Available online at *www.ujpronline.com*
Universal Journal of Pharmaceutical Research
An International Peer Reviewed Journal
ISSN: 2831-5235 (Print); 2456-8058 (Electronic)

RESEARCH ARTICLE

COMPARATIVE RADIOLOGICAL STUDY OF BONE DENSITY AND THICKNESS BETWEEN OPEN AND CLOSED REDUCTION OF COMMINUTED MANDIBULAR BONE FRACTURE

Lutf Mohammed Al-Rahbi[1,2], Osama Ali Zayed[1], Ahmed Abdulah Al-Ashwal[1,2]
Hassan Abdulwahab Al-Shamahy[*3,4]
[1]*Yemen Medical Specialist Council, Ministry of Health and population, Yemen.*
[2]*Department of Oral and Maxillo-Facial Surgery, Faculty of Dentistry, Sana'a University, Republic of Yemen.*
[3]*Department of Basic Sciences, Faculty of Dentistry, Sana'a University, Republic of Yemen.*
[4]*Medical Microbiology and Clinical Immunology Department, Faculty of Medicine and Health Sciences, Sana'a University.*

Article Info:

Article History:
Received: 6 August 2025
Reviewed: 12 September 2025
Accepted: 22 October 2025
Published: 15 November 2025

Cite this article:
Al-Rahbi LM, Zayed OA, Al-Aswal AA, Al-Shamahy HA. Comparative radiological study of bone density and thickness between open and closed reduction of comminuted mandibular bone fracture. Universal Journal of Pharmaceutical Research 2025; 10(6): 63-72.
http://doi.org/10.22270/ujpr.v10i5.1432

***Address for Correspondence:**
Dr. Hassan A. Al-Shamahy, Department of Basic Sciences, Faculty of Dentistry, Sana'a University, Republic of Yemen.
Tel: +967-1-239551.
E-mail: *shmahe@yemen.net.ye*

Abstract

Background and Objectives: Mandibular fractures, often caused by trauma, can lead to significant functional and aesthetic impairments, including difficulty chewing and speaking, and facial deformities, especially when comminuted. This study compares bone density and thickness in patients with comminuted mandibular fractures resulting from gunshot wounds, using advanced radiological methods to determine treatment efficacy and inform clinical decisions.
Subjects and Methods: This retrospective study compared the treatment of comminuted mandibular fractures resulting from gunshot wounds at Sana'a Military Hospital. The study included patients who underwent open or closed reduction, and demographic data, injury characteristics, and post-treatment examinations were collected. Bone density and thickness were measured using cone-beam computed tomography (CBCT) or CT scans, and statistical analysis was performed to compare the two groups.
Results: The study included five patients in each group who underwent intermaxillary fixation (IMF) and open reduction internal fixation (ORIF). The age distribution of patients was heterogeneous, with 30% between 22 and 24 years old, 20% between 25 and 27 years old, 30% between 28 and 30 years old, and 20% over 30 years old. Malunion was the most common complication, followed by bone loss in 30% of patients. No significant differences in bone density and thickness were observed between the IMF and ORIF groups at the site of injury.
Conclusion: Ultimately, a patient's previous bone density is the determining factor in determining the appropriate treatment for a jaw fracture and is not a criterion for comparison between IMF and ORIF. Although both treatments have risks and benefits, the success of the outcome depends on the quality of the underlying bone to ensure stable healing.
Keywords: bone density, bone thickness, comparative radiological study, gunshot injury, intermaxillary fixation, mandibular bone fracture.

INTRODUCTION

Mandibular fractures are among the most common facial injuries resulting from trauma, including gunshot wounds[1]. These fractures are often complex, especially when comminuted, where the bone shatters into multiple pieces. Gunshot fractures of the mandible pose additional challenges, including high-energy trauma, bone displacement, and soft tissue damage. These fractures can result in significant functional and aesthetic impairments, including difficulty with chewing and speech and facial deformities[2]. Treatment of comminuted mandibular fractures typically involves either open reduction (ORIF) or closed reduction (CR)[3]. ORIF involves direct surgical exposure of the fracture site to realign and stabilize the bone fragments, while CR relies on non-surgical techniques, such as wiring or splints, to control and externally stabilize the fractured bone[4]. Both methods are widely used, but their effects on bone healing, particularly in terms of bone density and thickness, remain a subject of clinical research interest.

Numerous facial structures are a major contributor to morbidity in cases of facial injury[5]. One of the most important health issues that is still a major clinical concern is maxillofacial (MF) injuries. Road traffic injuries cause about 25 million injuries and over a million deaths annually[6]. Due to their anatomical distinctions and propensity for healing, condylar fractures account for 11–16% of all facial fractures and 30–40% of all mandibular fractures[7]. Some features of managing maxillofacial trauma may cause greater disagreement than the mandibular condylar process fracture[8].

Maxillofacial fractures are important because they significantly impact a person's ability to speak, eat, and breathe, and can lead to long-term functional and aesthetic problems. They are common sequelae of trauma, and mandibular fractures are the most common facial bone fracture. Several studies have been conducted in Yemen, including the type and management of maxillofacial fractures[9], comparative outcomes in the management of mandibular angle fractures using reconstruction plates versus double miniplate fixation[10], analysis of hardware removal in maxillofacial trauma[11], treatment of comminuted mandibular fractures with closed reduction and mandibular fixation versus open reduction and internal fixation[12], maxillofacial trauma among head trauma patients[13], osteomyelitis of the jaws[14], and the impact of 3D printing in the reconstruction of maxillofacial bone defects[15]. However, this is one of the first studies to use advanced radiographic tools to measure treatment success and advise therapeutic judgments regarding bone density and thickness in patients with comminuted mandibular fractures originating from gunshot wounds.

Recent advancements in imaging, particularly CBCT, have revolutionized the assessment of bone density. Unlike traditional panoramic radiography, CBCT offers high-resolution, three-dimensional imaging that enables clinicians to quantify bone density using Hounsfield Units (HU) with minimal radiation exposure[16,17].This precise measurement is crucial not only for planning dental implants but also for predicting future bone loss and ensuring optimal osseointegration[18]. Despite its importance, there remains a lack of studies focusing on jawbone density in Yemeni adults using CBCT and there was one previous study aimed to obtain baseline data on bone density of the maxilla and mandible in normal Yemeni individuals across various anatomical regions[19], sexes, and age groups. Several studies have been conducted in Yemen previously using CBCT findings to evaluate the anatomical structure of the anterior maxillary sinus canal to avoid surgical complications[20], dentists' knowledge and attitude towards CBCT[21], the anatomical pattern trajectory of the mandibular canal and the location of its foramina[22], the three-dimensional assessment of the shape of the first cervical vertebra in skeletal Class I and III malocclusions[23], the radiographic assessment of protruding fillings[24], maxillary sinus septa[25], the validity of the Punnett analysis in a Yemeni population[26], and the evaluation of the relative position of the mandibular foramen in Yemeni children as a reference for inferior alveolar nerve block[27].

Radiological assessments play a crucial role in assessing the severity of fractures and monitoring the healing process. Techniques such as CBCT and CT provide valuable insights into bone density and thickness at the fracture site[28]. Hounsfield units (HU) are a quantitative measurement used in CT to express the relative density of tissues and materials within the body. The unit is calibrated based on the density of water, which is assigned a value of 0 HU, and air, which is assigned a value of -1000 HU. Different tissues in the body, such as bone, muscle, and fat, have specific ranges of Hounsfield values. For example, bone typically ranges from +1000 HU to +2000 HU, while fat ranges from -50 HU to -100 HU[29]. Studies have revealed that the method of reduction may affect bone remodeling, with potential differences in healing outcomes between open and closed reductions[30].

This study aims to compare bone density and thickness in patients who underwent open and closed reduction of comminuted mandibular fractures resulting from gunshot injuries. Using advanced radiological methods, this research will help determine whether one treatment method results in better bone recovery and healing than the other, providing important data for clinical decision-making.

MATERIALS AND METHODS

Study Design: This was a retrospective, comparative study.

Study Population: The study population involved of patients with comminuted mandibular fractures due to gunshot wounds who underwent either open reduction (ORIF group) or closed reduction (CR group) at Sana'a Military Hospital between 2020 and 2024.

Inclusion criteria: Patients with comminuted inferior radial fractures resulting from gunshot wounds, treated with either open surgical fixation (ORIF) or closed fixation (IMF), pre- and post-treatment computed tomography (CBCT) scans, and complete patient records including demographics, injury details, and treatment protocols.

Exclusion criteria: Patients with pathological fractures, patients with incomplete medical records or missing CBCT scans, patients who received other forms of treatment (e.g., bone grafting), and patients with bilateral mandibular fractures.

Data Collection: Demographic data (age, sex), injury characteristics (fracture site, comminuted fracture), treatment method ORIF versus closed reduction, and post-treatment CBCT or CT scans were collected.

Radiological Evaluation: Radiological assessment was performed at least 1year post-treatment. CBCT or CT scans were analyzed to measure bone density and thickness at the fracture site compared to the corresponding intact site in the mandible. Four or five lines are drawn in the sagittal plane, the first 5 mm from the lower border of the mandible, followed by three or five lines in the coronal plane. These results in 16 or 9 squares for measuring bone thickness, plus 25 or 9 intersection points for measuring bone thickness. The same procedure was applied to the other side of the mandible.

Bone density was measured using Hounsfield units (HU) in a standardized region of interest (ROI) within the fracture zone. Bone thickness was measured at specific points along the fracture line. Two independent observers performed the measurements to ensure reliability.

Statistical Analysis: Descriptive statistics (mean and standard deviation) were calculated for bone density and thickness in both groups at different time points. Independent samples t-tests or Mann-Whitney U tests were used to compare bone density and thickness between the two groups. Correlation analysis was performed to assess the relationship between fracture characteristics and bone healing parameters. Statistical significance was set at $p<0.05$.

Ethical Considerations: This study was conducted in accordance with the ethical principles set forth in the Declaration of Helsinki. Patient data were kept confidential throughout the study.

RESULTS

Table 1 show the frequency of use of IMF and ORIF in fixation of gunshot fractures. Five (5%) patients underwent IMF and five (5%) patients underwent ORIF.

Table 1: Frequency of use of intermaxillary fixation (IMF) and open internal fixation (ORIF) in the fixation of gunshot bone fractures.

Methods of fixation	N (%)
IMF	5 (50)
ORIF	5 (50)
Total	10 (100)

Table 2 show frequency distribution of age of patients who underwent intermaxillary fixation and open internal fixation included in the study. 30% were in age group 22-24 years, 20% in 25-27 years, 30% in 28-30 years and 20% in older than 30 years of age.

Table 2: Frequency distribution of age of patients who underwent intermaxillary fixation and open internal fixation.

Age	N (%)
22 to 24 years	3 (30)
25 to 27 years	2 (20)
28 to 30 years	3 (30)
More than 30 years	2 (20)
Total	10 (100)
Age Mean ± SD	28.2 ± 5.29

Table 3 shows the time of injury among patients who underwent IMF and ORIF included in the study. 4 (40%) patients sustained injury in 2021, 5 (50%) in 2022, and 1 (10%) in 2023.

Table 3: Time of injury among patients who underwent intermaxillary fixation and open internal fixation.

Year of Injury	N (%)
2021	4 (40)
2022	5 (50)
2023	1 (10)
Total	10 (100)

Table 4: Fracture sites of patients who underwent intermaxillary fixation and open internal fixation.

Location of Fracture	N (%)
Mandibular body	3(30)
Mandibular body and ramus.	2 (20)
Mandibular body and angle.	5 (50)

Table 4 shows the fracture locations of the patients who underwent intermaxillary fixation and open internal fixation included in the study. 30 %occurred in the mandibular body, 20% in the mandibular body and ramus, and 50% in the mandibular body and angle.

Table 5: Duration of surgery for the patients who underwent intermaxillary fixation and open internal fixation.

Duration of surgery	N (%)
Two hours	2 (20)
Three hours	3 (30)
Four hours	3 (30)
Five hours	2 (20)
Total	10 (100)

Table 5 show the surgical duration for patients who underwent IMF and ORIF. 2 (20%) patients had surgery lasting 2 hours, 3 (30%) 3 hours, 3 (30%) 4 hours, and 2 (20%) lasting 5 hours. Table 6 shows the complications in patients who underwent IMF and ORIF. The most common complication was malunion in 4 patients (40%), followed by bone loss in 3 patients (30%), and no complications occurred in 3 patients (30%) of the total.

Table 6: Complications among patients who underwent intermaxillary fixation and open internal fixation.

Complications	N (%)
Infection	0 (0.0)
Non-union	0 (0.0)
Malunion	4 (40)
Defeat bone	3 (30)
No complications	3 (30)
Total	10 (100)

Bone density in injury site for IMF comparing to ORIF: Table 7 shows bone density at the injury site among patients who underwent IMF compared to ORIF (IMF vs. ORIF). The study found no significant differences in bone density at the injury site between IMF and ORIF in Row 1 and Row 2, Row 2 and Row 3, Row 3 and Row 4, Row 4 and Row 5, as the *p* value was higher than the significance level of 0.05. The results suggest that there are no significant differences in bone density between the two groups.

Bone density in corresponding site for IMF comparing to ORIF: The study found no significant differences in bone density in corresponding sites between IMF and ORIF in between Row 1 and Row 2, Row 2 and Row 3, Row 3 and Row 4, Row 4 and Row 5, as the *p* value was higher than the significance level of 0.05. The results suggest that there are no significant differences in bone density between the two groups.

Table 7: Bone density at the injury site among patients who underwent intermaxillary fixation compared to open internal fixation (IMF vs. ORIF).

Site	Column	IMF Mean±SD	ORIF Mean±SD	*p* value
Between Row 1 & Row 2	Column 1	925.8±531.0	1101.9±636.8	0.730 NS
	Column 2	1396.3±550.6	1550.5±598.1	0.690 NS
	Column 3	1322.7±751.2	1546.3±653.2	0.548 NS
	Column 4	1148.5±997.0	1500.9±487.0	0.421 NS
	Column 5	1313.7±1275.4	1275.4±519.1	1.000 NS
Between Row 2 & Row 3	Column 1	884.6±483.9	1280.2±556.5	0.413 NS
	Column 2	1196.6±442.8	1215.4±642.1	1.000 NS
	Column 3	1195.4±960.9	1103.5±454.8	1.000 NS
	Column 4	1207.3±745.4	1457.9±533.7	1.000 NS
	Column 5	1214.6±848.8	1455.1±754.6	1.000 NS
Between Row 3 & Row 4	Column 1	893.1±385.7	1416.5±518.4	0.190 NS
	Column 2	1307.1±849.8	1276.2±392.5	1.000 NS
	Column 3	968.3±603.4	1131.4±381.1	0.841 NS
	Column 4	1315.6±857.9	1541.3±681.4	0.841 NS
	Column 5	1250.5±860.6	1438.3±711.8	0.905 NS
Between Row 4 & Row 5	Column 1	1083.5±572.7	1396.6±507.1	0.556 NS
	Column 2	1017.4±728.2	1618.7±539.2	0.400 NS
	Column 3	1519.0±778.1	1370.0±623.6	0.886 NS
	Column 4	1197.5±891.5	1576.1±280.7	0.571 NS
	Column 5	1089.5±822.1	1492.2±362.6	0.629 NS

p value Mann-Whitney Test, NS: Not significant.

Comparison of bone density in IMF patients by comparing the injury site with the corresponding site: The study found no significant differences in bone density between IMF patients at the injury site compared to corresponding sites in between Row 1 and Row 2, Row 2 and Row 3, Row 3 and Row 4, and Row 4 and Row 5, as the *p* value was higher than the significant value of 0.05.

Comparison of bone density in ORIF patients by comparing the injury site with the corresponding site: The study found no significant differences in bone density between injury sites in between Row 1 and Row 2, Row 2 and Row 3, Row 3 and Row 4, and Row 4 and Row 5, as the *p* value was higher than the significance level of 0.05. The results suggest that ORIF does not significantly impact bone density at these sites.

Table 8: Bone density in corresponding site for IMF comparing to ORIF.

Site	Column	IMF Mean±SD	ORIF Mean±SD	*p* value
Between Row 1 & Row 2	Column 1	730.9±746.3	1063.7±513.2	0.343 NS
	Column 2	652.4±623.3	1267.9±406.0	0.151 NS
	Column 3	849.2±594.2	1475.6±440.1	0.095 NS
	Column 4	868.7±486.1	1293.6±472.5	0.310 NS
	Column 5	983.4±755.7	1225.7±442.1	0.556 NS
Between Row 2 & Row 3	Column 1	486.3±525.7	1161.3±831.2	0.111 NS
	Column 2	608.8±602.7	1171.7±377.0	0.222 NS
	Column 3	775.5±650.5	1288.4±533.7	0.222 NS
	Column 4	649.2±608.4	1282.0±592.4	0.151 NS
	Column 5	939.6±647.1	1226.2±574.2	0.556 NS
Between Row 3 & Row 4	Column 1	557.4±527.0	823.6±283.9	0.190 NS
	Column 2	730.6±721.4	1300.5±744.9	0.421 NS
	Column 3	583.9±449.2	1486.7±841.8	0.095 NS
	Column 4	767.8±659.5	1327.1±853.0	0.222 NS
	Column 5	1023.4±802.0	1211.0±672.0	1.000 NS
Between Row 4 & Row 5	Column 1	661.5±670.3	1115.0±399.1	0.286 NS
	Column 2	768.3±606.8	1551.1±887.8	0.229 NS
	Column 3	1198.7±788.2	1328.7±679.3	0.686 NS
	Column 4	1029.8±750.4	1290.7±374.4	0.571 NS
	Column 5	881.3±789.6	1060.1±482.8	0.857 NS

Comparison bone thickness in injury site between IMF and ORIF: The study found no significant differences in bone thickness between IMF and ORIF in the injury site in Row 1 (Column 1), Row 2, Row 3, Row 4, and Row 5, as the *p* values were higher than the significance level of 0.05. The results suggest that there may be no significant differences in bone thickness between IMF and ORIF.

Comparison of bone thickness at the corresponding site for IMF patients compared to ORIF patients: The study found no significant differences in bone thickness between IMF and ORIF in corresponding sites in Row 1, Row 2, Row 3, Row 4, Row 5, and Row 6, as the *p* value was higher than the significant value of 0.05. The results suggest that there are no significant differences in bone thickness between IMF and ORIF.

Comparison of bone thickness in IMF patients at injury site comparing to the corresponding site: The study found no significant differences in bone thickness between injury sites using IMF in Row 1, Row 2, Row 3, Row 4, and Row 5. The *p* value was higher than the significance level of 0.05, indicating no significant differences in bone thickness between the injury sites. The results suggest that IMF may not significantly impact bone thickness in these sites.

Comparison of bone thickness in ORIF patients at injury site comparing to the corresponding site: The study found no significant differences in bone thickness between injury sites using ORIF (Orthometric Infertility Index) in Row 1, Row 2, Row 3, Row 4, and Row 5. However, in Row 5, the *p* value was 0.029, which is less than the 0.05 significance level, indicating that there were no significant differences in bone thickness between the injury sites.

Table 9: Comparison of bone density in IMF patients by comparing the injury site with the corresponding site.

Site	Column	Injury site Mean±SD	Corresponding site Mean±SD	*p* value
Between Row 1 & Row 2	Column 1	925.8±531.0	730.9±746.3	0.686 NS
	Column 2	1396.3±550.6	652.4±623.3	0.095 NS
	Column 3	1322.7±751.2	849.2±594.2	0.421 NS
	Column 4	1148.5±997.0	868.7±486.1	0.548 NS
	Column 5	1313.7±1275.4	983.4±755.7	0.486 NS
Between Row 2 & Row 3	Column 1	884.6±483.9	486.3±525.7	0.343 NS
	Column 2	1196.6±442.8	608.8±602.7	0.095 NS
	Column 3	1195.4±960.9	775.5±650.5	0.548 NS
	Column 4	1207.3±745.4	649.2±608.4	0.421 NS
	Column 5	1214.6±848.8	939.6±647.1	0.686 NS
Between Row 3 & Row 4	Column 1	893.1±385.7	557.4±527.0	0.343 NS
	Column 2	1307.1±849.8	730.6±721.4	0.310 NS
	Column 3	968.3±603.4	583.9±449.2	0.421 NS
	Column 4	1315.6±857.9	767.8±659.5	0.310 NS
	Column 5	1250.5±860.6	1023.4±802.0	0.686 NS
Between Row 4 & Row 5	Column 1	1083.5±572.7	661.5±670.3	0.200 NS
	Column 2	1017.4±728.2	768.3±606.8	0.686 NS
	Column 3	1519.0±778.1	1198.7±788.2	0.686 NS
	Column 4	1197.5±891.5	1029.8±750.4	0.841 NS
	Column 5	1089.5±822.1	881.3±789.6	0.700 NS

DISCUSSION

The fast-paced pace of modern life, coupled with an increasingly violent and intolerant society, has made facial injuries a social ill from which no society is immune. Yemen has been experiencing a war for 15 years, leading to an increase in facial injuries. It appears that divergent societal transformations may be responsible for recent changes in the patterns of facial injuries, their prevalence, and their clinical features, resulting in severe deformities of the maxillofacial structure. The mandible is the only mobile bone in the facial structure, and recent years have witnessed a marked increase in the number of cases.

Table 10: Comparison of bone density in ORIF patients by comparing the injury site with the corresponding site.

Site	Column	Injury site Mean±SD	Corresponding site Mean±SD	*p* value
Between Row 1 & Row 2	Column 1	1101.9±636.8	1063.7±513.2	0.905 NS
	Column 2	1550.5±598.1	1267.9±406.0	0.421 NS
	Column 3	1546.3±653.2	1475.6±440.1	0.690 NS
	Column 4	1500.9±487.0	1293.6±472.5	0.548 NS
	Column 5	1275.4±519.1	1225.7±442.1	0.690 NS
Between Row 2 & Row 3	Column 1	1280.2±556.5	1161.3±831.2	0.548 NS
	Column 2	1215.4±642.1	1171.7±377.0	1.000 NS
	Column 3	1103.5±454.8	1288.4±533.7	0.690 NS
	Column 4	1457.9±533.7	1282.0±592.4	0.548 NS
	Column 5	1455.1±754.6	1226.2±574.2	0.690 NS
Between Row 3 & Row 4	Column 1	1416.5±518.4	823.6±283.9	0.056 NS
	Column 2	1276.2±392.5	1300.5±744.9	0.690 NS
	Column 3	1131.4±381.1	1486.7±841.8	0.690 NS
	Column 4	1541.3±681.4	1327.1±853.0	1.000 NS
	Column 5	1438.3±711.8	1211.0±672.0	0.548 NS
Between Row 4 & Row 5	Column 1	1396.6±507.1	1115.0±399.1	0.310 NS
	Column 2	1618.7±539.2	1551.1±887.8	1.000 NS
	Column 3	1370.0±623.6	1328.7±679.3	1.000 NS
	Column 4	1576.1±280.7	1290.7±374.4	0.400 NS
	Column 5	1492.2±362.6	1060.1±482.8	0.343 NS

Table 11: Comparison of bone thickness at the injury site for IMF patients compared to ORIF patients.

Row	Column	IMF Mean±SD	ORIF Mean±SD	*p* value
Row 1	Column 1	9.98±1.98	6.76±1.94	0.016*
	Column 2	10.53±2.41	6.72±2.32	0.063 NS
	Column 3	8.28±2.75	9.34±2.70	0.548 NS
	Column 4	6.32±2.32	8.66±3.61	0.421 NS
	Column 5	8.15±2.47	8.04±2.41	0.905 NS
Row 2	Column 1	12.1±1.94	8.78±2.88	0.111 NS
	Column 2	12.3±1.97	10.28±3.94	0.413 NS
	Column 3	10.7±2.66	11.8±3.64	0.841 NS
	Column 4	9.02±2.20	11.58±4.49	0.548 NS
	Column 5	9.88±2.03	11.38±2.85	0.556 NS
Row 3	Column 1	12.98±2.12	9.36±3.64	0.111 NS
	Column 2	12.63±1.56	11.96±2.62	0.730 NS
	Column 3	11.56±3.32	13.02±4.14	0.841 NS
	Column 4	10.66±2.0	11.62±2.78	0.690 NS
	Column 5	10.9±0.77	11.14±3.57	0.730 NS
Row 4	Column 1	11.83±2.59	10.84±2.73	0.556 NS
	Column 2	12.45±1.85	10.66±1.85	0.286 NS
	Column 3	10.94±1.61	11.78±3.01	1.000 NS
	Column 4	11.52±2.97	9.94±2.46	1.000 NS
	Column 5	12.25±2.0	11.04±2.87	0.413 NS
Row 5	Column 1	9.35±1.59	9.58±2.15	0.905 NS
	Column 2	10.43±1.87	9.63±0.59	0.400 NS
	Column 3	9.33±2.13	10.7±1.07	0.486 NS
	Column 4	10.86±2.0	10.3±3.64	0.571 NS
	Column 5	11.13±1.95	2.36±2.36	0.857 NS

p value Mann-Whitney Test, NS: Not significant.

If undiagnosed or inadequately treated, mandibular fractures can lead to serious consequences, both cosmetic and functional[31]. As previously mentioned, the need to treat these fractures has increased. Fixation devices, such as IMF and ORIF, are used to treat bone fractures, particularly in the jaw. ORIF involves a surgical procedure to align and stabilize the fractured bone using instruments such as screws and plates. IMF is a less invasive method, connecting the upper and lower jaws together with wires to hold them in place. It is often used in conjunction with ORIF or as a standalone treatment. The choice between the two depends on the severity and location of the fracture, as well as other patient-related factors.

Table 12: Comparison of bone thickness at the corresponding site for IMF patients compared to ORIF patients.

Row	Column	IMF Mean±SD	ORIF Mean±SD	*p* value
Row 1	Column 1	10.83±1.69	8.76±2.77d	0.190 NS
	Column 2	11.02±1.34	10.04±1.90	0.222 NS
	Column 3	10.58±2.41	11.14±2.06	0.690 NS
	Column 4	9.4±2.59	10.88±1.91	0.310 NS
	Column 5	10.03±2.89	10.48±0.80	1.000 NS
Row 2	Column 1	11.08±1.01	9.72±2.40	0.413 NS
	Column 2	10.94±1.67	10.12±2.15	0.690 NS
	Column 3	10.2±2.50	10.42±1.82	1.000 NS
	Column 4	10.58±2.63	11.12±1.28	0.841 NS
	Column 5	10.95±2.14	10.64±0.90	0.905 NS
Row 3	Column 1	10.60±1.09	9.58±3.12	0.413 NS
	Column 2	10.36±1.47	9.74±2.78	0.690 NS
	Column 3	9.88±1.39	9.92±1.47	1.000 NS
	Column 4	10.36±1.99	10.36±0.51	0.841 NS
	Column 5	11.80±1.37	10.22±1.84	0.190 NS
Row 4	Column 1	10.38±0.85	8.98±2.98	0.286 NS
	Column 2	9.82±1.79	8.68±1.38	0.310 NS
	Column 3	9.72±0.73	9.22±1.03	0.690 NS
	Column 4	10.52±1.53	9.60±1.23	0.421 NS
	Column 5	11.68±1.77	10.62±1.10	0.556 NS
Row 5	Column 1	9.73±1.02	8.30±2.06	0.286 NS
	Column 2	9.28±0.95	7.63±1.21	0.229 NS
	Column 3	8.83±1.17	8.43±1.06	0.686 NS
	Column 4	10.02±0.83	9.63±1.32	0.786 NS
	Column 5	11.37±1.70	9.63±1.68	0.229 NS

Table 13: Comparison of bone thickness in IMF patients at injury site comparing to the corresponding site.

Row	Column	Injury site Mean±SD	Corresponding site Mean±SD	*p* value
Row 1	Column 1	9.98±1.98	10.83±1.69	0.486 NS
	Column 2	10.53±2.41	11.02±1.34	0.905 NS
	Column 3	8.28±2.75	10.58±2.41	0.222 NS
	Column 4	6.32±2.32	9.4±2.59	0.151 NS
	Column 5	8.15±2.47	10.03±2.89	0.686 NS
Row 2	Column 1	12.1±1.94	11.08±1.01	0.686 NS
	Column 2	12.3±1.97	10.94±1.67	0.286 NS
	Column 3	10.7±2.66	10.2±2.50	0.841 NS
	Column 4	9.02±2.20	10.58±2.63	0.310 NS
	Column 5	9.88±2.03	10.95±2.14	0.686 NS
Row 3	Column 1	12.98±2.12	10.60±1.09	0.200 NS
	Column 2	12.63±1.56	10.36±1.47	0.063 NS
	Column 3	11.56±3.32	9.88±1.39	0.421 NS
	Column 4	10.66±2.0	10.36±1.99	0.690 NS
	Column 5	10.9±0.77	11.80±1.37	0.343 NS
Row 4	Column 1	11.83±2.59	10.38±0.85	0.486 NS
	Column 2	12.45±1.85	9.82±1.79	0.111 NS
	Column 3	10.94±1.61	9.72±0.73	0.310 NS
	Column 4	11.52±2.97	10.52±1.53	0.841 NS
	Column 5	12.25±2.0	11.68±1.77	0.686 NS
Row 5	Column 1	9.35±1.59	9.73±1.02	0.886 NS
	Column 2	10.43±1.87	9.28±0.95	0.343 NS
	Column 3	9.33±2.13	8.83±1.17	0.686 NS
	Column 4	10.86±2.0	10.02±0.83	0.690 NS
	Column 5	11.13±1.95	11.37±1.70	1.000 NS

Accurate assessment of jaw bone density is a critical step in surgical planning, implant selection, and surgical outcome. This study evaluated bone density in the mandibular osseointegration zone of Yemeni patients using CBCT, providing valuable insights into variations related to surgical technique. The findings emphasize the importance of site-specific assessments and the use of advanced imaging techniques such as CBCT for accurate diagnosis and treatment planning in dental implant and restorative procedures. CBCT has emerged as a significant advancement in CT technology, widely adopted in dentistry due to its high-resolution imaging, reduced radiation exposure, and cost-effectiveness compared to conventional CT scans[32]. Its enhanced capabilities enable accurate assessment of bone density, optimal implant placement, and improved treatment predictability[32].

Table 14: Comparison of bone thickness in ORIF patients at injury site comparing to the corresponding site.

Row	Column	Injury site Mean±SD	Corresponding site Mean±SD	*p* value
Row 1	Column 1	6.76±1.94	8.76±2.77d	0.310 NS
	Column 2	6.72±2.32	10.04±1.90	0.056 NS
	Column 3	9.34±2.70	11.14±2.06	0.151 NS
	Column 4	8.66±3.61	10.88±1.91	0.151 NS
	Column 5	8.04±2.41	10.48±0.80	0.222 NS
Row 2	Column 1	8.78±2.88	9.72±2.40	0.548 NS
	Column 2	10.28±3.94	10.12±2.15	1.000 NS
	Column 3	11.8±3.64	10.42±1.82	0.690 NS
	Column 4	11.58±4.49	11.12±1.28	0.421 NS
	Column 5	11.38±2.85	10.64±0.90	0.841 NS
Row 3	Column 1	9.36±3.64	9.58±3.12	1.000 NS
	Column 2	11.96±2.62	9.74±2.78	0.310 NS
	Column 3	13.02±4.14	9.92±1.47	0.310 NS
	Column 4	11.62±2.78	10.36±0.51	0.151 NS
	Column 5	11.14±3.57	10.22±1.84	0.548 NS
Row 4	Column 1	10.84±2.73	8.98±2.98	0.421 NS
	Column 2	10.66±1.85	8.68±1.38	0.151 NS
	Column 3	11.78±3.01	9.22±1.03	0.151 NS
	Column 4	9.94±2.46	9.60±1.23	0.548 NS
	Column 5	11.04±2.87	10.62±1.10	0.421 NS
Row 5	Column 1	9.58±2.15	8.30±2.06	0.548 NS
	Column 2	9.63±0.59	7.63±1.21	0.100 NS
	Column 3	10.7±1.07	8.43±1.06	0.029*
	Column 4	10.3±3.64	9.63±1.32	1.000 NS
	Column 5	2.36±2.36	9.63±1.68	1.000 NS

In the current study, the fracture sites of the patients included in the study who underwent IMF and ORIF were identified. In 30% fractures occurred in the body of the mandible, 20% in the mandibular body and ramus, and 50% in the mandibular body and angle. Our results are similar to those reported worldwide, in that the most common sites of mandibular fractures are the condyle (most often the subcondylar region) and the angle. Other common sites include the body, the lateral union/fusion, and, less frequently, the ramus and the coronoid process[33]. This may be explained by the fact that bones fracture at sites of tensile stress, as their resistance to compressive forces is greater[34]. Areas showing weakness include the lateral region of the mental process, the mental foramen, the angle of the mandible, and the condylar neck[35]. The thickening on the inner side of the condylar neck, or apex of the neck, appears to act as a major support for the mandible, transmitting stress to the temporomandibular joint and the base of the skull[33].

The operative duration for patients who underwent ORIF in this study was 2 (20%) patients had surgery lasting 2 hours, 3 (30%) 3 hours, 3 (30%) 4 hours, and 2 (20%) lasting 5 hours. Our operative duration is longer than that reported elsewhere, where operative duration for ORIF with IMF typically ranges from 1 to 2 hours, but can be longer depending on the complexity of the fracture. For example, a mandibular fracture with an IMF takes an average of 85.5 minutes, whereas a similar fracture without an IMF may only take about 50 minutes[36]. The use of an IMF during surgery increases operative time. Other studies have noted that the average operative time for ORIF for a mandibular angle fracture with an IMF was 98.5 minutes, and without an IMF, 40.2 minutes[37,38]. Fordyce stated that while the procedure time with IMF increases, the cost of fabricating and applying the arch bars, the increased duration of general anesthesia, staff costs, and outpatient time required to remove this metal structure after surgery also increase the overall cost of treatment[39,40]. In our study, no difficulties were observed in reducing and fixing the fractured fragments in either group. No difficulties were observed in adapting the devices in either group.

In the current study, complications in patients who underwent maxillary fixation and open internal fixation were as follows: malunion was the most common in 4 patients (40%), followed by bone loss in 3 patients (30%). Although malunion can occur, malocclusion is often cited as the most common complication after surgical treatment of maxillofacial fractures, especially when malunion results in jaw and tooth misalignment. Other common complications include infection, facial deformities, and temporomandibular joint (TMJ) disorders[41]. Nussbaum *et al.*, presented a review of previous research that clearly evaluated whether open or closed treatment of condylar fractures yielded better outcomes. However, the results were ambiguous regarding the importance of using open or closed treatment for mandibular condylar fractures[42].

In the present analysis, there were no significant alterations in bone density at the site of injury between ORIF and IMF in between Raw1 and 2, between 2 and 3, between 3 and 4, and between 4 and 5, with a p value above the 0.05 significance level. These results reveal no significant variancesin bone density between the two groups. This finding is similar to that previously reported, in which no significant difference was found in changes in bone density at the site of injury when comparing ORIF and IMF with and without intermaxillary fixation (IMF) for mandibular fractures. Studies indicate that ORIF alone provides sufficient stability for healing. While ORIF can be used as a complement to IMF, its routine use does not significantly affect bone density outcomes, although it may increase surgical time and cost[36]. However, other researchers have suggested that there are significant differences in bone density at the injury site between IMF and ORIF. These researchers have attributed these differences in bone density at the injury site to the different degrees of soft tissue stripping and the amount of periosteal debridement. IMF, being less invasive, reduces disruption of the periosteum and surrounding tissues, potentially preserving blood supply and promoting better healing. In contrast, ORIF involves an incision to directly access the bone, which may cause greater stripping and debridement of the periosteum, although it provides more precise anatomical debridement[36].

CONCLUSION

Ultimately, a patient's previous bone density is the determining factor in determining the appropriate treatment for a jaw fracture, not a point of comparison between in IMF and ORIF. While both treatments have their risks and benefits, the success of the outcome depends on the quality of the underlying bone being sufficient to ensure stable healing.

ACKNOWLEDGEMENTS

The authors express their gratitude to the Sana'a City Military Hospital team for their gracious assistance.

AUTHOR’S CONTRIBUTIONS

Al-Rahbi LM: critical review, monitoring. **Zayed OA:** formal analysis, conceptualization, data organization, and laboratory and clinical exams. **Al-Aswal AA:** supervision. **Al-Shamahy HA:** critical review, monitoring. Final manuscript was checked and approved by all authors.

DATA AVAILABILITY

The accompanying author can provide the empirical data that were utilized to support the study's conclusions upon request.

CONFLICT OF INTEREST

None to declare.

REFERENCES

1. Kanno T, Suzuki Y, Saito T, *et al.* Radiological evaluation of mandibular fractures: Comparative study of open and closed reduction. Oral Surg Oral Med Oral Patho Oral Radio 2016;122(5):520-528. *https://doi.org/10.1016/j.oooo.2016.07.018*
2. Thompson L, Smith C, Lam WL, *et al.* Gunshot injuries to the mandible: Treatment and radiological outcomes. J Cran Surg 2017;28(6):e576-e581. *https://doi.org/10.1097/SCS.0000000000003962*
3. Tourné L, Lee J, Drennan M, *et al.* Bone density in mandibular fractures: A comparative study between open and closed reduction. J Cran-Maxi Surg 2018;46(10):1693-1699. *https://doi.org/10.1016/j.jcms.2018.06.021*
4. Moore T, Smith O, Pons S, *et al.* Postoperative bone healing of mandibular fractures: A radiological comparison of treatment methods. J Oral Maxi Surg 2019;77(2):244-252. *https://doi.org/10.1016/j.joms.2018.09.023*
5. Choi J, Lorenz HP. Spain DA: Review of facial trauma management. J Trau Acute Care Surg 2020;88:e124-30. *https://doi.org/10.1097/TA.0000000000002589*
6. Chrcanovic BR. Open versus closed reduction: Diacapitular fractures of the mandibular condyle. Oral Maxi Surg 2012;16:257-65. *https://doi.org/10.1007/s10006-012-0337-6*
7. Zhou HH, Liu Q, Cheng G, *et al.* Aetiology, pattern and treatment of mandibular condylar fractures in 549 patients: A 22-year retrospective study. J Cran Surg 2013;41:34-41. *https://doi.org/10.1016/j.jcms.2012.05.007*
8. Dahlström L, Kahnberg KE, Lindahl L. 15 year's follow-up on condylar fractures. Int J Oral Maxi Surg 1989;18:18-23. *https://doi.org/10.1016/s0901-5027(89)80009-8*
9. Abu-Taleb AM, Al-Rahbi LM, Al-Ashwal AA. Maxillofacial fracture type and their management in individuals referred to the Military Hospital in Sana'a City, Yemen. Universal J Pharm Res 2025; 10(4): 37-43. *https://doi.org/10.22270/ujpr.v10i4.1267*
10. Awad MMA, Al-Rahbi LM, Al-Ashwal AA, *et al.* Comparative outcomes in mandibular angle fracture management reconstruction plates versus dual miniplates fixation. Universal J Pharm Res 2025; 10(3): 22-27. *https://doi.org/10.22270/ujpr.v10i3.1349*
11. Sharaf Aldeen HMA, Al-Rahbi LM, Al-Ashwal AA. Analysis of hardware removal in maxillofacial trauma: A retrospective study in a military hospital in Sana'a, Yemen. Universal J Pharm Res 2024; 8(6):46-51. *https://doi.org/10.22270/ujpr.v8i6.1039*
12. Al-Rahbi LM, MAMF Gamel, Al-Shamahy HA. Treatment of comminuted mandibular fracture with closed reduction and mandibular fixation versus open reduction and internal fixation. Universal J Pharm Res 2024; 9(5): 1-8. *https://doi.org/10.22270/ujpr.v9i5.1192*
13. Rowida AAMA, Lutf M Alrahabi, Ahmed AAA, *et al.* Maxillofacial trauma among head trauma patients in 48 hospital, Sana'a city, Yemen, during 2022 and 2023. J Bio-Med Clin Res 2024; 1(1). *https://www.doi.org/rpc/2024/rpc.jb mcr/0084*
14. Al-Rahbi LM, Al-Badani NADA, Al-Ashwal AA, *et al.* Osteomyelitis of the Jaws: A 5 years retrospective study at ALThawra Hospital in Sana'a, Yemen. Universal J Pharm Res 2025;10(3):45-51. *https://doi.org/10.22270/ujpr.v10i3.1352*
15. Al-Rahbi LM, Mohammed Setten HH, Al-Shamahy HA. Impact of 3D printing in reconstruction of maxillofacial bone defects experimental study in a military hospital in Sana'a city, Yemen. Universal J Pharm Res 2025;10(1):1- 8. *https://doi.org/10.22270/ujpr.v10i1.1271*
16. Venkatesh E, Elluru SV. Cone beam computed tomography: Basics and applications in dentistry. J Istan Univ Facu Dent 2017;51(3 Suppl 1):102-121. PMID: 29354314 *https://doi.org/ https://doi.org/10.17096/jiufd.00289.*
17. Pauwels R, Jacobs R, Singer SR, *et al.* CBCT-based bone quality assessment: Are hounsfield units applicable? Dent maxi Radio 2015; 44(1):20140238. *https://doi.org/10.1259/dmfr.20140238*
18. Ekfeldt A, Johansson LA, Christiansson U, *et al.* A retrospective analysis of factors associated with multiple implant failures in maxillae. Clin Oral Impl Res 2021;12(5):462-467. PMID: 11564105 *https://doi.org/10.1034/j.1600-0501.2001.120505.x*
19. Farae SAMA, Al-Hadi YAA, Al-Shamahy HA. Maxilla and mandible bone density in sample of normal full dentition yemeni adults: Cone beam computed tomography (CBCT) retrospective study: Cone beam computed tomography (CBCT) retrospective study. Sana'a Univ J Med Health Sci 2025;19(2):170–175. *https://doi.org/10.59628/jchm.v19i2.1700*
20. Ahmed STA, SAA Da'er, WAHA Homaid, *et al.* Aassessment of the anatomical structure of canalis sinuosus in the anterior maxilla to avoid surgical complications. Universal J Pharm Res 2024;9(4):11-6. *https://doi.org/10.22270/ujpr.v9i4.1153*
21. AlKhawlani MMTA, Ziad AA, Daer NA, *et al.* Knowledge and attitude toward cone beam computed tomography: A questionnaire study among Yemeni dental practitioners. Universal J Pharm Res 2022;7(1):1-8. *https://doi.org/10.22270/ujpr.v7i1.723*
22. Alkohlani FHAAS, YAA Alhadi, AA Alasbahi, *et al.* Anatomical pattern course of mandibular canal and its foramina location on sample of Yemeni patients using cone beam computed tomography. Universal J Pharm Res 2023;8(1):1-8. *https://doi.org/10.22270/ujpr.v8i1.895*
23. Al-Ghola E, Al-Harazi G, Al-Shamahy HA. Three-dimensional evaluation of the first cervical vertebral morphology in skeletal class I and III malocclusions in Yemeni patients. Universal J Pharm Res 2025; 10 (1):1-8. *https://doi.org/10.22270/ujpr.v10i1.1269*
24. Alsada'a WAA, Al-Hamzi MA, Al-Khawlani AI, *et al.* Radiographic evaluation of overhanging restorations among Yemeni patients using cone-beam computed tomography (CBCT). Universal J Pharm Res 2023;8 (5):1-8. *https://doi.org/10.22270/ujpr.v8i5.1007*
25. Alhadi YAA, Al-Shamahi NYA, AL-Haddad KA, *et al.* Maxillary sinus septa: Prevalence and association with gender and location in the maxilla among adults in Sana'a city, Yemen. Universal J Pharm Res 2022; 7(3):1-8. *https://doi.org/10.22270/ujpr.v7i3.775*
26. Ahlam Mohammed AA, Almotareb FL, Al-Shamahy HA. Validity of pont's analysis in a group of Yemeni population. Universal J Pharm Res 2025; 10(1):1-8. *https://doi.org/10.22270/ujpr.v10i1.1267*
27. Al-Nomair JH, Al-Homaidi EA, Zabara AQMQ, *et al.* Evaluation of the relative position of the mandibular foramen in Yemeni children as a reference for inferior alveolar nerve block using an orthopantamograph. Universal J Pharm Res 2024;9(3): 1-8. *https://doi.org/10.22270/ujpr.v9i3.1117*
28. Hughes L, Clark M, O'Connell D, *et al.* Impact of reduction methods on bone healing: Radiological and clinical outcomes in mandibular fractures. J Trauma Acute Care Surg 2020;88(3):530-536. *https://doi.org/10.1097/TA.0000000000002567*
29. Hounsfield GN. Computerized tomography: A new diagnostic imaging method. British J Radio 1973;46(552):1016–1022. *https://doi.org/10.1259/0007-1285-46-552-1016*
30. Sadria M, Behnaz M, Tavakkol H, *et al.* Comparative analysis of bone healing after open vs closed reduction of mandibular fractures: A radiological study. J Cran Surg 2015;43(1):83-89.*https://doi.org/10.1016/j.jcms.2014.06.014*
31. Ueda N, Zaizen M, Imai Y, *et al.* Measurement of thickness at the inferior border of the mandible using computed tomography images: A retrospective study including 300 Japanese cases. Tomography 2023;9:1236–1245. *https://doi.org/10.3390/omography9040098*
32. Jacobs R, Salmon B, Codari M, *et al.* Cone beam computed tomography in implant dentistry: Recommendations for clinical use. BMC Oral Health 2018;18(1):88.

https://doi.org/10.1186/s12903-018-0523-5
33. Natu SS, Pradhan H, Gupta H, *et al.* An epidemiological study on pattern and incidence of mandibular fractures. Plast Surg Int 2012; 834364. PMID: 23227327; PMCID: PMC3503282. *https://doi.org/10.1155/2012/834364*
34. Hodgson VR. Tolerance of the facial bones to impact. Amer J Anat 1967; 120:113–122 .
35. Halazonetis JA. The "weak" regions of the mandible. British J Oral Surg 1968;6(1):37–48. *https://doi.org/10.1016/s0007-117x(68)80025-3*
36. Bhushan K, Unakalkar S, Sahu R, *et al.* Compare the efficacy of open reduction and internal fixation of mandibular fractures with and without use of intra-operative inter-maxillary fixation. Indian J Otol Head Neck Surg 2022; 74 (Suppl 3):4096-4099. PMID: 36742617; PMCID: PMC9895336. *https://doi.org/10.1007/s12070-021-02830-3*
37. Kronseder K, Runte C, Kleinheinz J, *et al.* Distribution of bone thickness in the human mandibular ramus—A CBCT-based study. Head Face Med 2020;16:13. PMID: 32513223 *https://doi.org/10.1186/s13005-020-00228-0*
38. Fordyce AM, Lalani Z, Songra AK, *et al.* Intermaxillary fixation is not usually necessary to reduce mandibular fractures. Br J Oral Maxi Surg. 1999;37(1):52–57. *https://doi.org/ 10.1054/bjom.1998.0372*
39. Qureshi AA, Reddy UK, Warad NM, *et al.* Intermaxillary fixation screws versus erich arch bars in mandibular fractures: A comparative study and review of literature. Ann Maxi Surg 2016;6(1):25–30. *https://doi.org/10.4103/2231-0746.186129*
40. Barodiya A, Thukral R, Agrawal SM, *et al.* Self-tapping intermaxillary fixation screw: An alternative to arch bar. J Cont Dent Pract 2017;18(2):147–151. *https://doi.org/10.5005/jp-journals-10024-2006*
41. Al Hasani KM, Bakathir AA, Al-Hashmi AK, *et al.* Complications of open reduction and internal fixation of mandibular condyle fractures in Oman. Sultan Qabo Univ Med J 2024;24(3):338-344. PMID: 39234321. *https://doi.org/10.18295/squmj.3.2024.020*
42. Nussbaum ML, Laskin DM, Best AM. Closed versus open reduction of mandibular condylar fractures in adults: A meta-analysis. J Oral Maxi Surg 2008;66:1087-92. PMID: 18486771. *https://doi.org/10.1016/j.joms.2008.01.025*