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Open Versus Closed Reduction in Treatment of The Closed Tibial Diaphyseal Fractures by locked Intramedullary Nail in Adults

A prospective case series study at Al-Jumhoori Teaching Hospital, Mosul, Iraq

By

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Abstract

Background: Treatment of tibial fracture in adult is a challenge to Orthopedic surgeons due to poor soft tissue coverage and blood supply. indirect reduction techniques are initially used to reduce tibia fractures prior to nail insertion. However, if appropriate reduction is not possible using less invasive techniques, a formal open reduction is considered.

Aim: The aim of this study was to compare the clinical and radiological outcomes of simple closed diaphyseal tibial fractures treated with intramedullary nail fixation preceded by closed vs open reduction and to evaluate the effect of open reduction through a limited incision and respectful handling of the soft tissue envelope in increasing the risk of complications, decrease the radiation exposure and operation time.

Patients and Method:

Design : A prospective case series study.

Setting : Orthopedic Unit, Al-Jumhoori Teaching Hospital **.**

Study period : 18 months (January 2013 - July 2014)

Sample size : 40

Inclusion criteria: Adult patients irrespective of sex, with closed OTA type 42 tibia frac-tures occurring in patients 18 years or older due to various causes, treatable by reamed locked intramedullary nail in the orthopedic department of Al jumhoori teaching hospital**.**

Exclusion criteria: All Patients with open fractures, pathological fractures ,active infection ,multiple fractures, earlier fractures of the tibial shaft on the same side, proximal intra-articular or distal intra-articular fractures of the tibia, and temporary treatment with an external fixator.

Intervention**:** Forty adult patients of acute closed tibial diaphyseal fractures were included in our study for treatment with locked intramedullary nailing, in twenty of them the closed reduction was failed and treated by open reduction and locked intramedullary nailing, the remaining group treated with closed reduction and locked intramedullary nailing and both groups followed with clinical and radiological outcomes.

Outcome measures: The patients of both open and closed reduction groups are followed for clinical outcomes through the infection rate ,implant failure ,partial and painless full weight bearing , Squat & Smile ,anterior knee pain and mal alignment , and radiological outcomes through the bridging callus in form of three of four cortices . Johner and Wruh's Criteria used for follow up.

Statistical Analysis: Chi square test at 95% confidence interval was used /P value**.**
Ethical Evaluation or Approval: This study is approved by the Local Scientific Council of Arab Board of Health Specializations of orthopedic Surgery in Iraq, and Mosul Ethical Research Committee, Directorate of Health in Nineveh.
Results: In the first group 20(50%) patients undergone closed reduction and locked intramedullary nailing 13(65%) of them had excellent results, 4(20%) had good results, 2(10%)had fair results and one patient (5 %)had poor results, while in the other group 20(50%) patients undergone open reduction 14(70%)had excellent results 3(15%)had good results, 2(10%)had fair results and one patient (5%)had poor results measured by Johner and Wruhs' criteria. This study found that the rate of infection for open versus closed reductions was higher but not statistically different and no considerable difference in union rates.
***Conclusion*: ** Closed reduction of tibial shaft fractures prior to intramedullary fixation is the preferred technique. However, closed or percutaneous techniques are not effective in some cases, and appropriate reduction is only attainable through formal open techniques. When Limited open reduction is performed though a well-placed incision with respectful soft tissue handling, it is a safe and effective technique and can greatly facilitate the reduction of closed tibial shaft fractures, but raise concern for infection through exposure of the fracture site and union rates. Judicious use of open reduction techniques during intramedullary nailing of closed tibia fractures seems to have a minimal risk of infection.

Keywords: Diaphyseal , tibia , bone , fracture, nail, fixation , trauma, reduction .

Introduction

The tibia by its location is exposed to frequent injuries as one third of its surface is subcutaneous.[(kamruzzaman,2011)] Treatment of tibial fracture in adult is a challenge to Orthopedic surgeons due to poor soft tissue coverage and blood supply.[(kamruzzaman,2011)] Moreover compartment syndrome, neurovascular injury and infection might add to this burden.[(kamruzzaman,2011)] Later delayed union, non union, and malunion are important late complications.[(kamruzzaman,2011)] The acceptable treatment goal for fracture tibia is union maintaining normal length, normal alignment without rotation, deformity, normal joint movement and reduced hospital stay.[(kamruzzaman,2011)] About 50 years ago Charnley (1961) said, "we have still a long way to go before the best method of treating a fracture of the shaft of tibia can be stated with finality".[(Charnley,1961)] As there are variations in treatment of tibial fracture, it is very difficult to manage all the cases by a single treatment method.[(kamruzzaman,2011)] Over last 50 years the management of tibial fracture has oscillated like a pendulum of a clock from non surgical treatment to surgical treatment.[(kamruzzaman,2011)] In the past, tibial shaft fractures were managed by immobilization in a p.o.p. cast.[(ElisH.,1952)] Thereafter functional brace has been used commonly.[(SarmientoA.,1970)]In 1960s and 1970s external fixation was most popular**.**[(Myers,2007)] In 1974 a semi-rigid triflange intramedullary nail is introduced for closed nailing in tibia without reaming**,**[(KyleR.,1985)] but problems remain with comminuted fractures and the nail does not provide rotational stability and normal length**.**[(LottesJ.,1974)] The plating resulted in higher incidence of non Union, infection and fixation failure**.**[(JanssenKW,2007)] The external fixation resulted in pin tract infection and sometimes osteomyelitis of bone.[(TornettaP,1994)] Due to these problems a new technique close tibial interlock nailing was developed that minimize the chances of post-operative infection**,**[(NiedwiedzkiL,2007)] promotes early union, regain early activity and reduce exposure and operative trauma**.(CourtBrownCM,1992)**.

Historically, open reduction and internal fixation of tibial shaft fractures has been associated with high infection and nonunion rates.[(BoneLB,1986,TraftonPG,2009)] However, closed reduction and intra-medullary nail fixation avoids soft tissue dissection around the fracture and has evolved into the treatment of choice for most unstable fractures of the tibial diaphysis and some proximal and distal metaphyseal fractures**.**[(NorkSEB.,2006,NorkSE Sch,2005)] In general, indirect reduction tech-niques are used to reestablish proper tibial length, alignment, and rotation prior to nailing while preserving the local fracture biology**.**[(Leunig,2000)] Because of the high priority assigned to preserving the soft tissues at the fracture site, some authors report that open reduction techniques should be avoided**.**[(BoneLB,1986)] However, nonanatomic reduction has been shown to decrease the strength of a healing fracture and to be a significant risk factor for reoperation**.**[(Panjabi,1985,Bhandari,2003)] Malreduction can also compromise the mechanical axis of the limb, adversely affecting knee and ankle function**.**[(Panjabi,1985,Bhandari,2003)] In some cases, interposed soft tissue, intramedullary bone fragments, or complex deforming forces mean that reduction is only possible with open techniques.[(NorkSE,2006)]

Anatomy :

The tibia is the large weight-bearing medial bone of the leg **Figs.(1).** It articulates with the condyles of the femur and the head of the fibula above and with the talus and the distal end of the fibula below. It has an expanded upper end, a smaller lower end, and a shaft. At the upper end are the lateral and medial condyles (sometimes called lateral and medial tibial plateaus), which articulate with the lateral and medial condyles of the femur and the lateral and medial menisci intervening. Separating the upper articular surfaces of the tibial condyles are anterior and posterior intercondylar areas; lying between these areas is the intercondylar eminence **Fig.(1).** The lateral condyle possesses on its lateral aspect a small circular articular facet for the head of the fibula. The medial condyle has on its posterior aspect the insertion of the semimembranosus muscle **.**

The shaft of the tibia is triangular in cross section, presenting three borders and three surfaces. Its anterior and medial borders, with the medial surface between them, are subcutaneous. The anterior border is prominent and forms the shin. At the junction of the anterior border with the upper end of the tibia is the tuberosity, which receives the attachment of the ligamentum patellae. The anterior border becomes rounded below, where it becomes continuous with the medial malleolus. The lateral or interosseous border gives attachment to the interosseous membrane. The posterior surface of the shaft shows an oblique line, the soleal line , for the attachment of the soleus muscle. The lower end of the tibia is slightly expanded and on its inferior aspect shows a saddle-shaped articular surface for the talus. The lower end is prolonged downward medially to form the medial malleolus. The lateral surface of the medial malleolus articulates with the talus. The lower end of the tibia shows a wide, rough depression on its lateral surface for articulation with the fibula.**(RichardSnell,2012)**

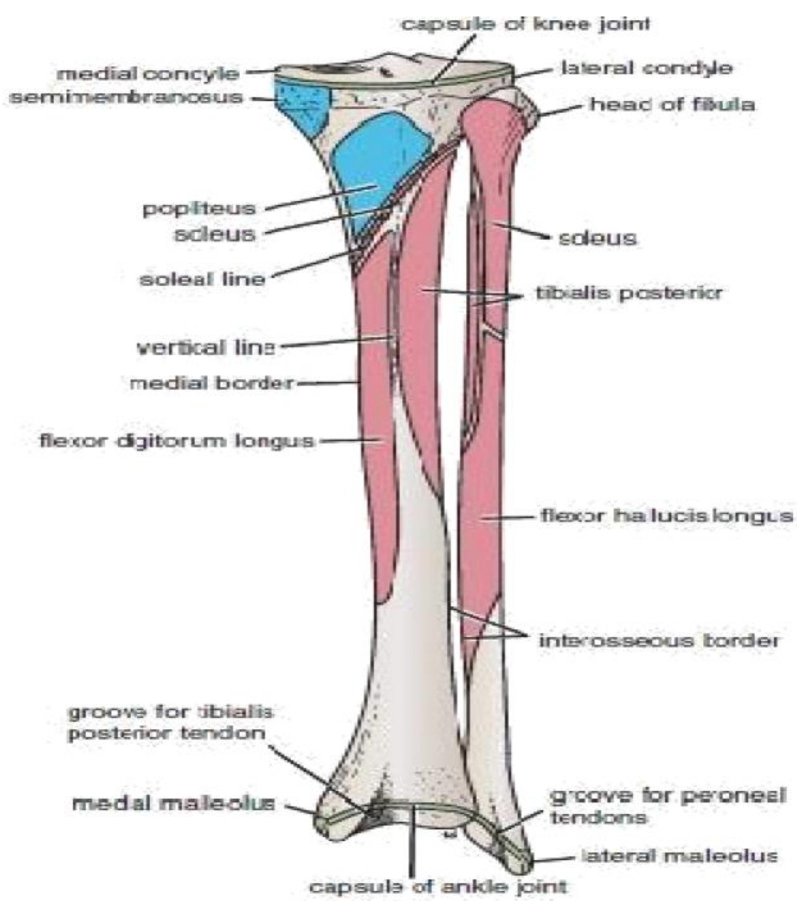

Figure : (1)Muscles and ligaments attached to the surfaces of right tibia and fibula(RichardSnell,2012)

Mechanism of injury and classification of tibial diaphyseal fractures:

A direct impact on the subcutaneous surface of the tibia is the most common cause of a tibial shaft fractures, it is frequently seen after motor vehicle accidents.(Rahij,2008) Indirect violence usually occurs as a result of a sports injury (e.g. football) or after a fall, the tibia is subjected to a large amount of stress caused by a twist to the leg when the foot is still anchored to the ground. A low energy twisting force causes a spiral

fracture, whereas a high-energy force may lead to a comminuted fracture with varying patterns.(Rahij,2008)

These fractures have been classified by the AO group as follows.(Rahij,2008) **Fig.(2).**

Bone = tibia = 4 Segment = middle =2 Types = A , B , C = simple ,wedge ,complex

Groups

A1: Simple fracture, spiral
A2: Simple fracture, oblique ≥30o
A3: Simple fracture, transverse, <30o
B1: Wedge fracture, spiral wedge
B2: Wedge fracture, bending wedge
B3: Wedge fracture, fragmented wedge
C1: Complex fracture, spiral
C2: Complex fracture, segmental
C3: Complex fracture, irregular

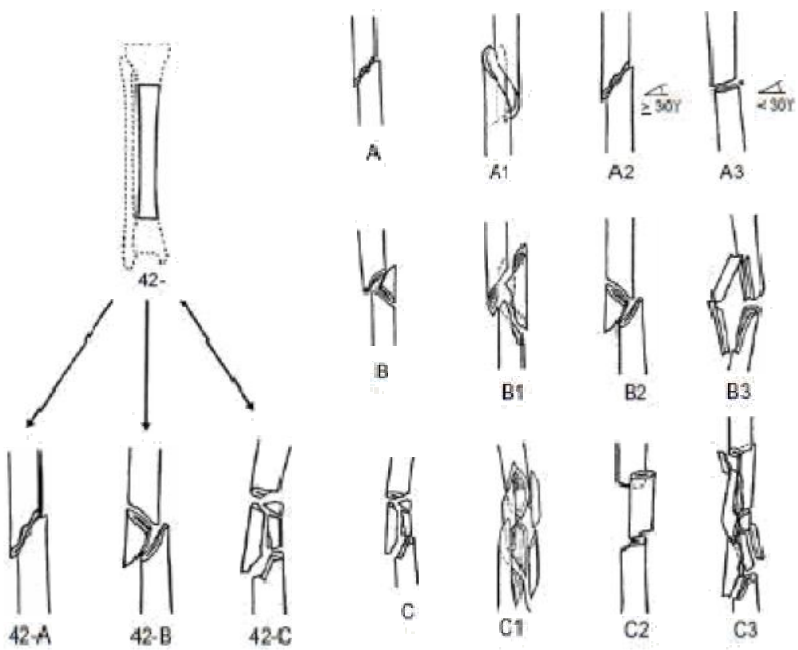

Figure :(2). AO classification of the mid-diaphyseal fractures of tibia.(Rahij,2008)

Nail Indications:

- unacceptable alignment with casting .
- soft tissue injury that will not tolerate casting .
- segmental fx. .
- ipsilateral limb injury .
- polytrauma .
- bilateral tibia fx. .
- morbid obesity.
- pathologic fractures .
- nonunion ,reconstructive surgery.(CourtBroun,1992 ,NorkSE,2006)

Nail Complications:

Intra-operative complications :

- problems during reposition of particles (usually because of impinged soft tissues or particles).
- improper choice of entry in proximal tibial fractures (valgus deformity or inclination forward can occur).
- additional fractures caused during the placement of the nail (improperly chosen entry, overlooked fractures).
- incorrect locking when the screw does not go through the opening in the intramedullary nail.
- improper rotation of the tibia.[(NorkSE,2006)]

Post-operative complications :

- deep vein thrombosis and pulmonary embolism.
- compartment syndrome.
- extensive hematoma that needs to be drained.
- infection of soft tissues and bones, bacteremia and sepsis.
- fracture of the locking screws.
- Fracture of intramedullary nail.
- Anterior knee pain at site of nail insertion.
- Nonunion and malunion.
- Metal sensitivity or allergic reaction.[(NorkSE,2006)]

Biomechanics of intramedullary nail:

The nail and the bone form a composite material. The nail acts as a splint.

Nail contact with the bone occurs at the insertion site, diaphysis, and interlocking screws. There is some motion at the fracture site. This promotes callus formation. As the bone heals, it gradually assumes more of the load and less stress is seen by the implant. Ideally, the bone-nail composite has enough fatigue resistance to allow fracture healing to occur, yet is not overly rigid to impair the physiologic stimulus for healing. One advantage of this technique is that the implant is load sharing, and the construct is strong enough to allow immediate weight bearing. Advantages of intramedullary fixation include providing good fracture stability through a minimally invasive technique of insertion. The implant is central in the bone, close to the mechanical axis of the limb, which is optimally positioned to reduce bending forces. Proximal and distal locking control length and rotation. Early weight bearing, even in comminuted fractures, is allowed with this configuration.[(Weinstein,2005)]

General considerations:

Preparation:

The mechanism of injury from the history and physical examination of the injured limb are important factors because high energy fractures will be more likely to become unstable with cast immobilization and prone to delayed union and malalignment. The decision to proceed with surgery is made by both the patient and surgeon. The patient, and especially the injured leg, must be carefully inspected before surgery for degree of swelling, palpation of the muscle compartments, presence of open wounds or abrasions , neurovascular status, In the operating room, surgical instruments should be checked before the patient enters the operating theater. The surgical site on the patient’s limb should be marked, The entire surgical team should be oriented to the nature of the procedure to be performed and the steps involved.[(TannerJ,2006,AltpeterT,2007)]

Positioning:

After induction of anesthesia, the patient should be positioned on the operating table such that at least 110 degrees of knee flexion can be obtained **Fig.(3).** Many surgeons use a flannel blanket placed under the ipsilateral buttock. This serves to place the trans condylar axis of the distal femur parallel to the floor and assist with rotational alignment during IM nailing of multi fragmentary tibial fractures. External rotation of the limb is also prevented by using such a roll. Triangles, bumps made from sterile gowns, dropping the end of the table, and placing the leg over the side of the table may facilitate this degree of knee flexion.

The use of a padded kidney rest at the lateral aspect of the proximal thigh, often at the level of the tourniquet can be used to maintain knee flexion and prevent external rotation of the hip in deep knee flexion **Fig.(4).** Care must be taken not to place any pressure on the neurovascular bundle in the popliteal fossa.[(RobertJ,2009)]

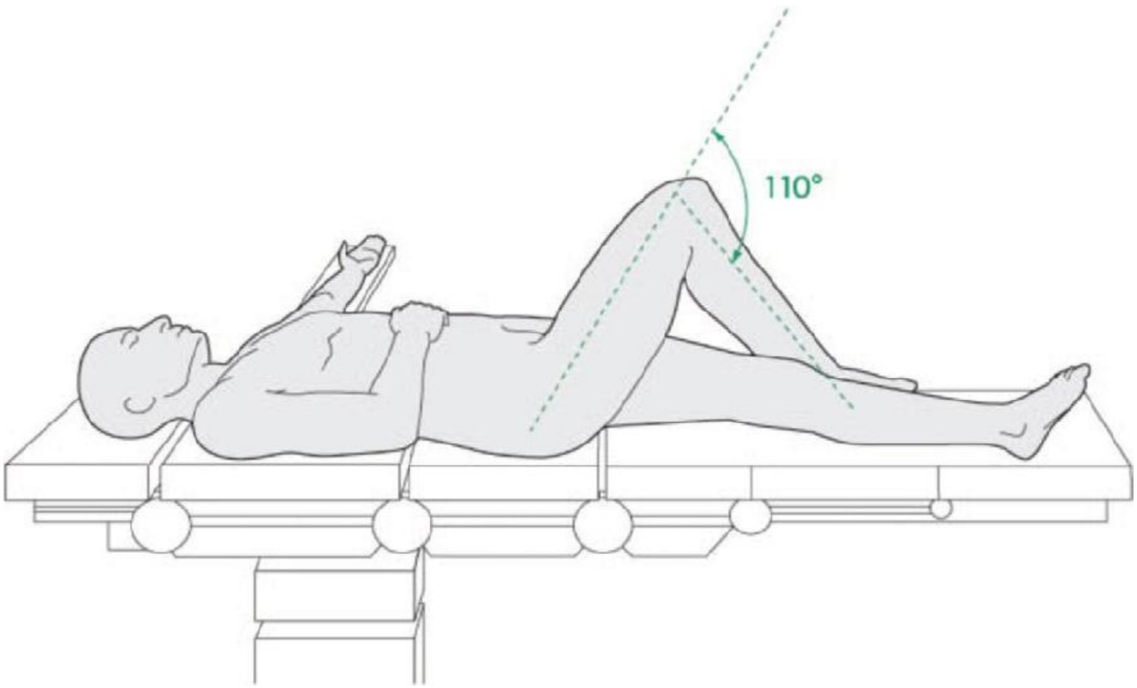

Figure : (3) patient positioning (RobertJ,2009)

Figure :(4) padded kidney .(RobertJ,2009)

Closed Reduction:

The reduction technique varies based on the level of the fracture, Proximal fractures may be reduced by using the Figure 4 position with emphasis placed on flexing the proximal fragment to 110 degrees. Flexing the proximal fragment in relation to the knee allows the tibial entry point to be placed in its appropriate position. When using cannulated tibial nailing systems and image intensification, a "cheat lateral" x-ray of the distal tibial can be obtained efficiently without swinging the C-arm into a full lateral position. The "cheat lateral" simply requires the C-arm to be rotated 20 to 30 degrees away from the surgeon and fractured tibia. The operating table is rotated toward the surgeon 10 to 15 degrees, the leg is externally rotated 20 to 30degrees and a few degrees of gentle external rotation at the fracture site allow the centering of the guide wire to be visualized on the lateral ankle view **Fig. (5).** This maneuver avoids possible contamination of the set-up as the C-arm swings to a lateral position**.** (RobertJ,2009)

Figure :(5)"Cheat" lateral x-ray. When using an image intensifier, positioning of the guide wire for a cannulated intramedullary nail system is noted in the distal tibia by gentle external rotation of the leg and rotation of the OR table toward the surgeon. (RobertJ,2009)

Open Reduction for Closed Fractures:

If closed reduction is not possible after a short time, a small incision for open reduction can be made. This is made just over the fracture site on the anterolateral side. Aperiosteal elevator can align the bone canals. It requires concentration and careful planning for the surgeon to use a small, appropriately placed open reduction incision. Palpate the fracture site and determine whether there is any overlapping of the fragments. In this situation, palpate the distal end of the proximal fragment, place the incision at this site and use a periosteal elevator to bluntly reflect muscle fibers laterally and dissect down to the fracture site. Most trauma surgeons recommend an anterior incision placed 1 to 2 cm lateral to the crest of the tibia and pulling the anterior compartment muscles laterally to expose the fracture site. Use of cutting electrocautery(RobertJ,2009) or a knife to cut through muscle is not recommended. After the end of one of the fracture fragments has been identified. Find the other bony fragment and do likewise. Once these fragments have been freed enough to allow correction of the telescoping, the fracture may be reduced. Sometimes a periosteal elevator must be placed between these fragments to stretch the tissues for the last 1 cm of length. One possible obstruction can be the eager assistant who attempts to apply traction without flexing at the fracture site. Proximal tibial fractures require care with respect to appropriate reduction and prevention of valgus and procurvatum deformity. An open reduction may be required for a fresh proximal tibial fracture if there is a tendency for the fracture to fall into either or both of these positions. Nork recommends using unicortical screw fixation and small fragment plates during limited open reduction of the fracture. Once the fracture is anatomically aligned, the IM nailing can then proceed in a more controlled manner.(NorkSE,2006)

Incision and Proximal Tibial Entry Point:

The patella tendon is palpated with the knee in flexion. A central longitudinal incision through the tendon allows a predictable and accurate placement of the bone entrance when an image intensifier is not used . The fat pad should never be entered.(WeningerP,2009,Weinstein,2005) The bony entrance is anterior to the articular surface . A curved awl is used and is directed anteriorly, especially in a proximal tibia fracture . Usually several times of passing the awl to provide a good pathway for the reamers.(WeningerP,2009)

Reaming:

After reduction, reaming is accomplished by starting with the 7 mm reamer and progressively increasing the diameter until chatter is felt for at least a 4 cm distance along the canal. The resistance to progression of the reamer is also an indicator. One should feel the reamer in its full 180 degrees arc to know the reamer is in the canal. If there is a question about whether the reamer is in the canal, push on it and see whether there is a stop. If not, the reamer is not in the canal. The length of the nail is measured by pushing the blunt reamer until it abuts the subchondral bone of the ankle joint. The advantage of hand reaming is that the surgeon can feel when the reamer is in the bone, measure the length and diameter of the nail from the reamers and use the bone from the flutes of the reamers for a bone graft. The nail is then attached to the target arm, and the target arm is adjusted.

The target arm is then removed and the locking bolt and L-handle are used to introduce the nail . Reduction must be maintained during this process. The nail is placed either by direct pressure from the surgeon or by light taps using the mallet.(ShearerD,2009)

Distal Interlocking:

The target arm is reattached and the alignment pin used to dimple the skin. Interlocking screws are placed through the medial side of the tibia. If 2 screws are used, dimple the skin by passing the alignment pin through both apertures and connect the dots. Avoid injury to the saphenous vein and nerve . Distal interlock should be done before proximal interlock to allow the nail to be rotated to adjust orientation of the slot for screw insertion.(ShearerD,2009)

Insert Cannula:

Use the alignment pin to mark the location of the skin incision. Dissect the bone with a periosteal elevator to remove all soft tissues. Place the cannula through the incision down to the bone using a clamp to spread and remove the soft tissues from under the cannula. Tight bands of tissue must not displace the cannula.(ShearerD,2009)

Drilling the Near Cortex:

Insert the small drill guide into the cannula. Drill a hole in the near cortex using the small drill bit. If the bone is hard, do not maintain persistent pressure on the drill. Pulsing the drill involves drilling for 10 seconds followed by withdrawal of the drill to allow it to cool. The drill bits become dull when heated. Change the small drill guide to the large drill guide and use the step drill to enlarge this hole. The large drill bit may also be used when the bone is too hard for the step drill. Stop immediately when the step drill engages the slot in the nail. The hole can now accommodate the slot finders and the threaded head of the screws.(ShearerD,2009)

Insert Solid Slot Finder:

The solid slot finder is used to find the slot in the nail . Insert the solid slot finder into the cannula. The solid slot finder is stronger and has a narrower tip than the cannulated slot finder. The solid slot finder is aligned using the flat portion of the handle with the plane of the nail. It is then pushed into the slot in the nail.(ShearerD,2009)

Measure for Screw Length and Insert Screw:

The depth gauge is placed through the cannulated slot finder and left in place as the slot finder and drill guide are removed . The depth gauge is calibrated to be read off in the side of the cannula. We add 2 or 3 mm so the proximal end of the screw can be left slightly prominent in case removal is required at a late date.(ShearerD,2009)

Compression of the Fracture:

Once the distal interlocking screw or screws have been placed, the fracture may be compressed, if necessary. This is accomplished by attaching the extractor-compressor rod containing the weight and backslapping the fracture .(ShearerD,2009)

Aim of the Study

The aim of this study was to compare the clinical and radiological outcomes of closed reduction versus open reduction in treatment of closed diaphyseal tibial fractures with locked intramedullary nail fixation and to evaluate the effect of open reduction through a limited incision and respectful handling of the soft tissue envelope in increasing the risk of complications.

Patients and Methods

A prospective ,case series study carried out at the orthopedic Surgical Unit, Department of Surgery at the Al-Jumhoori Teaching Hospital, Mosul, Iraq. The Study last 18 months, started from January 2013, to July 2014. Total of 40 patients with closed diaphyseal tibial fractures were included in the study. All the surgeries of interlocking nailing were done within two weeks of injury. Adult patients irrespective of sex, with closed OTA type 42 tibia fractures occurring in patients 18 years or older due to various causes, treatable by interlocking intramedullary nail were included in the study. Patients with open fractures, pathological fractures ,active infection ,multiple fractures, earlier fractures of the tibial shaft on the same side, proximal intra-articular or distal intra-articular fractures of the tibia, and temporary treatment with an external fixator were excluded from the study. Well formed consent taken from all patients after complete explanation of the procedure. All patients were admitted through accident and emergency department. Thorough history with general physical and systemic examination of each patient was recorded in patient's record file. Fractures were coded according to the AO/Orthopedic Trauma Association (OTA) fracture classification system

.Initial immobilization of affected limb with long leg plaster of Paris as posterior splint was done. X-ray of the affected leg, anteroposterior and lateral view including knee and ankle joint were done. The closed reduction failed in twenty patients who treated by open reduction and locked intramedullary nailing technique, the other remaining treated with closed reduction and locked intramedullary nailng technique. At the time of anesthesia induction a single dose of third generation cephalosporin was given to each patient.

For open technique , after general anesthesia patient was operated in supine position , a pneumatic tourniquet was applied above the knee. A small incision for open reduction of fracture was made. Then longitudinal incision was made over the patellar ligament at the level of the joint, about 5-6 cm long splitting the tendon longitudinally for entry portal. **Fig.(6)** The proximal and distal medullary canal was reamed with hand reamer with increments of 1 mm. The nail length was measured by hand reamer and the fracture was reduced for insertion of the nail. Already measured nail was inserted and locked both distally and proximally with the help of external jig. then wounds were closed.

Figure(6).Open reduction in tibial nailing technique.

For closed technique the patients were placed supine on a normal table. The tibia was approached with the midline patellar incision which extends from the lower pole of patella to just 1 cm distal to the tibial tuberosity. The entry point was made after retracting the patellar tendon in line with medial half of tibial tuberosity about 1.5 to 2 cm distal to joint line. Care was taken to flex the knee joint while making the entry point. After the entry point was connected to the medullary canal an olive tipped guide wire was passed **Fig.(7).** The fracture was reduced by longitudinal traction and manipulation. After reduction, the guide wire was passed in the distal fragment and centered in antero-posterior and lateral projections. After sequentially incremental reaming, the guide wire was exchanged and appropriately sized nail inserted. Proximal locking was done by means of the jig, the fracture was impacted and distal locking done by freehand technique.

Figure(7) closed reduction in tibial nailing technique.

In all the patients, intravenous antibiotics was given up to the third post-operative day. Postoperative X-ray films were taken on first postoperative day. No splint or cast was applied after surgery and the patients were advised to start isometric quadriceps exercises and knee and ankle joints movements on the second day after surgery. All the forty patients were followed after discharge from hospital at set intervals of 3 weeks, 6 weeks and 12 weeks in post-operative period for at least three months, then monthly follow up till 12 months. Radiographs were used to determine the time to union of the fractures. Radiographic union was defined as the presence of bridging callus in 3 of the 4 cortices as seen on anteroposterior and lateral radiographs. There was no standardization of the radiographs. Delayed union was defined as radiographic union after >24 weeks. Statistical analyses were performed to compare differences between the two groups with regard to the time to union, time to weight-bearing, the Knee Society Rating score and squatting (to assess anterior knee pain), early or late postoperative complications(inform of infection, compartment syndrome and implant failure), the time patients were unable to work, the hospital stay, and the operating time.

Data Collection Procedures:

The results of evaluation of stable fixation of closed diaphyseal fractures of tibia fixed with interlocking intramedullary nail were composed according to the data analysis during study. Data was collected on individual proforma for each patient including patient age, sex and smoking history. Nonunion and infection rates were also recorded. Nonunion was defined by the need for an additional procedure to promote bony healing. Infection was defined as a requirement for antibiotic treatment or the need for irrigation debridement.

Results

Forty closed tibia fractures in 40 patients were studied. There were 08 females and 32 males giving a ratio of (F:M)1:4 **fig.(8).**

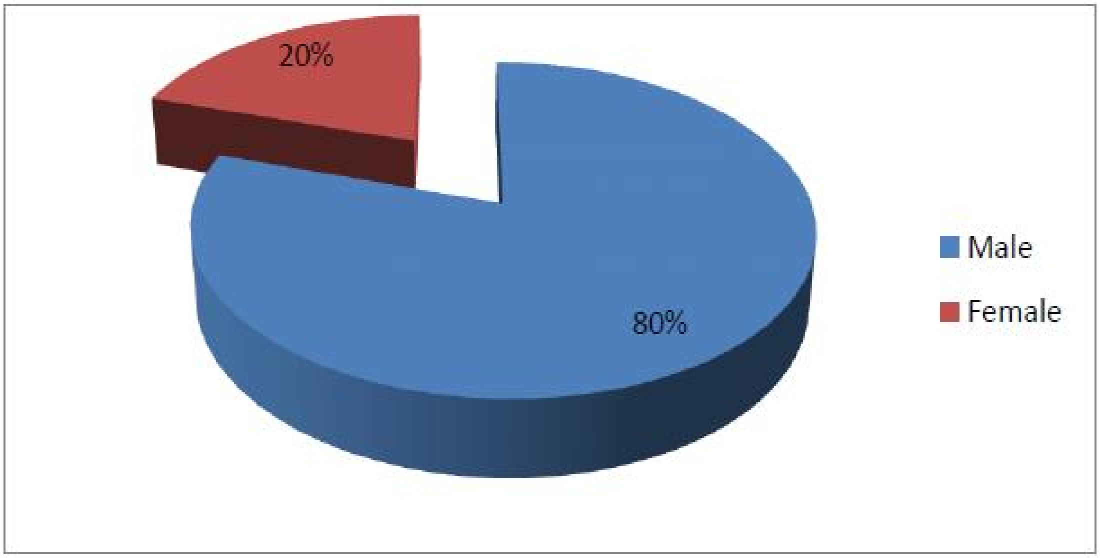

Figure (8) Male to female ratio.

The patients age ranged from 18-60 years. Predominantly, right sided tibia was more injured as compared to left side (28 versus 12). Most common mechanism of injury was road traffic accident (n=26; 65%), followed by fall (n=9; 22.5%) and assault or violence (n=5; 12.5%) **fig.(9).**

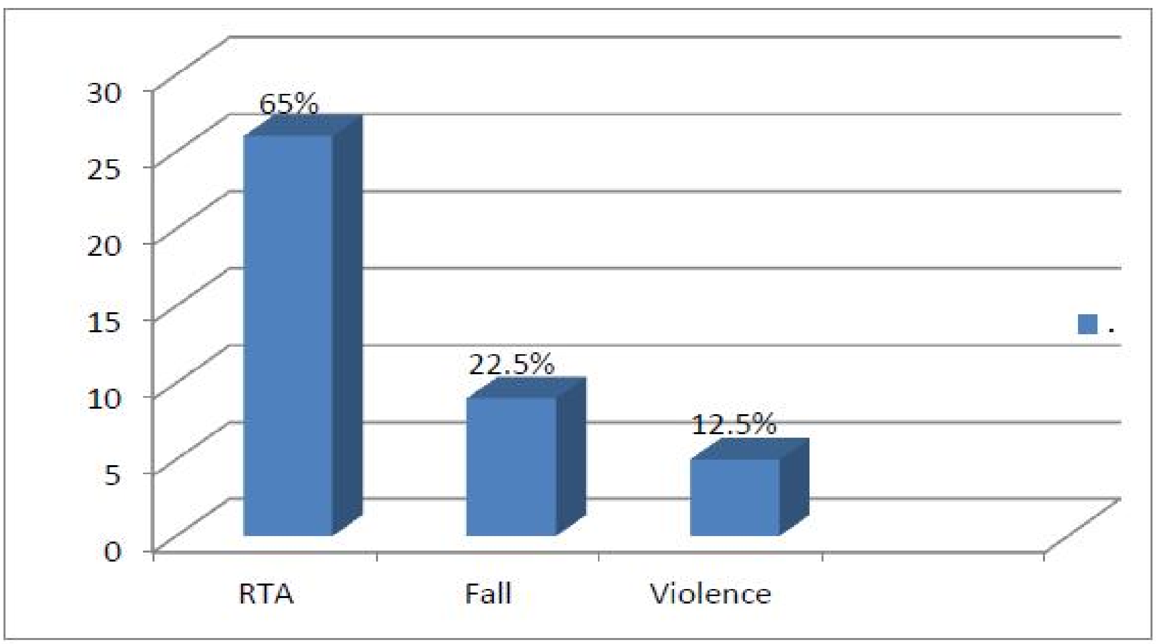

Figure (9) Mechanism of injury.

Fracture types according to geometry were transverse (n=17; 42.5%), oblique (n=07; 17.5%) and spiral (n=16; 40%) **Table(1).**

Table (1)Fracture Pattern

Fracture pattern	No. of patients (%)
Transverse	17(42.5%)
Oblique	7(17.5%)
Spiral	16(40%)
Total	40 (100%)

Majority of the fractures were at the junction of lower third and middle third (n=25; 62.5%); four (10%) were in the proximal third and rest (n=11 ;27.5%) were in the middle third **Table(2)**.

Table (2) Fracture site distribution

Fracture Site	No. of patients(%)
Junction of lower and middle third	25(62.5%)
Proximal third	4 (10%)
Middle third	11 (27.5%)
Total	40 (100%)

None of our patients in both groups developed acute or chronic compartment syndrome and no hematoma collection for open reduction group. Reflex sympathetic dystrophy was seen in one patient of closed reduction group.

One patient of open reduction group (5%) developed infection and no infection in patients of closed reduction group(0%). Fracture union was attained in 3- 5 months **fig.(10)** , with no difference in both groups. Three patients had delayed union in open reduction group, out of them, one was also infected and went into infected nonunion. For that patient we had to remove the nail and apply external fixator. Two of closed reduction group had delayed union. Locking screws were removed (dynamization) in all patients with delayed union to reach union.

At time of injury **Two days after surgery** **Four months later**

Figure(10) Closed tibial fracture treated by open reduction and interlocking nail.

No malunion occurred in both groups. None of our patients had implant failure. Also no nail was removed till one year of follow up except the one who got infected non-union who needed repeated surgery. Eight patients had pain at 6 weeks post-op. it persisted till three months in only three patients including only those with non-union or delayed union. Persistent pain at fracture site was noted in only one patient of open reduction group at the last follow up of one year .Two patients of open reduction group (10%) and three patients of closed reduction group(15%) had anterior knee pain . five patients (25%) in open reduction group and four patients (20%) in closed reduction group had transient restricted Post-operative range of movements at ankle and knee joint till 12 weeks follow up.

Partial and painless full weight bearing and squatting achieved in the follow up of both groups in one and three months respectively **fig.(11).**

Painless full wt. bearing **squatting** **Incisions sites**

Figure (11) Full weight bearing in patient treated by open reduction in tibial nailing.

The final functional outcome of both groups measured by Johner and Wruhs' criteria with modification was based upon Nonunion, infection, neurovascular injury, deformity and mobility which are depicted in **fig.(12).**

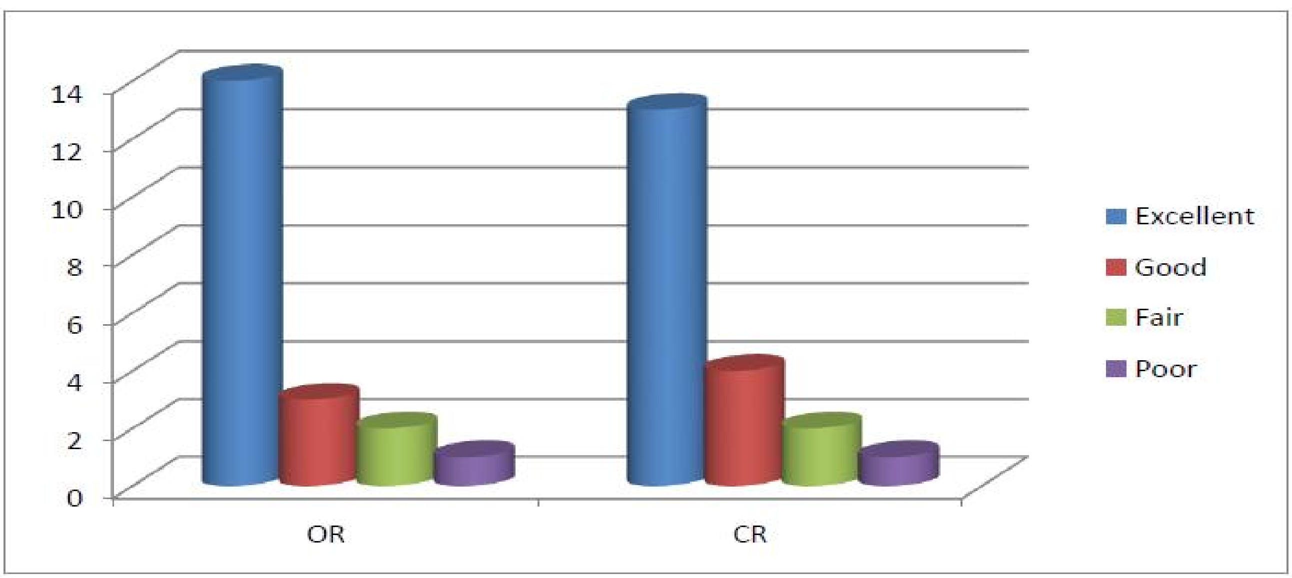

Figure (12) Functional results of both group patients at last follow up of one year.

Table**(3)** demonstrate that there is no difference between the open and the closed method of reduction with P value of 0.736, o.677, 1.000, 1.000 for excellent, good, fair, and poor results respectively**.**

Table (3) Final functional outcome in surgical treatment of diaphyseal tibial fracture by johner and wruh's criteria.

Results	Method of treatment				P-value*
	Open reduction and locked intramedullary nail fixation(n=20)		Closed reduction and locked intramedullary nail fixation(n=20)		
	No.	%	No.	%	
Excellent	14	70	13	65	o.736
Good	3	15	4	20	0.677
Fair	2	10	2	10	1.000
Poor	1	5	1	5	1.000

***chi square test was used**.

During the course of each follow up visit, every patient was assessed for the functional and radiological outcome based upon Johner and Wruh's Criteria with modification **Table(4).**

Although duration of surgery varied in different patients according to the configuration of fractures but the average time required for one procedure of interlocking intramedullary nailing ranging from 50 to 80 minutes. As all the procedures were carried out after the application of tourniquet so there was no significant amount of blood loss during the surgery.

Table(4). Johner and Wruh's Criteria with Modification

Criteria	Excellent	Good	Fair	Poor
Nonunion/infection	None	None	None	Yes
Neurovascular injury	None	Minimum	Moderate	Severe
Deformity				
Varus/valgus	None	2-5	6-10	>10
Anterior/Posterior	0-5	6-10	11-20	>20
Shortening	0-5 mm	6-10 mm	11-20 mm	>20 mm
Mobility				
Knee	Full	>90 %	90 - 75 %	<75 %
Ankle	Full	>75 %	75-50 %	<50 %
Pain	None	Occasional	Moderate	Severe
Gait	Normal	Normal	Mild limp	Significant limp

In our forty surgeries, there was no need for blood transfusion during the operation. In patients with no complications, the hospital stay was one day . Long stay was due to wound infection.

Discussion

Fractures involving the shaft of long bones are common worldwide and tibial fractures are among the most common lower limb injuries to be treated by anorthopedic surgeon.[(CourtBroun,1998)]

The common site of tibial fractures in our study was tibial diaphysis in a rate of (62.5%) and the right tibia is the common(70%) which is comparable with a study of Howard M. [(HowardM,1997)]Intramedullary nailing can be considered the "gold standard" for the treatment of tibial mid shaft fractures, but there are concerns about their use in distal tibia fractures because of some technical difficulties. [(ZellaBA,2006)]

The common cause of fracture tibia in our study found to be road traffic accident (65%), which is comparable with a study done by Greitbauer M. et al [(GreitbauerM,1998)] and thought to be related to crowded streets and loss of respect to traffic rules.

In the current study , we found that the age group of patients ranged from 18 – 60 years , which is similar to results in a study of Vallier HA et al [(VallierHA,2012)] and Wu HT et al [(WuHT,2008)]. Male to female ratio 4:1. (fig. , this is similar to the study of Ali Akhtar et al [(AliAkhtar,2013)] and SKGiri et al.**(SKGiri,2008)**.

In our study the cause of doing open reduction prior to locked intramedullary was the difficulty in passing the reamers and nails due to the presence of intramedullary cortical fragments from the fracture site which is the same cause in a recent study done by Bishop JA. et al.**(BishopJA,2012)**

In his study Bishop JA concluded that open reduction is a safe technique and that the failure to judiciously use such techniques can result in prolonged surgery, increased radiation exposure, further soft tissue injury from multiple reduction attempts, and acceptance of suboptimal osseous alignment.**(BishopJA,2012)**.

Closed interlocking nailing using image intensifier for fixing these fractures is a standard practice around the word now.[(BrumbackRJ,1996)] But other factors likes less surgical expertise, non-availability of image intensifier for closed locked intramedullary nailing were also the reasons for open locked intra-medullary nailing for treatment of our patient's fractures which is similar to that of Ikem IC. et al [(IkemIC,2007)], and we add mass injuries as what is going in our country.

In our study results we found important point of ability to avoid the danger of radiation to medical teams and patients as it conducted by a study done by Tsalafoutas et al, which is a mathematical method used to estimate the entrance surface dose (ESD) to the patient and the scattered dose (Ds) to the operating surgeon during various fluoroscopically guided surgical orthopaedic procedures. The estimated Ds rates for the hands, chest, thyroid, eyes, gonads and legs of the operating surgeon were on average to 0.103, 0.023, 0.013, 0.012, 0.066 and 0.045 mSV/ min,respectively. **(TsalafoutasIA,20088)**

Fluoroscopy used in an operating theatre environment could lead to a radiation exposure equivalent to between 250 and 3500 chest radiographs. [(MettlerFA,2008)] Several techniques have been described for locking distal screws, which fall into five categories: computer assisted, nail-mounted guides, image-intensifier mounted techniques, hand-held guides and free-hand techniques.[(WhatlingGM,2006)] In routine practice, it appears that a freehand technique is the most commonly used. This relies on using an image intensifier to obtain perfect circles for distal screws.[(MoorBK,2012)] In our study we encountered infection in one patient of open reduction group giving a rate of (5%), who went into infected nonunion and no statistically significant differences existed between the two groups in terms of infection or fracture healing which is comparable with the results of Bishop JA.[(BishopJA,2012)], Ali Akhtar et al[(AliAkhtar,2013)] and Tang P.**(TangP,2006)**

By the using of johner and wruh's criteria for measurement of the final functional outcomes of both groups we achieved excellent results in 70% in open reduction and 65% in closed reduction which is less than 76.6 % patients achieved by Ali Akhtar et al [(AliAkhtar,2013)] and comparable with 70.6 % achieved by a recent Indian study in which author used the same Johner and Wruhs' criteria in patients treated with tibial IL nail.[(BattaV,2012)] Oswaldo et al reported results almost similar to present study.[(NascimentoOR,2009)] But a Chinese study using same criteria obtained almost 51 % combined excellent and good results.[(XiaoM,2011)] However, the exclusion of an image intensifier automatically eliminates the harmful effect of an increased dose of radiation to both the Orthopedic surgeon and the patient.(TaanaDD,1994)

Conclusion

Closed or percutaneous techniques are not effective in some cases as the presence of obstructive intramedullary cortical fragments and suboptimal osseous alignment , and appropriate reduction is only attainable through formal open techniques. When limited open reduction is performed though a well-placed incision with respectful soft tissue handling, it is a safe and effective technique and can greatly facilitate the reduction of closed tibial shaft fractures , prevent radiation exposure of the medical staff and the patient and reduce operation time ,but raise concern for infection through exposure of the fracture site and union rates. Judicious use of open reduction techniques during intramedullary nailing of closed tibia fractures seems to have a minimal risk of infection.

Recommendations

open reduction though a well-placed incision with respectful soft tissue handling prior to locked intramedullary nail is a safe technique and can be used in treatment of acute tibial diaphyseal fractures in adults when the closed reduction becomes difficult , because open reduction technique carry no significant difference in infection rate and bone healing and union rate, prevent the danger of radiation exposure to both medical team and patients, and decrease operation time which benefit in our country today due to mass injuries and shortage of facilities .

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Thanks to all those patients who have ever suffered the burdens of the procedures, required examination and follow up.

Annex -1

Al –Jumhoori Teaching Hospital orthopedics ward

Mini-Open versus Closed Reduction in Treatment of The Closed Tibial Diaphyseal Fractures by Locked Intramedullary Nail in Adults

Name: 9	File No.9		Ward 9
Sex F ☐ M ☐	Age:	Weight:	Mobile no.:
Stay in hosp.:	Address9		
Surgeon:	ةربخلاةٌحارجلا9 ☐ رثكأ نم 01 تاونس ☐ لقأ نم 01 تاونس		Resident 9

Injury:

Date of injury:	Associated injury:	level of fracture: site(limb):
Cause of injury:	Shape of fracture:	Open VS. closed:

Surgery:

Date of surgery:	Time between injury & nail surgery:	Reaming: Non ☐ Hand ☐ Powered ☐
Previous intervention: pop ☐ plat ☐ external fixation ☐ nail ☐	No. of Screws: proximal ☐ distal ☐	Size of nail: length ☐ Diameter ☐
	Type of reduction:	Screen used:
Compression applied:	Blood loss: Reaming product:	Incision length:
Type of anesthesia:	Patient position:	Post-operative complications:

Follow up : date of follow up: compartment syndrome: hematoma formation:

Partial weight bearing:	Screw breakage:	Infection:	
Painless full weight bearing:	Screw loosening:	Wound breakdown:	
Squat & Smile:	Nail breakage:	Patient satisfaction:	
Healing by X-ray:	Nail loosening:	Deformity:	Angulation >30
			Rotation>10
Anterior knee pain: Stiff knee:	Repeated surgery:	Shortening:	

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البحث خالصة

:االهداف

هنالك كانت اذا فٌما معرفة و العظم نخاع داخل المقفل الصٌخ طرٌقة القصبة عظم نصل كسر عالج فً المفتوح الكسر ردطرٌقة وفعالٌة جدوى لدراسة النخاعً بالصٌخ الكسر تثبٌت عملٌة خالل المفتوحة بالطرٌقة البالغٌن عند المغلق القصبة عظم نصل كسر ارجاعطرٌقة لستخدام نتٌجة ومضاعفات مشاكل العملٌة وقت وقصر لإلشعاع التعرض تقلٌل فً فائدة من الطرٌقة لهذه مما ، والشعاعٌة السرٌرٌة بالنتائج مقارنة اجراء خالل من وذلك المقفل، الداخلً المفتوحة الطرٌقة لستخدام عند الجراحٌة .

.مستقبلٌة حاالت تجمٌع دراسة 9 **البحث تصميم**

.التعلٌمً الجمهوري المستشفى ، العظمٌة الجراحة وحدة 9 **المكان**

1024(تموز 1023- الثانً كانون(شهرا عشر ثمانً 9 **المدة**

309 **العيّنة حجم**

: االدخال معايير

المغلق بالصٌخ عالجها والممكن متعددة لسباب نتٌجة المغلق القصبة عظم نصل بكسر المصابٌن الجنسٌن كل من عشر الثامن سن فوق البالغٌن المرضى العظم نخاع داخل.

: االستثناء معايير

المصابٌن المرضى ، متعددة بكسور المصابٌن ،المرضى النشطة باالتهابات المصحوبة ،الكسور المرضٌة الكسور ، المفتوحة بالكسور المصابٌن المرضى الخارجً بالتثبٌت مؤقتا عولجت التً ،الكسور المتفصلٌة السطوح من القرٌبة الكسور العظم، نفس فًسابقة بكسور .

: التداخل

تنجح لم منهم مرٌض عشرٌن فً ، العظم نخاع داخل المغلق بالصٌخ للعالج دراستنا فً ادخلوا المغلق الحاد القصبة عظم بكسر مصابون مرٌضا أربعون خالل من المجموعتٌن ومقارنة متابعة تمت ثم العظم نخاع داخل المقفل الصٌخ ووضع الجراحً المفتوح الكسر رد طرٌقةفعولجوا المغلق الكسر ردطرٌقة والشعاعٌة السرٌرٌة النتائج .

9 Chi square test at 95% confidence interval **االحصائي** التحليل

:الطرق

الدراسة وشملت 1023 حزٌران من والثالثٌن الحادي الى 1022 الثانً كانون من للفترة الموصل فً التعلٌمً الجمهوري مستشفى فً اجرٌت مستقبلٌة دراسة 30 مرٌض من 30 كانون ٌعانون كسر نصل عظم القصبة ،تم تقسٌم الحاالت الى مجموعتٌن ، المجموعة االولى تتألف من عشرٌن حالة كسر نصل عظم القصبة تم عالجها بواسطة رد الكسر المغلق ووضع الصٌخ المقفل داخل نخاع العظم والمجموعة الثانٌة تتألف من عشرٌن حالة كسر نصل عظم القصبة تم عالجها بواسطة رد الكسر المفتوح الجراحً ووضع الصٌخ المقفل داخل نخاع العظم .

:النتائج

أظهرت النتائج ان كسر نصل عظم القصبة عند البالغٌن اكثر شٌوعا فً المرضى الذكور).% 70(كما اظهرت النتائج ان)%60(من الحاالت كانوا فً حوادث هو للكسر االسباب اكثر وكان)%60(سنة والستٌن عشر الثامنة ٌن ما عمرف كانوا 61 %( )المصابٌن المرضى اغلب وان االٌمن القصبة عظم عظم لكسر تعرضا االكثر المكان هو البعٌد الثلث مع االوسط الثلث التقاء ومكان 26%((المستعرض الكسر لشكل ً االكبر النسبة وكانت 54%((المرور)54%(مقابل ممتاز الى جٌدشفاءسجلوا العظم نخاع داخل المقفل الصٌخ ووضع المفتوح الكسر رد بواسطة عولجت التً الحاالت من 51%.(القصبة رد مع حدثت التً االلتهابات نسبة .ممتاز الى جٌدشفاءسجلوا العظم نخاع داخل المقفل الصٌخ ووضع المغلق الكسر رد بواسطة عولجت التً الحاالت من ووضع المغلق الكسر رد بواسطة عالجهم تم مع المضاعفات نسبة بٌنما)4%(كانت العظم نخاع داخل المقفل الصٌخ ووضع الجراحً المفتوح الكسر الصٌخ المقفل داخل نخاع العظم كانت .)8%(

االستنتاجات:

- من قطع وجود مثل الحاالت بعض فً فعالة غٌر لكنها المفضلة الطرٌقة ًه المغلقة بالطرٌقة القصبة عظم نصل كسر رد ان من الرغم على المفتوحة بالطرٌقة الكسر لرد ضرورة ٌجعل مما الكسرطرفً ٌن جٌد واتصل لستقامة احراز وعدم النخاع داخل العظم.

- فإنها الرخوة االنسجة مع باحترام التعامل مع الكسر مكان على صغٌرة جراحٌه فتحة خالل من المفتوح الكسر ردطرٌقة تستخدم عندما بشكل وتسهل وفعالة امنةطرٌقة

اهتمام تتطلب ولكنها الجراحٌة العملٌات وقت وتقصر االشعاع لخطر والمرضى الطبً الكادر تعرض وتمنع القصبة عظم لنصل المغلقة الكسور رد كٌبٌر الكسر التئام نسبة فً وتأخٌر جراحٌا الكسر مكان فتح نٌتجة التهابات من تحصل قد التً المضاعفات لتالفً .

- ٌوجد ال انه كما قٌلٌا فارقا تشكل ول المفتوح الكسر ردطرٌقة باستخدام جدا قٌلٌة بنسبة اعلى ًه االلتهابات نسبة ان وجدت الدراسة هذه القصبة عظم نصل كسور ردفً الطرٌقتٌن باستخدام الكسور التئام بنسب ملحوظ فارق.

- التهاب خطر تقٌل الى ٌؤدي القصبة عظم لنصل المفتوح كسر رد لطرٌقة المتعقل االستخدام .

كلمات مفتاحية : رد ، الصدمة ، تثٌبت ، المقفل الصٌخ ، ،نصل القصبة عظم كسر، الكسر .

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