REAMED TIBIAL INTERLOCK NAILING; PREOPERATIVE AND POSTOPERATIVE COMPARTMENT PRESSURE MEASUREMENT

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ABSTRACT... Objective: The objective is to measure preoperative and postoperative compartment pressure in reamed tibial interlock nailing using Whitesides infusion technique. **Duration:** This study is carried out from September 2007 to August 2008 **Setting:** Department of Orthopedic and Spine Surgery of Hayatabad Medical Complex Peshawar **Material and Methods:** Thirty consecutive patients that were candidates for closed reamed interlock nailing of the tibia and there compartment pressure were measured preoperatively and postoperatively by Whiteside infusion technique. **Results:** Average age of patient was 35 years. Male were 26(86.66%) and female were 4(13.34%). There were 12(40%) type A and 18(60%) type B fractures according to Orthopedic Trauma Association (OTA) AO classification. Twenty seven (90%) factures were due to motor vehicle accident and 3(10%) were due to fall. The minimum preoperative pressure in superficial posterior compartment was 7 millimeter of mercury (mm Hg), deep posterior compartment was 10 mm Hg, anterior compartment was 10 mm Hg, lateral compartment was 10 mm Hg while maximum pressure in was 25, 25, 25 and 25 mm Hg respectively. The maximum post operative pressure in superficial posterior compartment was 10 mm Hg minimum and 25 mm Hg maximum, deep posterior compartment was 15 and 28 , anterior compartment was 15 and 30 and in lateral compartment was 10 mm Hg minimum and 30 mm Hg maximum. The minimum diastolic blood pressure was 65 and maximum was 90 mm Hg. **Conclusions:** Compartment pressure measurement by Whitesides' infusion technique is a simple and effective method for monitoring the intracompartmental pressure. It avoids unnecessary fasciotomy that has an extra morbidity in terms of infection and skin coverage.

Key words: Tibia, Interlock nailing, Intracompartmental pressure, Compartment syndrome.

INTRODUCTION

Compartment Syndrome is elevation of the interstitial fluid pressure in a closed osseofascial compartment that results in microvascular compromise[1]. The Compartment syndrome has been documented in 1881 by Richard Volkmann[2] and in 1906 the name - Volkmann's Ischemic Contracture- has been given to the after effects of Compartment Syndrome[3]. Compartment Syndrome may result from fractures, soft tissue injuries, limb compression, burns, post ischemic swelling, constrictive dressing and tight casts. Compartment Syndrome has also been reported in normal leg in patients put in hemilithotomy positions during surgical procedures for wide exposure[4]. It has been documented that the total ischemia of 8 hours' duration results in complete irreversible muscle changes and irreversible changes in nerves[5]. Most of morbidities develop when it is not treated with in first few hours[6].

The Compartment Syndrome may be diagnosed clinically by finding the five P's (pain, pulselessness, parasthesias, pallor, paralysis and sixth P is perishing cold)[7] but these signs and symptoms are present in full blown compartment syndrome in which fasciotomies usually do not save the limbs. Also in unconscious patients, the pain, parasthesias and paralysis can not be elicited and the clinical diagnosis of compartment syndrome may be missed[8]. In such circumstances the compartment pressure measurement is extremely important. So, early diagnosis of compartment syndrome can be possible by measuring the tissue pressure which can help in preventing the development of morbidities. Different devices are available to measure intra compartmental pressure like Whitesides infusion method, Slit catheter, Side porter needle, Wick catheter and Fiberoptic transducer[9]. Most of these devices are either expensive or not easily available. Wick and Slit catheter are dangerous because these are sometime left behind in the compartment[9]. Whitesides' apparatus is the device which is simple, effective and can easily be

construed with the materials available in any hospital ward. Moreover, it is inexpensive, safe, reproducible and most importantly ideal for use in any hospital[9].

In closed reamed tibial interlocking nail there is overspill of reamed material at fracture site to soft tissue after reaming of the medullary cavity which may increase the tissue pressure locally and compartment syndrome may develop[10]. The objective of this study is to measure preoperative and postoperative compartment pressure in reamed tibial interlock nailing using Whitesides infusion technique.

MATERIAL & METHODS

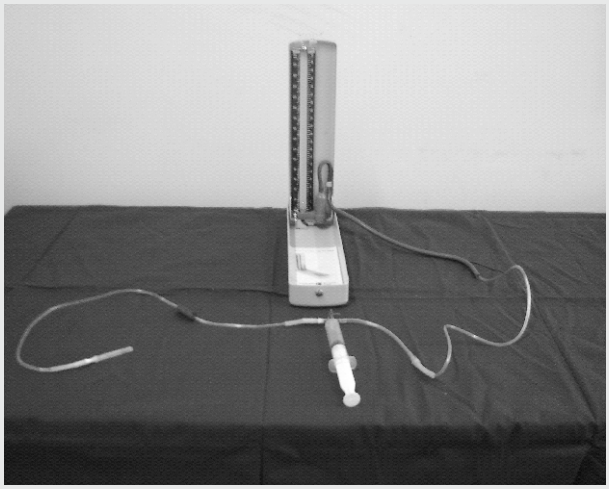
This quasi-experimental study was carried out in Department of Orthopedic and Spine Surgery of Postgraduate Medical Institute Hayatabad Medical Complex Peshawar on thirty consecutive patients that were candidates for closed reamed interlock nailing of the tibia and there compartment pressures were measured preoperatively and postoperatively by Whiteside infusion technique. All those patients were included in the study who were candidates for close reamed tibial interlock nailing. While open fractures in tibia, pathological fractures in tibia and open interlocking nailing were excluded.

After fitting in the inclusion criteria of the admitted patient, a thorough history were elucidated, complete physical examination performed and investigations carried out. All the patients were counseled about their conditions which necessitated an urgency of the procedure they had to undergo, the purpose of the study was explained to them, their cooperation sought, their reservations and concerns were addressed and informed written consent was taken.

The data was then collected with the help of a proforma which is constructed using different variables. The variables measured by Whitesides infusion technique are; preoperative pressure in superficial posterior, deep posterior, anterior and lateral compartments of leg and postoperative pressure in superficial posterior, deep posterior, anterior and lateral compartments of leg. The preoperative compartment pressure was measured by Whitesides apparatus when the patient was anesthetized before positioning for operation and postoperative compartment pressure was measured after six hour of operation. The blood pressure of the patient was also measured by mercury manometer.

The apparatus for pressure measurement in compartments was constructed from two drip sets, a blood pressure mercury manometer, a 20 cc syringe, a 20-gauge needle and a three way stopcock. One drip set is connected to the manometer. The other is connected to the 20-gauge needle and is half filled with saline. The plunger of the syringe is withdrawn to the l5 milliliter (ml) mark. The syringe and drip sets are then connected to the stopcock. After preparation of the leg, the needle is inserted into the muscle compartment. When the plunger on the syringe is depressed, the mercury column in manometer will begin to rise. When the saline starts to flow into the leg compartment, the manometer raises and measure the compartment pressure. (Figure No 1)

Fig-1. Photograph of whitesides' apparatus



In this study pressure more than 30 mmHg was counted as significant. If pressure is equal to thirty or less than that then no surgical intervention was done but the patient was kept under vigilant observation for any increase in pressure.

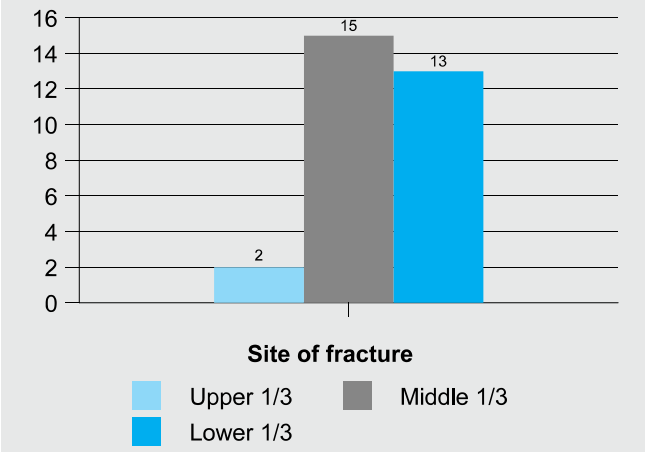
In this study we have also used the Whiteside' Theory which stated that the development of a compartment syndrome depends not only on intra-compartment

pressure but also depends on diastolic blood pressure: DBP – ICP=Delta P should be greater than 30 mmHg where the DBP is diastolic blood pressure, ICP is intracompartmental pressure and Delta P is differential pressure.

RESULTS

Total numbers of patients were 30. There were total eight readings of compartment pressure per patient; four readings of the compartment pressure preoperatively and four postoperative. The pressure was measured in superficial and deep posterior, anterior and lateral compartments preoperatively and postoperatively. Age range was between 20 and 62 years and average age was 35 years. Twenty six (86.66%) were male patients and 4(13.34%) female. In 22 (73.34%) patients there was right sided fracture and in 8 (26.66%) left sided fracture had been recorded. Two (6.66%) patients had fracture of upper third, 15 (50%) of middle third and 13 (43.33%) of the lower third of tibia (Figure No 2).

Fig-2. Mechanism of injury (n=30)



There were 12 (40%) type A and 18 (60%) type B fractures according to Orthopedic Trauma Association (OTA) AO classification (Figure No 3). Twenty seven (90%) factures were due to motor vehicle accident and 3(10%) were due to fall (Figure No 4). The statistics were shown in Table No I.

There was 7 mm Hg minimum and 25 mm Hg maximum pre operative pressure in superficial posterior compartment with 15 and 20 mm Hg were the most frequent, that were observed in 9 patients respectively. There was 10 mm Hg minimum and 25 mm Hg maximum post operative pressure in superficial posterior compartment with 20 mm Hg was the most frequent, which was observed in 14 patients.

Fig-3. Classification of fracture by orthopedic trauma association type A and B (n=30)

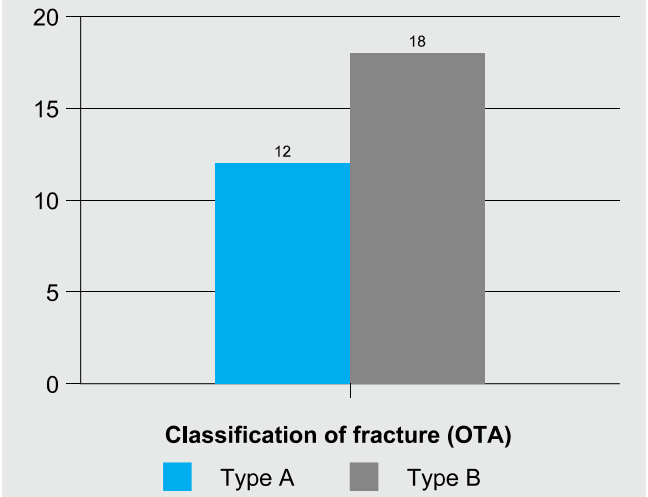
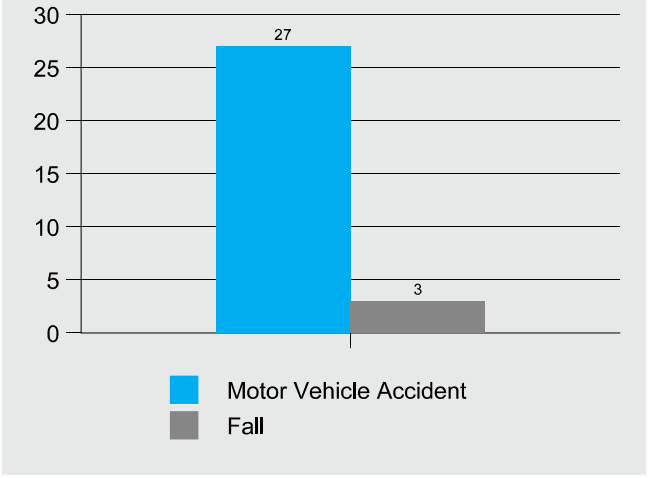


Fig-4. Mechanism of injury (n=30)



The pre operative pressure in deep posterior compartment was 10 mm Hg minimum and 25 mm Hg maximum. The post operative pressure in deep posterior compartment was 15 mm Hg minimum and 28 mm Hg maximum with 25 mm Hg was the most frequent.

Table-I. Preoperative and postoperative compartment pressure measurement Statistics (n=30)

		Preoperative				Post-operative				Diastolic
		Compartment				Compartment				
	Age	Superficial Posterior	Deep Posterior	Anterior	Lateral	Superficial Posterior	Deep Posterior	Anterior	Lateral	Blood Pressure (mmHg)
N	30	30	30	30	30	30	30	30	30	30
Mean	35.03	16.0333	17.3333	18.63	17.73	19.40	21.53	22.93	20.60	77.50
Median	30.00	15.00	17.50	20.00	17.50	20.00	22.50	24.00	20.00	80.00
Mode	25	15.00	15.00	20.00	15.00	20.00	25.00	25.00	25.00	70
Minimum	20	7.00	10.00	10.00	10.00	10.00	15.00	15.00	10.00	65
Maximum	62	25.00	25.00	25.00	25.00	25.00	28.00	30.00	30.00	90
Std. Deviation	12.26	4.4449	4.9989	4.6866	4.6158	4.4691	4.0406	4.1930	5.0895	7.04

The pre operative pressure in anterior compartment was 10 mm Hg minimum and 25 mm Hg maximum with 20 mm Hg was the most frequent. The post operative pressure anterior compartment was 15 mm Hg minimum and 30 mm Hg maximum with pressure of 25 mm Hg was the most frequently seen.

The pre operative pressure in lateral compartment was 10 mm Hg minimum and 25 mm Hg maximum with 15 and 20 mm Hg were the most frequent, that were observed in 9 patients respectively. The post operative pressure in lateral compartment was 10 mm Hg minimum and 30 mm Hg maximum with 25 mm Hg was the most frequent observed.

The diastolic blood pressure was noted of all the patients and the minimum diastolic blood pressure was 65 mm Hg and maximum was 90 mmHg. The diastolic blood pressure of one patient was 90 mm Hg and his post operative compartment pressure was 30 mm Hg, so the difference was 60 mm Hg and that was not an indication for fasciotomy. One other patient had diastolic blood pressure of 85 mm Hg and her post operative compartment pressure was 30 mm Hg, again the difference was 55 mm Hg which was not an indication for fasciotomy. These two patients were vigilantly kept under observation for compartment syndrome and were found to have no signs of the compartment syndrome. These two patients were also followed up for three months for late manifestation of compartment syndrome like ischemic contracture but were found normal and there were no signs/residual signs of the compartment syndrome.

DISCUSSION

Compartment syndrome can be a life or limb threatening emergency[11]. Early diagnosis is important for prevention of disability. Approximately 40% of the Compartment syndromes occur after fracture of shaft of tibia. The clinical features cannot always be relied upon for the diagnosis[11]. Compartment pressure measurement is the most reliable and objective method for early detection of the compartment syndrome.

A normal resting intramuscular pressure is 0-8mmHg. Pain and parasthesia occurs at 20-30 mmHg[10]. An intracompartmental pressure (ICP) of 30mmHg is often used as a basis for performing a fasciotomy. Whitesides et al[8] and later Court-Brown[6] however use a differential between diastolic pressure and ICP of 10-30mmHg as the threshold for doing so. This method severely reduces the number of patients that undergo fasciotomy without endangering those who do not[9]. Tiwari et al[11] suggest that fasciotomy should be performed when Delta P is ~ 30 mmHg. But the ideal pressure threshold for performing a fasciotomy remains unknown. If ICP exceeds 30mmHg

and observations are compatible with compartment syndrome, prompt therapies to decrease the pressure such as removal or opening of casts, skeletal fixation of unstable fractures, maximizing local arterial pressure, placing the limb at a level with the heart or in some instances anticoagulation to prevent complications are necessary. If ICP exceeds 40mmHg, emergency treatment is needed because blood flow through the capillaries and therefore oxygen delivery will cease[11].

The Whitesides infusion technique is used widely to assess the compartment syndrome. Ogunlusi et al[12] studied the normal range of compartmental pressure in Nigerians with this technique and showed that the anterior compartment pressures ranged from 3mmHg to 18mmHg with a mean 7.6 +/- 2.6 mmHg and the deep posterior compartment ranged from 3mmHg to 14mmHg with mean of 7.4 +/- 2.7mmHg. They concluded that these values are similar to those reported in the literature measured with other techniques[12].

The pressure in the anterior and lateral compartment was elevated more than other compartments in my study. Sheridan and Matsen[13] also reported that the anterior compartment was most commonly involved. Gershuni et al[14] found that 30 of 32 tibial fractures complicated by an acute compartment syndrome had anterior compartmental involvement, but they did not use pressure measurements in all compartments. The monitoring of all four compartments is cumbersome and it seems likely that the anterior compartment will be involved in an acute compartment syndrome[15]. The anterior compartment should be monitored routinely while other compartments need to be investigated only if there is clinical suspicion of involvement[15].

Kutty et al[8] study is comparable to our study as he studied 14 patients and observed that the mean postoperative measurements were higher in all four compartments after traction for intramedullary nailing but none of the pressures reached the critical level. Bonnaire et al[16] studied sixteen patients and observed the closed tibia nailing does not favor the development of a compartmental syndrome. Use of direct compartment measurements with existing thresholds and formulations to determine the diagnosis of compartment syndrome may not accurately reflect a true existence of the syndrome. A search for other quantitative measures like diastolic blood pressure may accurately reflect the presence of compartment syndrome[4]. The same was done in our study in which the diastolic pressure was measured in all cases. Only two cases had intracompartmental pressure of 30 mmHg but there Delta P was 55 and 60 mmHg and was shown to have no compartment syndrome. Ozkayin et al[17] studied 39 patients with high risk for the development of a compartment syndrome in tibial diaphyseal fracture. They measured the intracompartmental and the diastolic pressure of the patients[17].

Fasciotomy of the extremity was only indicated when the differential pressure (Delta P) was less than 30 mmHg for more than 30 minutes. They observed that none of the patients showed any sequelae of compartment syndrome[17]. Kowalski et al[18] carried out an investigation on 24 patients based on measuring the pressure in the deep posterior compartment during tibial intramedullary nailing with reaming. The mean increase of the pressure was 7% (+ 1.6 mmHg) but it did not cause any risk of compartment syndrome[18]. McQueen and his colleagues studied the intracompartmental pressures of 66 patients with 67 tibial fractures treated by intramedullary nailing[19]. In their study no patient had developed any sequelae of compartment syndrome, they concluded that intramedullary nailing does not increase the incidence of acute compartment syndrome in tibial fractures and it is only the delay in treatment of the fracture that does not reduce the risk of raised compartment pressures[19].

Tischenko et al[20] reported three patients that had compartment syndrome by measuring the ICP of the leg after tibial intramedullary nailing with reaming while in our study none of the patients had compartment syndrome.

Most of the studies in literature are consistent with our study which shows that tibial interlock nailing do not increase compartment pressure to the level to make the tissues vulnerable to compartment syndrome. It is only the delay in the treatment of fracture which may increase

intracompartmental pressure and develop compartment syndrome[19].

CONCLUSIONS

Whitesides' apparatus is a simple and effective apparatus that can easily be construed with the materials available in any hospital ward. Moreover, it is inexpensive, safe, reproducible and most importantly ideal for use in any hospital.

Compartment pressure measurement by Whitesides' apparatus is the mainstay of monitoring the intracompartmental pressure either after fracture or intramedullary nailing. It avoids unnecessary fasciotomy that has an extra morbidity in terms of infection and skin coverage.

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