maxillofacial trauma to KLES Dr. Prabhakar Kore Hospital, Belagavi.

INCLUSION CRITERIA:

- Maxillofacial injuries with bone fractures.
- All age groups.
- Both male and female.

EXCLUSION CRITERIA:

Patient with any medical or surgical emergency.

METHODOLOGY:

Patients reported to Trauma Care and Emergency centre of KLES Dr. Prabhakar Kore Hospital with maxillofacial trauma were included based on the inclusion criteria. After taking a case history and clinical examination of the patients, suspected of any fractures underwent CT Scan to rule out any neurological disorder and diagnosis of the fractures was made. Primary care was given to patient which included wound debridement and closure. Ultrasonography was done after taking consent from the patient. CT scan and USG results were analysed by two different radiologists. Here, CT scans diagnostic result was considered as gold standard for identifying fractures and results of USG was verified with CT scan results to determine its diagnostic accuracy.

INSTRUMENTS AND MATERIALS:

CT scans was done with GE VOLUSON EVO-Germany (Assembled in India).

Ultrasonography was done using GE VOLUSON PR-8 ultrasound machine with linear probe(5-7MHz) & curvilinear probe(7-12MHz).

DETAILS OF THE PROCEDURES TO BE CONDUCTED DURING RESEARCH

Patients reported to Trauma Care & Emergency centre of KLES Dr. Prabhakar Kore Hospital with maxillofacial trauma following Road traffic accident, fall, assault etc. during the period of October 2018-September 2020 were included in the study.Following a CT scan, based on the inclusion criterion, the patient underwent an ultrasonographic examination of any fracture that had been confirmed by a CT scan to verify it.

The patient selected were clinically examined to determine the area for carrying out the ultrasonography. The linear/curvilinear probe used for USG was cleaned and covered with glove. Medigel Ultrasound jelly placed over the affected area and on the probe. The probe was applied on the affected area for the diagnosis of underlying fracture. In case of patients with contused lacerated wounds or any form of abrasion, they were given primary care before and investigation was carried out later.

Image 2 : Straight and Curved transducer probe

Image 1 : Ultrasound Scanner

Image 3 : CT Scan Machine

Image 4: Placement of straight transducer probe

Image 5a : Nasal Bone Fracture- CT Axial

Image 5b : Nasal Bone Fracture- USG

Image 6a : Orbital floor Fracture-3D

Image 6b : Orbital floor Fracture - USG

Image 7a : Left condylar neck fracture - 3D

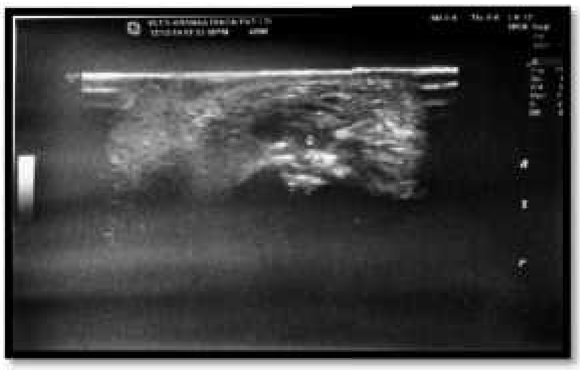


Image 7b : : Left condylar neck fracture -USG

Image 8a : Anterior wall maxillary sinus- Axial CT

Image 8b: Anterior wall maxillary sinus - USG

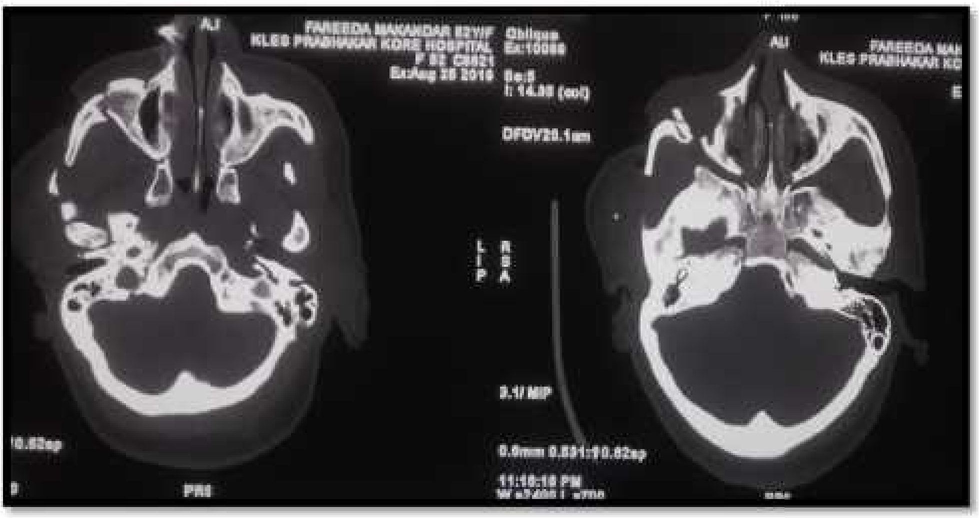


Image 9a :Zygomatic Arch fracture- Axial CT

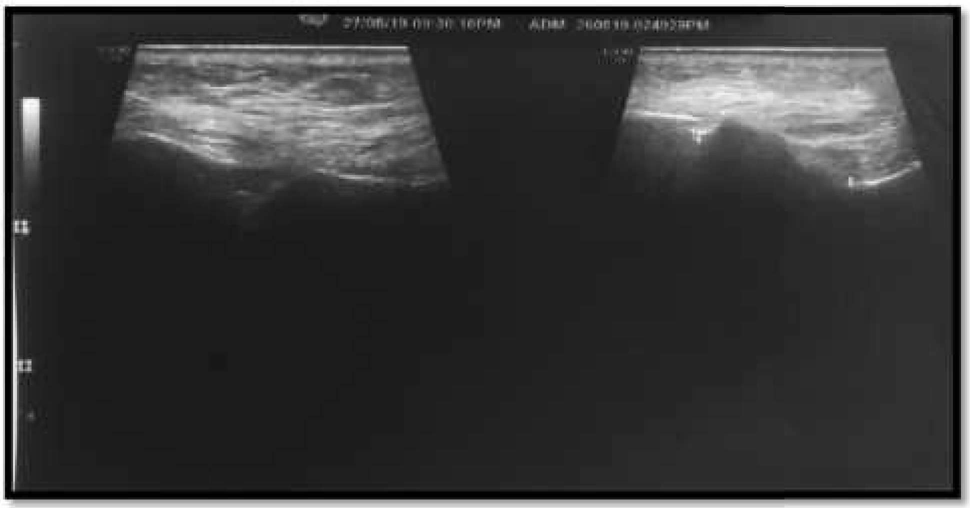


Image 9b : Zygomatic arch - USG

Image 10a : Symphysis fracture - Axial CT

Image 10b : Symphysis fracture - USG

Image 11a :Mandibular Body – Axial CT

Image 11b : Mandibular Body - USG

STATISTICAL TEST:

- Kappa Statistics.
- Sensitivity Analysis.
- Unpaired t-test.

VALUES TO BE CALCULATED:

Sensitivity tests how much a test properly produces a positive outcome for people who are tested for the condition (also known as the "true positive" rate). A test that is highly sensitive would flag almost everyone that has a disease and will not yield many false-negative results.(Example: a 90 percent sensitivity test will correctly produce a positive result for 90 percent of people with the disease but will produce a negative — a false-negative — result for 10 percent of those with the disease and who should have tested positive.)

Specificity tests the ability of a test for people who do not have the disorder being tested for (also called the "real negative" rate) to deliver a negative result properly. A high-specificity test would correctly rule out almost everyone without the disease and will not produce many false-positive outcomes.(Example: a 90 percent specificity test would correctly return a negative outcome for 90 percent of people who do not have the disease but will return a positive outcome— a false-positive one— for 10 percent of people who do not have the disease and who should have tested negative.)

RESULTS

A total of 32 patients were selected based on the inclusion criteria. Patients who had maxillofacial fractures and underwent CT scans were taken up for ultrasound examination. The age group was classified into three categories: <=30years, 31-40yearsrs, >=41years. According to age group, 16 out of 32 (50%) were below 30 years of age. There were 8 Patients in the age group of 31-40 years and 8 patients were above 40 years of age (Table 1). Of the 32 patients selected, 27 were males and 5 were females. (Table 2). The mean age for selected patients was 35.78± 14.21 as shown in Table 1.

Table 1: Age-wise distribution of patients selected in the study

Age groups	Number	Percentage
<=30yrs	16	50.00
31-40yrs	8	25.00
>=41yrs	8	25.00
Total	32	100.00
Mean age	35.78	
SD age	14.21	

Figure 1 : Age wise distribution

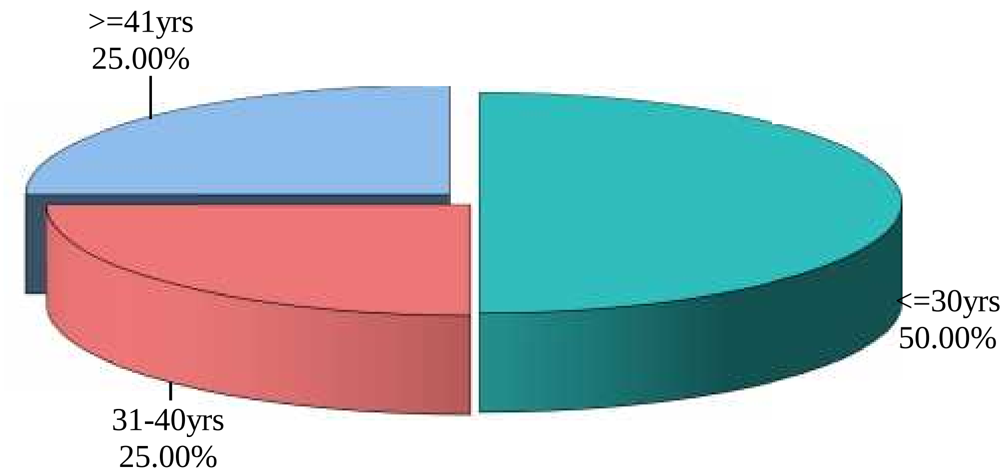
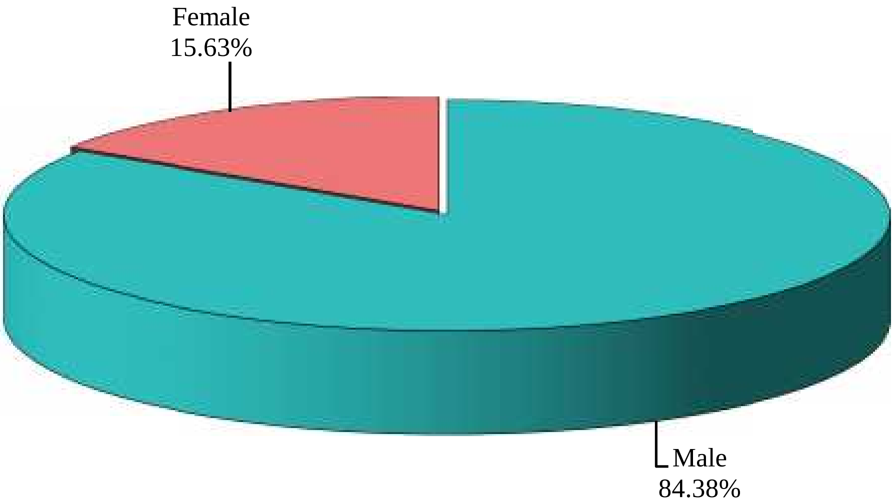


Table 2: Gender wise distribution of patients

Gender	Number	Percentage
Male	27	84.38
Female	5	15.63
Total	32	100.00

Figure 2 : Gender wise distribution

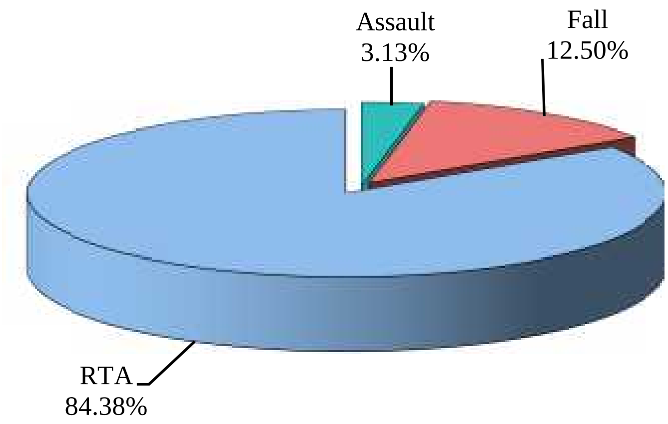


Of all the patients taken up for the study, the history presented was of Road Traffic accidents, Falls and Assault respectively. The majority of the patient i.e. 27 out of 32 had a history of RTA, 4 patients had a history of fall and one patient gave a history of Assault. A complete case history following the maxillofacial trauma was acquired for all the patients before going for an ultrasound examination.

Table 3: History wise distribution of patients

History	Number	Percentage
Assault	1	3.13
Fall	4	12.50
RTA	27	84.38
Total	32	100.00

Figure 3 : History wise distribution



After the patients underwent CT scans, ultrasound was carried out on the affected sites in the maxillofacial region. A total of fourteen sites were selected in the maxillofacial region. Based on the clinical diagnosis, the ultrasound was carried in those regions to look out for fracture. The sites included were Frontal bone (anterior wall), Lateral wall of the orbit, Roof of the orbit, Medial wall of the orbit, Floor of the orbit, Zygomatic arch, Zygoma(Malar bone), Anterolateral wall of the maxillary sinus. In the mandible, the sites were Symphysis/Para symphysis region, Body, Angle, Ramus and Condylar/sub condylar region.

Based on the interpretation of USG, the fractures were further verified with the CT scans. The results obtained were tabulated identifying the sensitivity and specificity of each site.

Table 4: Showed USG with CT scan in assessment of Frontal bone (anterior wall)

USG	CT scan			
	Present	Absent	Total	%
Present	8	0	8	25.00
Absent	0	24	24	75.00
Total	8	24	32	100.00

Statistics	Figures	95% CI
Sensitivity	100 %	63.06% -100.00%
Specificity	100 %	85.75% - 100.00%
Accuracy	100 %	89.11% - 100.00%

Table 5: Comparison of USG with CT scan in assessment of lateral wall of orbit

USG	CT scan			
	Present	Absent	Total	%
Present	15	0	15	46.88
Absent	0	17	17	53.13
Total	15	17	32	100.00

Statistics	Figures	95% CI
Sensitivity	100 %	78.20% to 100%
Specificity	100 %	80.49% to 100%
Accuracy	100 %	89.11% to 100%

Table 6: Comparison of USG with CT scan in assessment of Zygomatic arch

USG	CT scan			
	Present	Absent	Total	%
Present	21	0	21	65.63
Absent	0	11	11	34.38
Total	21	11	32	100.00

Statistics	Figures	95% CI
Sensitivity	100 %	83.89% -100.00%
Specificity	100 %	71.51% -100.00%
Accuracy	100 %	89.11% - 100.00%

Table 7: Comparison of USG with CT scan in assessment of Roof of orbit

USG	CT scan			
	Present	Absent	Total	%
Present	4	0	4	12.50
Absent	0	28	28	87.50
Total	4	28	32	100.00

Statistics	Figures	95% CI
Sensitivity	100 %	39.76% - 100.00%
Specificity	100 %	87.66% - 100.00%
Accuracy	100 %	89.11% -100.00%

Table 8: Comparison of USG with CT scan in assessment of zygoma Bone (Malar bone)

USG	CT scan			
	Present	Absent	Total	%
Present	5	0	5	15.63
Absent	0	27	27	84.38
Total	5	27	32	100.00

Statistics		95% CI
Sensitivity	100 %	47.82% -100.00%
Specificity	100 %	87.23% - 100.00%
Accuracy	100 %	89.11% - 100.00%

Table 9: Comparison of USG with CT scan in assessment of Symphysis/Para symphysis

USG	CT scan			
	Present	Absent	Total	%
Present	5	0	5	15.63
Absent	0	27	27	84.38
Total	5	27	32	100.00

Statistics	Figures	95% CI
Sensitivity	100 %	2.50%- 100.00%
Specificity	100 %	88.78% - 100.00%
Accuracy	100 %	89.11% - 100.00%

Table 10: Comparison of USG with CT scan in assessment of Angle of Mandible

USG	CT scan			
	Present	Absent	Total	%
Present	1	0	1	3.13
Absent	0	31	31	96.88
Total	1	31	32	100.00

Statistic	Figures	95% CI
Sensitivity	100 %	63.06% - 100.00%
Specificity	100 %	85.75% - 100.00%
Accuracy	100 %	89.11% - 100.00%

Table 11: Comparison of USG with CT scan in assessment of Nasal bone

USG	CT scan			
	Present	Absent	Total	%
Present	12	0	12	37.50
Absent	0	20	20	62.50
Total	12	20	32	100.00

Statistic	Figures	95% CI
Sensitivity	100 %	73.54% - 100.00%
Specificity	100 %	83.16% - 100.00%
Accuracy	100 %	89.11% - 100.00%

OBSERVATION: All the fractures present in the CT scan were identified in the nine sites which are shown Table 4-11. The sites which were fractured and identified with 100 % accuracy were Frontal bone, Lateral wall of orbit, Anterior wall of maxillary sinus, Roof of orbit, Zygomatic arch, Zygomatic bone, Nasal bone, Symphysis/Para symphysis and Angle of Mandible respectively. In this study, the sensitivity and specificity for all these sites was 100%.

Table 12: Comparison of USG with CT scan in assessment of Floor of orbit

USG	CT scan			
	Present	Absent	Total	%
Present	10	0	10	31.25
Absent	2	20	22	68.75
Total	12	20	32	100.00

Statistic	Figures	95% CI
Sensitivity	83.33%	51.59% to 97.91%
Specificity	100 %	83.16% to 100.00%
Positive Predictive Value	100 %	-
Negative Predictive Value	90.91%	73.84% to 97.26%
Accuracy	93.75%	79.19% to 99.23%

OBSERVATION: Table 12 showed the comparison of USG and CT scan for the Floor of the orbit fractures. The fractures were identified in 10 out of 12 cases which gave an accuracy of 93.75%. The sensitivity and specificity of the same were 83.33% and 100% respectively. The positive predictive value of 100% indicated there was no false positive case reported. The negative predictive value of 90.91% indicated that 2 out of 12 fractures were false negative.

Table 13: Comparison of USG with CT scan in assessment of Medial wall of orbit

USG	CT scan			
	Present	Absent	Total	%
Present	5	0	5	15.63
Absent	2	25	27	84.38
Total	7	25	32	100.00

Statistic	Figures	95% CI
Sensitivity	71.43%	29.04% to 96.33%
Specificity	100 %	86.28% to 100.00%
Positive Predictive Value	100 %	-
Negative Predictive Value	92.59%	79.48% to 97.58%
Accuracy	93.75%	79.19% to 99.23%

OBSERVATION: Table 13 showed the comparison of USG and CT scan for the Medial wall of the orbit. The fracture was identified in 5 out of 7 cases which gave an accuracy of 93.75%. The sensitivity and specificity were 71.43% and 100% respectively. The positive predictive value of 100% indicated there was no false positive case reported. The negative predictive value of 92.59% indicated that 2 out of 7 cases were false negative.

Table 14: Comparison of USG with CT scan in assessment of Anterolateral wall maxillary sinus

USG	CT scan			
	Present	Absent	Total	%
Present	15	0	15	46.88
Absent	0	17	17	53.13
Total	15	17	32	100.00
%	46.88	53.13	100.00	

Statistic	Figures	95% CI
Sensitivity	100 %	63.56% to 98.54%
Specificity	100 %	78.20% to 100.00%
Positive Predictive Value	100 %	
Negative Predictive Value	100 %	67.11% to 96.50%
Accuracy	100%	79.19% to 99.23%

OBSERVATION: Table 14 showed comparison of USG and CT scan for the Anterolateral wall of maxillary sinus. The fracture was identified in 17 out of 17 cases which gave an accuracy of 100. The sensitivity and specificity were 100% and 100% respectively.

Table 15: Comparison of USG with CT scan in assessment of Body of Mandible

USG	CT scan			
	Present	Absent	Total	%
Present	2	0	2	6.25
Absent	1	29	30	93.75
Total	3	29	32	100.00

Statistic	Figures	95% CI
Sensitivity	66.67%	9.43% to 99.16%
Specificity	100.00%	88.06% to 100.00%
Positive Predictive Value	100.00%	-
Negative Predictive Value	96.67%	85.41% to 99.31%
Accuracy	96.88%	83.78% to 99.92%

OBSERVATION: Table 15 showed comparison of USG and CT scan for the Body of Mandible. The fracture was identified in 2 out of 3 cases which gave an accuracy of 96.88%. The sensitivity and specificity were 66.67% and 100% respectively. The positive predictive value of 100% indicated there was no false positive case reported. The negative predictive value of 96.67% indicated that 1 out of 3 cases was false negative.

Table 16: Comparison of USG with CT scan in assessment of Ramus of Mandible

USG	CT scan			
	Present	Absent	Total	%
Present	1	0	1	3.13
Absent	1	30	31	96.88
Total	2	30	32	100.00

Statistic	Figures	95% CI
Sensitivity	50.00%	1.26% to 98.74%
Specificity	100.00%	88.43% to 100.00%
Positive Predictive Value	100.00%	-
Negative Predictive Value	96.77%	88.24% to 99.17%
Accuracy	96.88%	83.78% to 99.92%

OBSERVATION: Table 16 showed comparison of USG and CT scan for the Ramus of Mandible. The fracture was identified in 1 out of 2 cases which gave an accuracy of 96.88%. The sensitivity and specificity were 50% and 100% respectively. The positive predictive value of 100% indicated there was no false positive case reported. The negative predictive value of 96.77% indicated that 1 out of 2 cases was false negative.

Table 17: Comparison of USG with CT scan in assessment of Condylar/Sub condylar

USG	CT scan			
	Present	Absent	Total	%
Present	1	0	1	3.03
Absent	3	29	32	96.97
Total	4	28	32	100.00

Statistic	Figures	95% CI
Sensitivity	33.33%	0.84% to 90.57%
Specificity	100.00%	88.06% to 100.00%
Positive Predictive Value		
Negative Predictive Value	93.55%	86.69% to 96.99%
Accuracy	93.75%	

OBSERVATION: Table 17 showed comparison of USG and CT scan for the Condyle/Sub condylar. The fracture was identified in 1 out of 4 cases which gave an accuracy of 93.75%. The sensitivity and specificity were 33.33% and 100% respectively. The positive predictive value of 100% indicated there was no false positive case reported. The negative predictive value of 93.55% indicated that 3 out of 4 cases was false negative.

Table 18: Kappa Statistical comparison of USG with CT scan

	Agreement	Kappa	Std. Error	Z-value	p-value
Frontal bone	100.00%	1.0000	0.1768	5.6600	0.0001*
Lateral wall of orbit	100.00%	1.0000	0.1768	5.6600	0.0001*
Zygomatic arch	100.00%	1.0000	0.1768	5.6600	0.0001*
Roof of orbit	100.00%	1.0000	0.1768	5.6600	0.0001*
Floor of orbit	93.75%	0.8621	0.1751	4.9200	0.0001*
Medial wall of orbit	93.75%	0.7962	0.1731	4.6000	0.0001*
Lateral wall maxillary sinus	100.00%	1.0000	0.1768	5.6600	0.0001*
Zygoma	100.00%	1.0000	0.1768	5.6600	0.0001*
Symphysis/Para symphysis	100.00%	1.0000	0.1768	5.6600	0.0001*
Angle	100.00%	1.0000	0.1768	5.6600	0.0001*
Body	90.91%	0.3694	0.1351	2.7300	0.0001*
Ramus	96.88%	0.7838	0.1726	4.5400	0.0001*
Nasal bone	100.00%	1.0000	0.1768	5.6600	0.0001*
Condylar/Sub condylar	93.75%	0.7962	0.1731	4.6000	0.0031*

*$p<0.05$

SUMMARY OF RESULTS

In this study, it was found that 9 out of 14 sites taken up for the ultrasound examination were able to identify all the fractures with 100% accuracy which were verified with CT scans.

Only in the cases of Condylar/Sub condylar region, Floor of the orbit, Medial wall of the orbit, Body and Ramus of mandible all the fractures were not seen with the help of ultrasound.

Table 17 depicts the Kappa statistics and showed that there is almost perfect agreement (0.8-1) in identifying the fractures on Ultrasound.

DISCUSSION

Ultrasound is a type of energy composed of high-frequency sound waves that are not audible to the human ear. The inception of Ultrasonography in medical practice was during the Second World War when Ian Donald introduced it to obstetric practice[2]. Ultrasonography is a diagnostic technique that is non-invasive and does not contain ionizing radiation. It is a quick and painless technique and has no known harmful effect on the body. When it was applied to the head and neck medicine, it was limited to the imagery of superficial structures of the head and neck and was considered to have a limited role in bone lesions[2].On the other hand, Computed Tomography was introduced in 1970s and it has become an important tool in medical imaging to supplement X-rays and ultrasonography.

Ultrasonography can be done rapidly and safely and is risk-free. Many literature studies have already identified the possibility of ultrasonographic fracture visualisation in the maxillofacial region[21]. The Ultrasonography has its own set of advantages when compared to CT scans such as no exposure to radiation, painless technique, inexpensive and easy availability, patient cooperation required is less and there is no requirement of patient positioning[2]. Secondly, USG is portable which makes it available intra-operatively to check the reduction of the fracture in cases of isolated zygomatic arch fractures, nasal bone fractures. It can also be used on a variety of occasions for diagnostic purpose of pregnant women and children who are not cooperative. The various stages of fracture healing can also be revealed by ultrasonography and is therefore critical for diagnosis and follow-up. The relative merits of ultrasonography are quite notable and its resources are widely available, also at the smallest quality of healthcare. However, ultrasound cannot penetrate deeper bony structures, and thus its use is only restricted to superficial facial landmarks[23].

The present study compares the diagnostic accuracy of ultrasound which is verified with the Computed Tomography. **Ord et al** used ultrasound for the first time in 1981to detect orbital wall fractures.[27]In that study USG showed 95% sensitivity to screen all the fractures[1]. In the literature, the lowest sensitivity found for the identification of medial and lateral wall fractures in the literature was 56% and 88%, respectively, while the lowest specificity was 90% and 87%, respectively. The precision for detecting orbital wall fractures typically varies from 90 to 100 percent[2]. Previous studies of orbital sonographic examinations did not differentiate between all the orbital walls. Owing to poor fitting of the linear transducer to the curved orbital margins, they yielded unreliable results. Further studies done using a curved array (sector) transducer achieved sensitivities and specificities of 79–94 and 90–100%, respectively[10]. *Jenkins et al* conducted a study in which it suggested USG could be used in zygomatic fractures with co-existing orbital floor fractures but USG has been inconclusive in cases of absolute blowout fracture[26].

In the present study, medial orbital wall fracture showed the values for sensitivity and specificity of 71.43% and 100% respectively. For the lateral orbital wall, the sensitivity and specificity were 100% i.e. all fractures were identified. Siegfried et al. concluded in their analysis that there is good reliability in detection of fractures of medial and lateral orbital walls with a 90 per cent accuracy rate[10]. The Ultrasound has the potential to reach the same diagnostic quality as CT in the future, but further studies must be performed to improve the diagnostic quality of the method.

The orbital floor fracture have their sensitivity and specificity varying from 85% to 100% and 57% to 100%, respectively, and accuracy varies from 86–98%.[5,9,10,26]It was repeatedly found out that orbital floor fractures beyond 4 cm to the orbital margin which are present posteriorly, is poorly identified by ultrasound.[5] Fractures of the inferior orbital margin are seen easily by ultrasonography with sensitivity and specificity up to 94% and 92%, respectively.[9] The current study showed us the sensitivity and specificity of 83.33% and 100% respectively for orbital floor fracture.

The literature mentioned little work on orbital roof fractures. The present study showed a sensitivity and specificity of 100% for diagnosis of orbital roof fracture. The overall diagnostic accuracy for all orbital wall fractures was seen ranging from 90-100% which shows a good reliability[3,9,10,18].

Nasal bone, frontal bone and zygomatic arch fractures have 100% precision in the ultrasound detection of fractures has been shown in the literature.[27] In 2019, Rajeev et al conducted a analysis in which ultrasound identified all the fractures at some anatomical landmarks, i.e. the zygomatic arch, the frontal sinus(anterior wall), infraorbital margin, roof of orbit, mandibular symphysis/Para symphysis, and mandibular angle[23]. The current study showed a similar result in diagnosing fracture with 100% accuracy at all these sites. In addition, lateral wall of orbit, Zygoma (malar bone) and Nasal bone were able to diagnose all the fractures with 100% accuracy. The sensitivity and specificity for all these eight sites were observed as 100%.

For nasal bone fractures, a radiographic investigation is the first step for the assessment of injury, but its not accurate in identyfying and evaluating sidewall injuries[13]. On the other hand, USG have been effective for the detection of nasal bone fractures with sensitivity varying from 90% to 100%, specificity varying from 98–100%.[12,13,28] Ultrasonography is an effective method for clinically diagnosed isolated nasal fracture. There are studies in the literature by Friedrich et al.[8] and Hirai et al[4] whose results support this. It was proven to be greater than CT scan in the studies conducted by Lee et al.[13] and Hong et al.[28] in which it was able to detect undisplaced, non-depressed fractures of the nasal bone and anterior septal cartilage deviation, which were not identified by CT scans. In our study, all the fractures of nasal bone were identified by ultrasound with 100% sensitivity, specificity and accuracy. In two cases, there were non displaced fractures which were confirmed based on clinical examination of crepitations and tenderness.

The zygomatic complex region is inclusive of lateral orbital wall, anterior wall of maxillary sinus, infraorbital margin, Zygoma bone and zygomatic arch. The inferior orbital rim fractures are easily identified by ultrasonography with sensitivity and specificity up to 94% and 92%, respectively. It is also efficient in detecting fractures of the anterolateral wall of the maxilla sinus.[11,8,5] In the cases of zygomatic arch fractures, it has been found to be precise in all cases including the non-displaced zygomatic arch fractures. In their research, Sallamet al[14] concluded that USG has been tool of choice for detecting uncomplicated fractures in the frontozygomatic process, the zygomatic arch and the infraorbital rim, but it has some drawbacks in case of orbital floor and medial wall fractures. Ultrasound is more reliant in postoperative time to check the reduction of underlying fracture and can be used in follow up period, which has reduced the cost and unwanted radiation exposure[14].

In this cotemporary study, fractures of the zygomatic arch, anterolateral wall of maxillary sinus, Zygoma (malar bone) were detected easily by ultrasound with the sensitivity and specificity of 100%. This is in agreement to study conducted by McCann et al[5], who concluded that ultrasound as an initial examination is a valuable method in imaging facial injuries, which may help to cut down on the total number of radiographs required for the detection of zygomatico-orbital complex fractures[5].

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[2]. Kleinheinzet al.[31] and Friedrich et al.[7] reported ultrasonographic sensitivity and specificity of 100% and 100%, respectively, and 66% and 52%, respectively, in the detection of mandibular subcondylar/ramus fractures. In our study, the mandibular ramus and condylar/subcondylar region showed the sensitivity of 50% and 33.33% respectively, while it showed specificity of 100%. Only in one case of the sub condylar fracture, it was identified on ultrasound because there was subluxation of Temporo-mandibular joint. Other fractures seen on CT scan were condylar head and intracapsular fracture of condyles. Friedrich et al.[7] highlighted the shortcomings of ultrasound to detect intracapsular condylar fractures because of its overlap by the zygomatic arch[7]. One of the ramus fractures was not detected on ultrasound, but was identified as nondisplaced vertical ramus fracture on CT scan. All the fractures in the region of Symphysis/Para symphysis, Angle, Body of the mandible were identified correctly on ultrasound which were verified with CT scan.

Ultrasound imaging has some benefits for the diagnosis of mandibular fractures[7]: the ultrasound probe can be applied directly to the area of concern. Preparation of patients for the assessment is not required. Imaging can be performed repeatedly without harming the patients. Before the open reduction, the soft tissue embedded in the fracture line can be visualised. The dislocation of fragments can be quantified. The development of Callus can be demonstrated before taking radiographs. No special electrical equipment (X-ray diagnosis) is required in the operating theatre. The use of sterilizable applicators can be used intraoperatively to track fracture reduction. The dislocation of fragments can be quantified. The formation of Callus can be illustrated prior to the X-ray examination. No high-current conductor (X-ray diagnosis) is required in the operating theatre. The use of sterilizable applicators may be used intraoperatively to monitor the reduction of fractures[7].

A systematic review conducted by W. L. Adeyemo has mentioned about the factors affecting credibility of USG in maxillofacial trauma[2]:

1. Expertise of sonographer.
2. Transducers type and its resolution.
3. Lack of a traditional facial skeleton scanning technique.
4. Visualization in real time is better than hard-copy interpretation.
5. Ultrasound evaluation from the time of injury.

The systematic review also mentioned limitations of ultrasound imaging in maxillofacial fractures which included[2];

1. Inability to represent multiple facial fractures that are complex in nature. In this study, all the fractures were identified even in patients with pan facial fractures.
2. Difficulty in detecting undisplaced fractures. In the present study, all the fractures were identified by USG except in case of one ramus fracture which was undisplaced.
3. Not able to investigate posterior orbital floor≥4cm. Orbital floor fractures were not seen in some cases as they were present posteriorly in current study.
4. Inability to detect the intracapsular fracture of condyles because of the overlapping of zygomatic arch.

TO SUMMARIZE

The Sensitivity and Specificity of 100 % was observed at these anatomical sites:

1. Frontal bone (anterior wall)
2. Lateral wall of orbit
3. Roof of orbit
4. Zygomatic arch
5. Zygomatic bone
6. Nasal bone
7. Symphysis/Para symphysis
8. Angle of Mandible
9. Body of Mandible

CONCLUSION

In this study, the overall sensitivity observed for diagnosis of maxillofacial fracture was 85.21% and specificity observed was 100%. Fractures of nasal bone, uncomplicated orbital wall fractures, anterior maxillary wall of maxillary sinus, zygomatic arch fractures, mandibular fractures of symphysis/parasymphysis, body and angle were readily detected on ultrasound.

Ultrasonography shows favorable results in the detection of extracapsular sub condylar fractures, but the maxillofacial surgeons must know its shortcomings in undisplaced fractures, complex maxillofacial fractures, posterior orbital floor fractures and intracapsular mandibular condyle fractures.

The sonographic techniques needs to be upgraded and special transducer probes should be made for certain regions to detect fractures without any difficulty. The maxillofacial surgeons should be trained for the use of ultrasound so that intraoperative and postoperative reduction of fractures can be checked and radiation exposure can be avoided.

Ultrasonography gives a good utility in diagnosis and treatment of maxillofacial trauma. If properly developed and implemented, the relative advantages of ultrasonography over CT could minimize the use of CT scan to exclusive circumstances and thus revolutionize maxillofacial imaging in trauma care.

Furthermore, studies should be conducted with a considerable amount of sample size as the literature mentions limited work regarding ultrasonography as a primary technique in maxillofacial fractures detection. Also, it should be validated as a procedure along with CT scan and conventional radiographs in medicolegal cases for detection of fractures.

In conclusion, ultrasonography can be a handy, diagnostic, additional , non-invasive and inexpensive tool in the detection of maxillofacial fractures when compared to computed tomography in primary healthcare center.

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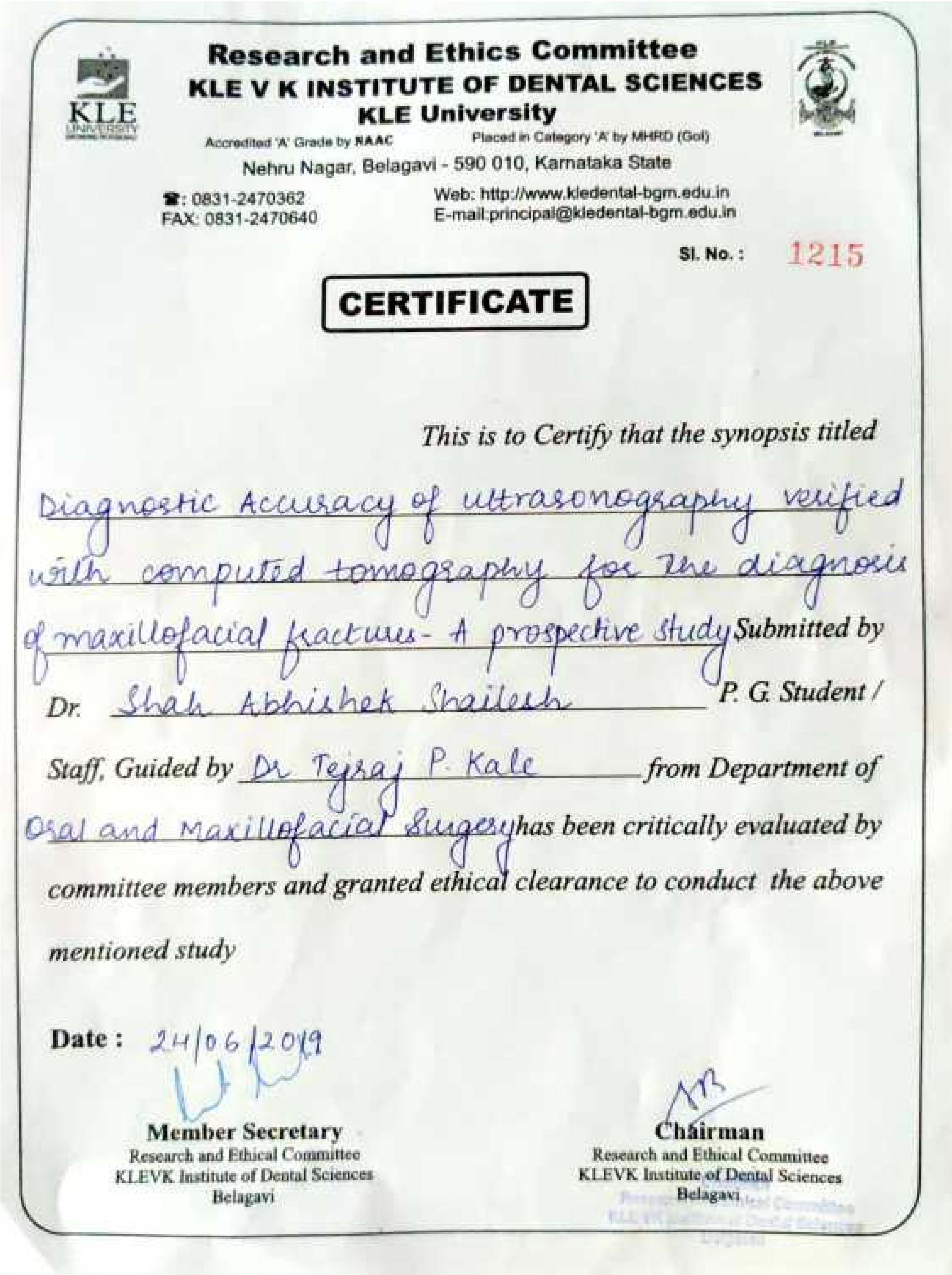
ANNEXURE – I

ETHICAL CLEARANCE CERTIFICATE



Research and Ethics Committee
KLE V K INSTITUTE OF DENTAL SCIENCES
KLE University

Accredited 'A' Grade by NAAC — Placed in Category 'A' by MHRD (GoI)

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Sl. No. : 1215

CERTIFICATE

This is to Certify that the synopsis titled Diagnostic Accuracy of ultrasonography verified with computed tomography for the diagnosis of maxillofacial fractures- A prospective study *Submitted by Dr.* Shah Abhishek Shailesh *P. G. Student / Staff, Guided by* Dr Tejraj P. Kale *from Department of* Oral and Maxillofacial Surgery *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date : 24/06/2019

Member Secretary
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

ANNEXURE II – BIOSTATISTICS CLEARANCE CERTIFICATE

KLE V.K. Institute of Dental Sciences
(A Constituent unit of KLE Academy of Higher Education & Research
Deemed-to-be-University u/s 3 of the UGC Act, 1956)
Nehru Nagar, Belagavi-590 010 INDIA
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FAX: 0831-2470640
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E-mail: principal@kledental-bgm.edu.in

Biostatistics Clearance Certificate

This is to certify that the Biostatistics aspect of the Dissertation / Research work of **Dr. Abhishek Shah** entitled **"DIAGNOSTIC ACCURACY OF ULTRASONOGRAPHY VERIFIED WITH COMPUTED TOMOGRAPHY FOR THE DIAGNOSIS OF MAXILLOFACIAL FRACTURES – A PROSPECTIVE STUDY"** has been done under my guidance and considered satisfactory.

Place: Belagavi
Date: 05/09/2020

Name & Signature of Biostatistician
(Dr. S. B. Javali)

ANNEXURE III – PLAGIARISM ACCEPTED LETTER

Scientific Correspondence and Review Committee

KLE VK Institute of Dental Sciences

A Constituent Unit of KLE Academy of Higher Education and Research
(Deemed-to-be-University u/s 3 of the UGC Act, 1956)
Nehru Nagar, Belagavi - 590 010, Karnataka State

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E-mail:principal@kledental-bgm.edu.in

Date : 24.9.20 | Serial No. : 042

PLAGIARISM CHECK REPORT

Name of the Applicant : Dr. Abhishek Shah
UG / PG / Ph.D / Staff : Post Graduate
Batch & Year : 2018 - 2021
Department : Oral & Maxillofacial surgery.

The soft copy of Research Work / Manuscript by Abhishek Shah entitled "Diagnostic accuracy of ultrasonography verified with computed tomography for the diagnosis of maxillofacial fractures - A prospective study" under the guidance of .... has been submitted for Anti-Plagiarism check to the Scientific Correspondence & Review Committee of KLE VK Institute of Dental Sciences using "Turn-it-in" software.

The scan has been carried out and the scanned output reveals a Similarity Index of 6 %, which is **within / not within** the acceptable limits of 10% as per the UGC guidelines.

Member Secretary
Scientific Correspondence and Review Committee
KLEVK Institute of Dental Sciences
KAHER-Belagavi

Chairman
Scientific Correspondence and Review Committee
KLEVK Institute of Dental Sciences
KAHER - Belagavi

ANNEXURE IV

CASE HISTORY PROFORMA

GENERAL INFORMATION

1.Name: Age: Sex:

2.Religion:

3.Address:

4.Occupation:

7..Date, month and Time of accident______________

9..How did the injury occur?

Road Traffic Accident / Assault / Fall / Any other (Specify)

Medical / Surgcial History :

Vital signs :

Cerebral status :

Loss of consciousness :

Glassgow Coma Scale :

Airway : Clear / Obstucted

C.S.F. Leakage :

Through Nose : Yes / No

Ear : Yes / No

<u>Bleeding :</u>

From Nose : Yes / No

Ears : Yes / No

Mouth : Yes / No

<u>Maxillofacial Examination :</u>

Facial Symmetry : Yes / No

TMJ :

Mouth Opening :

<u>Inspection</u> :

Laceration –

Swelling –

Abrasion –

<u>Palpation :</u>

Frontal Bone region-

Nasal Bone-

Supraorbital rim margin-

Infraorbital rim margin-

Malar Prominence-

Zygomatic Arch-

Symphysis/Para symphysis-

Angle/Body-

Ramus/Condyle-

<u>Intraoral examination :</u>

<u>Inspection :</u>

Trismus :

Ecchymosis –

Laceration –

Swelling –

Provisional Diagnosis-

CT Scan Diagnosis

<u>Diagnostic impression of the Maxillofacial trauma</u>

Type of fracture :	**USG**		CT Scan
	Fracture seen	**Fracture not seen**	
Frontal bone			
Lateral wall of orbit			
Medial wall of orbit			
Floor of orbit			
Roof of orbit			
Zygomatic arch			
Zygoma (malar bone)			
Lateral wall of maxillary sinus			
Symphysis/Para symphysis			
Body			
Angle			
Ramus			
Condylar/ sub condylar			

ANNEXURE V – WRITTEN INFORMED CONSENT

CONSENT FORM

DEPARTMENT OF ORAL AND MAXILLOFACIAL SURGERYKLE UNIVERSITY'S KLE VK INSTITUTE OF DENTAL SCIENCES,BELAGAVI – 590010.

'DIAGNOSTIC ACCURACY OF ULTRASONOGRAGHY VERIFIED WITH COMPUTED TOMOGRAPHY FOR THE DIAGNOSIS OF MAXILLOFACIAL FRACTURES- A PROSPECTIVE STUDY'.

I, ____________________ aged ___ have been informed about my involvement

in the study:

1. I agree to give my personal details like name, age, sex, address and the details required for the study to the best of my knowledge.
2. I have been informed about the ultrasonography imaging procedure for diagnosis & I give my consent to the oral and maxillofacial surgeon to perform the procedure.
3. I have been informed about the possible complications like infection,allergy to applicator gel, purulent discharge, bleeding, pain at the affected region.
4. I permit the doctor to utilize the information given by me and results obtained from this study for presentation and publication purpose.
5. I will not claim any returns for my cooperation in the study, even if it is being sponsored by any agency.
6. I will follow the instructions given by the doctor.
7. During the study, if I wish to resign from the study, I am free to do so and my treatment will still be completed in the department.

In my full consciousness and presence of mind, after understanding the procedure in my vernacular language, I am willing and give my consent to participate in this study.

Date:

Place:

Subject's Signature Signature of witness

CONSENT FORM

DEPARTMENT OF ORAL AND MAXILLOFACIAL SURGERYKLE UNIVERSITY'S KLE VK INSTITUTE OF DENTAL SCIENCES,BELAGAVI – 590010.

'DIAGNOSTIC ACCURACY OF ULTRASONOGRAGHY VERIFIED WITH COMPUTED TOMOGRAPHY FOR THE DIAGNOSIS OF MAXILLOFACIAL FRACTURES- A PROSPECTIVE STUDY'.

संमतीफॉर्म

मी, _____________ वयाची __ याअभ्यासातमाझ्यागुंतवणूकीबद्दलमाहितीदिलीगेलीआहे:

1. मीमाझ्यावैयक्तिकमाहितीजसेकीनाव, वय, लिंग, पत्ताआणिअभ्यासासाठीआवश्यकतपशीलांसहमाझ्यामाहितीचेसर्वोत्तमवर्णनकरण्याससहमत आहे.

2. मलानिदानकरण्यासाठीअल्ट्रासोनोग्राफीइमेजिंगप्रक्रियेबद्दलमाहितीमिळालीआहेआणिमीप्रक्रियापूर्णकरण्यासाठीतोंडीआणिमॅक्सिलोफेशियलसर्जनलामाझीसंमतीदेतो.

3. मलासंभाव्यगुंतागुंतयासारख्यासंभाव्यगुंतागुंतांविषयीमाहितीदिलीगेलीआहेजसे, आवेदकजेल, पुर्वीयंटडिसचार्ज, रक्तस्त्राव, प्रभावितक्षेत्रावरवेदना.

4. मीडॉक्टरांनीदिलेलीमाहितीआणिसादरीकरणआणिप्रकाशनउद्देशासाठीयाअभ्यासातूनमिळालेल्यापरिणामांचावापरकरण्यासपरवानगीदेतो.

5. अभ्यासातमाझ्यासहकार्यासाठीमीकोणत्याहीपरताव्याचादावाकरणारनाही, जरीतीकोणत्याहीसंस्थेद्वारेप्रायोजितकेलीजातअसलीतरीही.

6. मीडॉक्टरांनीदिलेल्यानिर्देशांचेपालनकरू.

7. अभ्यासादरम्यान, जरमीअभ्यासातूनराजीनामादिलाअसेलतरमीतसेकरण्यासस्वतंत्रआहेआणिमाझेउपचारअद्यापविभागांतपूर्णकेलेजातील.

माझीसंपूर्णचेतनाआणिमनाचीउपस्थिती, माझ्यास्थानिकभाषेतीलप्रक्रियासमजूनघेतल्यानंतर, मीयाअभ्यासातसहभागीहोण्यासाठीमाझीइच्छाव्यक्तकरतोआणित्यासमान्यतादेतो.

तारीख:साक्षीदाराचाविषयस्वाक्षरी

ठिकाण:

CONSENT FORM

DEPARTMENT OF ORAL AND MAXILLOFACIAL SURGERYKLE UNIVERSITY'S KLE VK INSTITUTE OF DENTAL SCIENCES,BELAGAVI – 590010.

'DIAGNOSTIC ACCURACY OF ULTRASONOGRAGHY VERIFIED WITH COMPUTED TOMOGRAPHY FOR THE DIAGNOSIS OF MAXILLOFACIAL FRACTURES- A PROSPECTIVE STUDY'.

ನಾನು, _________________ವಯಸ್ಸಿನ __ ಈಅಧ್ಯಯನದನನ್ನಪಾಲ್ಗೊಳ್ಳುವಿಕಬಗ್ಗತಿಳಿಸಲಾಗಿದ:

ನನ್ನಹಸರು, ವಯಸ್ಸು, ಲಿಂಗ, ವಿಳಾಸಮತ್ತುನನ್ನಜ್ಞಾನದಅತ್ಯುತ್ತಮಅಧ್ಯಯನಕ್ಕಅಗತ್ಯವಿರುವವಿವರಗಳಂತಹನನ್ನವ್ಯಯಕ್ತಿಕವಿವರಗಳ ನ್ನುನೀಡಲುನಾನುಒಪ್ಪುತ್ತೇನೆ.

2. ನಾನುರೋಗನಿರ್ಣಯಕ್ಕಶ್ರವಣಾತೀತಚಿತ್ರಣಪ್ರಕ್ರಿಯಯಬಗ್ಗತಿಳಿಸಲಾಗಿದಮತ್ತುನಾನುಕಾರ್ಯವಿಧಾನವ ನ್ನುನಿರ್ವಹಿಸಲುಮೌಖಿಕಮತ್ತುಮ್ಯಾಕ್ಸಿಲೊಫೇಸಿಯಲ್ಶಸ್ತ್ರಚಿಕಿತ್ಸಕರಿಗನನ್ನಒಪ್ಪಿಗಯನ್ನುನೀಡುತ್ತೇನ.

3. ಸೋಂಕಿನಂತಹಸಂಭಾವ್ಯತೊಡಕುಗಳಬಗ್ಗ, ಸೂಚಕಜಲ್ಗಅಲರ್ಜಿ, ಭ್ರೂಣದಉಸಿರಾಟ, ರಕ್ತಸ್ರಾವ, ಪೀಡಿತಪ್ರದೇಶದನೋವುಬಗ್ಗೆನನಗೆತಿಳಿಸಲಾಗಿದೆ.

4. ನನಗನೀಡಿದಮಾಹಿತಿಮತ್ತುಪ್ರಸ್ತುತಿಮತ್ತುಪ್ರಕಟಣಯಉದ್ದೇಶಕ್ಕಾಗಿಈಅಧ್ಯಯನದಿಂದಪಡದಫಲಿತಾಂಶ ಗಳನ್ನುಬಳಸಿಕೊಳ್ಳಲುನಾನುವೈದ್ಯರಿಗೆಅನುಮತಿನೀಡುತ್ತೇನೆ.

5. ಯಾವುದೇವಿಜ್ಞಾನಯಪ್ರಾಯೋಜಕತ್ವವನ್ನುಹೊಂದಿದ್ದರೂ, ನಾನುಅಧ್ಯಯನದಲ್ಲಿನನ್ನಸಹಕಾರಕ್ಕಾಗಿಯಾವುದೇಲಾಭವನ್ನುಪಡಯುವುದಿಲ್ಲ.

6. ವೈದ್ಯರುನೀಡಿದಸೂಚನಗಳನ್ನುನಾನುಅನುಸರಿಸುತ್ತೇನ.

7. ಅಧ್ಯಯನದಸಮಯದಲ್ಲಿ, ನಾನುಅಧ್ಯಯನದಿಂದರಾಜೀನಾಮಬಯಸಿದರ, ನಾನುಹಾಗಮಾಡಲುಮುಕ್ತನಾಗಿರುತ್ತೇನಮತ್ತುನನ್ನಚಿಕಿತ್ಸಯುಇನ್ನೂಇಲಾಖಯಲ್ಲಿಪೂರ್ಣಗೊಳ್ಳುತ್ತದ.ನ ನ್ನಸಂಪೂರ್ಣಪ್ರಜ್ಞಮತ್ತುಮನಸ್ಸಿನಉಪಸ್ಥಿತಿಯಲ್ಲಿ,

ನನ್ನದೇಶೀಯಭಾಷಯಲ್ಲಿನಕಾರ್ಯವಿಧಾನವನ್ನುಅರ್ಥಮಾಡಿಕೊಂಡನಂತರ,
ನಾನುಈಅಧ್ಯಯನದಲ್ಲಿಪಾಲ್ಗೊಳ್ಳಲುನನ್ನಒಪ್ಪಿಗೆನೀಡುತ್ತೇನೆ.

ದಿನಾಂಕ: ಸ್ಥಳ:

ವಿಷಯದಸಹಿಸಾಕ್ಷಿಸಹಿ

ANNEXURE VII – MASTER CHART

				FRONTAL		LAT ORBIT		Z.ARCH		ROOF ORBIT		FLOOR.O		MED.ORBIT		AL SINUS		ZYGOMA		SYM/PARA		ANGLE		BODY		RAMUS		NASAL		CON/SUB	CON/SUB
No	Age	Gendr	History	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG	CT scan	USG
1	63	1	RTA	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
2	16	1	RTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0
3	21	1	RTA	0	0	0	0	1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	52	2	RTA	0	0	1	1	1	1	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
5	40	2	FALL	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	23	1	FALL	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	40	2	RTA	1	1	1	1	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	50	1	RTA	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0
9	29	1	RTA	1	1	1	1	1	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	26	1	RTA	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1	1
11	55	1	RTA	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0
12	38	2	RTA	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
13	30	1	RTA	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
14	31	1	FALL	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0
15	26	1	RTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
16	63	1	RTA	0	0	1	1	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0
17	21	1	RTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
18	29	1	RTA	1	1	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	37	1	RTA	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	0	0	0	0	0	1	1	1	0	1	1	0	0
20	27	1	RTA	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	50	1	RTA	0	0	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
22	40	1	RTA	0	0	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0	0
23	32	1	RTA	0	0	1	1	1	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
24	21	1	RTA	0	0	1	1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	0	0	0	0
25	30	1	ASSAULT	1	1	1	1	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	40	1	RTA	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
27	29	1	RTA	0	0	1	1	1	1	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	22	1	RTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
29	50	1	RTA	0	0	1	1	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
30	22	2	RTA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	0	0	0
31	22	1	FALL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
32	70	1	RTA	0	0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Introduction

Objectives

Review of Literature

Methodology

Results

Discussion

Conclusion

Bibliography

Annexures