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Intracompartmental pressure changes after anterolateral bridge plating of tibial fractures

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Objective: Compartment syndrome is one of the most devastating complications in orthopedics both for the patient and the treating physician. Among the many causes, trauma and its treatment are the most common reasons for compartment syndrome, which most frequently occurs in the lower leg following tibial fractures. Since bridge plating of difficult metadiaphyseal tibial fractures is becoming increasingly popular, serious concerns have been raised about the increased intracompartmental pressures and possible compartment syndrome.

Methods: This study investigated the intracompartmental pressure changes in anterolateral compartment of the leg during and immediately after anterolateral bridge plating of tibial fractures. Intracompartmental pressures were measured before and during plate application, just after the completion of fixation, and immediately and 4–5 min after the tourniquet release in 22 isolated closed comminuted tibial fractures.

Results: Baseline anterolateral compartment pressures were higher than those on the uninjured side (9.3 vs 27.8 mmHg). Pressures were 69.5, 57.4, 65.8, and 56.8 mmHg, respectively, for the other measurements times. None of the patients received prophylactic fasciotomy, and none developed clinical compartment syndrome.

Conclusion: We found that anterolateral compartmental pressures were higher than pressures on the uninjured side in all patients. Although there is a considerable increase in intracompartmental pressures during and immediately after anterolateral percutaneous bridge plating of comminuted tibial fractures, intraoperative prophylactic fasciotomy is not routinely needed. One should monitor the patients on the first postoperative day for signs of compartment syndrome. Fasciotomy decisions should be based on both clinical symptoms and serial intracompartmental pressure measurements rather than a single measurement.

Keywords: Bridge plating; compartment syndrome; intracompartmental pressure; tibial fracture.

Level of Evidence: Level IV, Therapeutic study.

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Compartment syndrome is one of the most devastating complications in orthopedics both for the patient and for the treating physician. Regarding the patient, even after appropriate treatment, it has a very negative impact on health-related quality of life.[1] On the other hand, from the physician aspect, inability to detect compartment syndrome or being negligent about its appropriate treatment is one of the most common medicolegal claims against orthopedic surgeons.[2,3] Among the many causes, trauma and its treatment is the most common reason for compartment syndrome, which most frequently occurs in the lower leg following tibial fractures.[4] Bridge plating is considered as a viable option for comminuted tibial diaphyseal and meta-diaphyseal fractures.[5] Although compartmental pressure changes and compartment syndrome occurring after intramedullary nailing of tibia have been reported,[6–11] recent review unable to reveal any work on the same subject after bridge plating for tibial fractures.

Since bridge plating of difficult metadiaphyseal tibial fractures is becoming increasingly popular, serious concerns have been raised about the increased intracompartmental pressures and possible occurrence of compartment syndrome. The current study aimed to investigate the intracompartmental pressure changes in anterolateral compartment of the leg during and immediately after the anterolateral bridge plating of tibial fractures. The main question is whether prophylactic percutaneous fasciotomy is needed if there is a substantial compartmental pressure increase with plating.

Materials and methods

Between January 2007 and January 2011, 47 patients with comminuted tibial fractures were treated with bridge plating technique using biological fracture fixation principles. Data were collected prospectively. Patients with open fractures, ipsilateral femoral and/or ankle, foot fractures, neurologically impaired patients, and those who had previous operation and/or significant trauma to the same extremity were not included in the study population. Patients with closed and isolated tibial fractures amenable for bridge plate fixation were included after obtaining informed consent. Patients were hospitalized after preliminary reduction, and posterior long leg splint was used until surgery. All patients were operated by the same surgeon who is experienced in fracture care. Operations were performed with patients under neuraxial anesthesia and under tourniquet hemostasis. Extremities were elevated for 2 min, and tourniquet was inflated 150 mmHg above the systolic blood pressure of the patients. Compartment pressures were measured using the slit-catheter method, described and verified by McQueen.[12] Only modification of original technique is the use of a large 18-G blood transfusion needle instead of a slit catheter, which is verified by Hammerberg et al.[13] Needle is attached to a sterile manometer tube coupled a with three-way tap and filled with isotonic sterile fluid. This tube system is then attached to an invasive blood pressure monitor available in operating theater. The fluid is left freely moving, and both monitor and needle tip is kept at the level of extremity. While the needle is still out of the tissues, "0" (zero) reading is set at the monitor. After draping, baseline anterior compartment pressure at the level of the main fracture line was measured by inserting the needle 0–5 cm close to the main fractured segment. Intracompartmental needle placement is felt as the needle passes two resistances and two loose progressions; namely, the skin and subcutaneous tissue and fascia covering the compartment and muscle tissue, respectively. Patients' diastolic and systolic blood pressures were also recorded with each compartmental pressure measurement. After fracture reduction with traction and percutaneous manipulations, continuous compartmental pressure recording was started. Pressures during plate sliding, at the end of completion of fixation, and immediately and 4–5 min after tourniquet release were recorded. Recording was extended if the pressure did not settle to a stable level. Postoperatively, soft dressings were applied without any pressure to all patients. Legs were elevated to the heart level at the first postoperative day, and patients were checked for any signs of imminent compartment syndrome, such as increased tightness over any compartment of the leg, inability to actively move ipsilateral ankle, overresponsiveness to light touch, and passive stretching of ankle dorsi or plantar flexors. If any of the above-mentioned signs were observed, patients were considered for compartment pressure measurements. Postoperative pain management was decided according to the type of anesthesia. Parenteral opioids and nonsteroidal anti-inflammatory drugs were used in patients who were operated under spinal anesthesia. Anesthetics through the patient-controlled device were used in patients with epidural catheters. In the absence of any clinical signs, neither specific compartment pressure recording nor a specific deltaP value was set as an indication for prophylactic fasciotomy in this series.

Results

Results of 22 patients having unilateral isolated closed tibial fractures were evaluated after applying the inclusion and exclusion criteria. Demographic data of the study group are presented in Table 1. The most common

Table 1. Demographics of study population.

	n	%
Gender		
Male	14	64
Female	8	36
Mean age		
Years	33.4	
Range	18–55	
Injury mechanism		
Pedestrian traffic accident	9	41
In-car traffic accident	7	32
Fall from height	4	18
Simple fall	2	9
Time to surgery		
Mean (days)	1.8	
Range (days)	1–5	
Type of anesthesia		
Spinal	20	81
Spinal + epidural	2	9

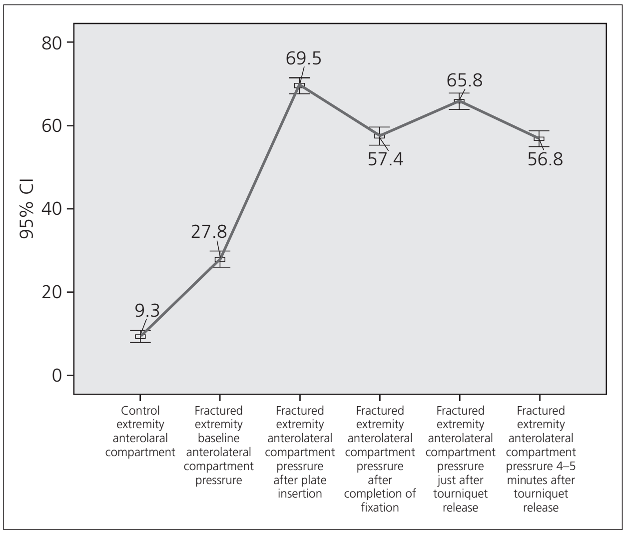

Fig. 1. Pressure changes during anterolateral bridge plating of tibial fractures. Numbers in boxes represent the means of pressures in mmHg at each measurement point.

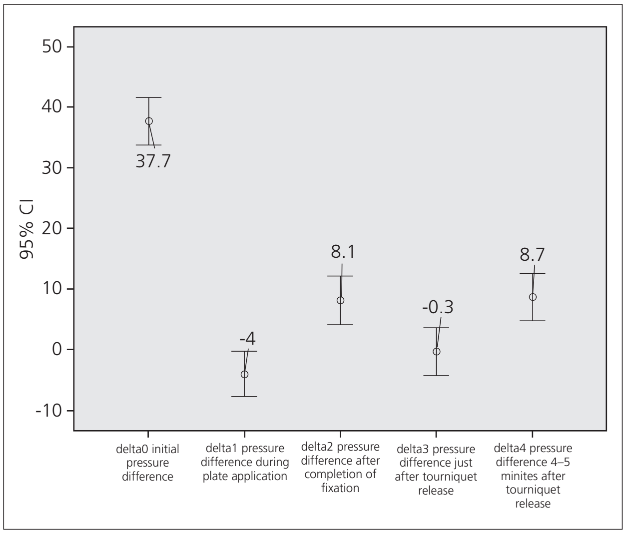

Fig. 2. DeltaPs in mmHg for each measurement point.

injury mechanism was traffic accident. Patients were admitted mainly after being struck by car, followed by in-car traffic accident. The type of anesthesia was mainly decided by common decision of anesthesiologists and patients. Mostly, spinal anesthesia was chosen (Table 1). We observed that fractured legs have increased baseline anterolateral intracompartmental pressures (Figure 1). During plate insertion, this pressure further increased and stabilized to a slightly lower level after completion of fixation. After tourniquet release, pressures raised again with a small decrease at the end of 4–5 min after the release (Figure 1). Overall, we observed that there is a measurable increase in the intracompartmental pressures during and immediately after percutaneous anterolateral bridge plating of tibial fractures. Delta P computed by subtracting compartmental pressure from diastolic pressure of the patient was found to be greater than 20 mmHg in all patients at the beginning of operation (Figure 2). However, just after the plate insertion, deltaP became even negative. Means of deltaP after completion of fracture fixation and immediately and 4–5 min after tourniquet release are presented in Figure 2. Prophylactic fasciotomy was not performed in any of our patients. During postoperative ward follow-ups, only one patient with increased tightness and increased pain in her leg needed repeat pressure measurement. This patient was operated a day after a pedestrian accident under spinal anesthesia. She was closely followed up clinically with cold application, gentle active assistive ankle, and foot manipulation and did not need any further action. No clinical compartment syndrome was diagnosed during immediate after treatment in this series. All patients were followed up at least until the fracture union. Mean follow-up time was 14.3 months (3–20 months).

Discussion

In this series, neither clinical compartment syndrome was diagnosed nor was any kind of fasciotomy performed. Although almost all patients had increased compartmental pressures above the accepted fasciotomy limits, none had clinical symptoms. There are many controversial issues about the diagnostic value of signs and symptoms of compartment syndrome. Literature has a consensus on the fact that compartment syndrome diagnosis is a clinical one. Pressure measurements are usually supplementary. However, one can easily find data about the exact compartmental pressure cut-off values for fasciotomy indication. Whitesides recommend that fasciotomy be performed as the intracompartmental pressure approaches 20 mmHg below diastolic pressure in any patient who has a worsening clinical condition, a documented rising tissue pressure, a significant tissue injury, or a history of 6 hours of total ischemia of an extremity.[14] Heckman et al. performed prophylactic fasciotomy, which was successful in aborting ischemic injury to the muscle and neural tissues of the leg in all patients with closed tibial fracture and intracompartmental pressure measurement within 20 mmHg of diastolic blood pressure.[15]

Some orthopedic surgeons routinely perform percutaneous anterior compartment fasciotomy in all patients whom they treated with anterolateral bridge plating. On the other hand, intracompartmental pressures are found to be significantly elevated compared to normal control extremity without clinical compartment syndrome.[16] Latter information further complicates the decision making in many trauma patients, especially if they are unconscious. In these cases, continuous compartment pressure monitoring might be considered.[17] Although the diagnosis of compartment syndrome is mainly a clinical one, intracompartmental pressure measurements play a supporting role in decision making when patients can not accurately respond to physician's questions, e.g., patients under anesthesia.[4,18] Literature reveals some reports about missed compartment syndrome in patients with continuous analgesia after fracture surgery.[19–22] That is why we suggest that patients with comminuted tibial fractures undergoing surgery using the anterolateral bridge plating technique should be closely monitored both during and immediately after the surgery for possible occurrence of compartment syndrome. However, neither literature review nor our data supports prophylactic fasciotomy in the absence of clinical signs or symptoms.

Another concern about patients at risk for compartment syndrome is overtreatment, i.e., performing fasciotomies when it is not necessary. Unnecessary fasciotomies may increase bone healing and wound complications.[23,24] To decrease unnecessary fasciotomy probability, some laboratory and radiological data are suggested for diagnosing compartment syndrome besides the clinical clues. Increased levels of creatine kinase, myoglobin, and fatty-acid binding protein and continuous increase trend in their levels may contribute to the diagnosis of acute compartment syndrome.[25] Relatively new ultrasonographic techniques such as pulsed phase–locked loop, 99-technetium (99Tc)-methoxyisobutilisonitrile (MIBI) scintigraphy, laser-Doppler flowmetry, and near-infrared spectroscopy are some of those promising additional diagnostics.[25]

Some limitations of our study should be mentioned. The first limitation is our small population size. A larger patient series with better stratification of fracture, implant, and elapsed time from trauma to treatment may have stronger conclusions. The second limitation of this study is that we did not verify our needle position by means of any methods other than tactile feeling. Although the treating physician is experienced enough in orthopedic trauma surgery, verification of exact needle placement might be good idea to increase measurement precision. Lastly, we only measured anterior compartment pressure changes. Measuring all compartments might be another idea. However, acute and chronic compartment syndromes are both seen in anterolateral compartment of the leg more frequently than in other leg compartments. This clinical finding may be explained by the different elastic responses of the fascia covering these compartments. Stecco et al. showed that the fascia in the anterior compartment is stiffer than in the posterior compartment, both along the proximal–distal and medial–lateral directions.[26] Fascia has the stress relaxation curves confirming that about 90% of this phenomenon takes place in the first minute after application of the strain. These data could suggest that the maintenance of a static stretching position for about 1 min is enough to let the fasciae reach a new balance. Further time cannot modify significantly the fascial tension.[26] That is why we only measured single anterior compartment pressures.

Overall, our data indicates that there is a significant pressure rise in the anterolateral compartment of the leg during and after the anterolateral bridge plating of tibial fractures. Although there is no clear cut-off value for the definitive diagnosis of clinical compartment syndrome, one should keep that increase in mind and monitor the patient very closely. According to interpretation of our data, we do not recommend routine fasciotomy decisions based solely on the increased intracompartmental pressure or decreased deltaP values. In responsive co-operative patients, clinical suspicion supported by pressure measurement judgment may necessitate fasciotomy. However, if the clinical signs are obscured by uncooperative patient or strong analgesia, the treating surgeon still needs some additional information like serial intracompartmental pressure measurements rather than single measurement.

Conflics of Interest: No conflicts declared.

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