Satish Kutty · Alan J. Laing · C. V. R. Prasad ·
John P. McCabe

The effect of traction on compartment pressures during intramedullary nailing of tibial-shaft fractures. A prospective randomised trial

Received: 16 January 2005 / Accepted: 10 February 2005 / Published online: 7 April 2005
© Springer-Verlag 2005

Abstract Our aim was to study the effect of traction on the compartment pressures during intramedullary nailing of closed tibial-shaft fractures. Thirty consecutive patients with Tscherne C1 fractures were randomised into two groups. Sixteen patients underwent intramedullary nailing of the tibia with traction and 14 patients without traction. Compartment pressures were measured before the application of traction or commencement of the procedure and at the end of the procedure. The data collected was analysed using Student's *t* test. There was no statistically significant difference ($p>0.05$) in the pre-operative mean compartment pressures for both groups. The mean post-operative measurements were higher in all four compartments in the traction group ($p<0.05$). None of the pressures reached the critical level. These results show that traction as an aid unnecessarily increases compartment pressures.

Résumé Notre but était d'étudier l'effet de la traction sur la tension compartimentale pendant l'enclouage centromédullaire des fractures tibiales fermées. Trente malades consécutifs avec des fractures Tscherne C1 ont été randomisés dans deux groupes. Seize malades ont subi un enclouage centromédullaire tibial avec traction et quatorze malades sans traction. Les pressions compartimentales ont été mesurées avant la mise en traction ou au commencement de l'opération et à la fin de l'opération. Les données ont été analysées avec le Student *t*-test. Il n'y avait aucune différence statistiquement significative ($p>0.05$) dans les pressions moyennes préopératoires des compartiments pour les deux

groupes. Les mesures postopératoires moyennes étaient plus élevées dans les quatre compartiments dans le groupe avec traction ($p<0.05$). Aucune des pressions n'est arrivée au niveau critique. Ces résultats montrent que la traction augmente les pressions des compartiments.

Introduction

Acute compartment syndrome is a condition in which the circulation and function of tissues within a closed space are compromised by increased pressure within that space [4]. It is a devastating consequence of extremity trauma that is preventable with early recognition and treatment [1]. Traction was shown to increase compartment pressures [8]. Mullett et al. identified 16 cases of compartment syndrome in a consecutive series of 626 tibial shaft fractures [7]. All were associated with intramedullary nailing performed on traction. Hence, our aim was to randomise and prospectively evaluate the effect of traction on compartment pressures during closed intramedullary nailing of Tscherne C1 tibial shaft fractures. There are no similar studies reported in the literature to date. The ethical committee of the institution approved the experimental protocol.

Patients and methods

The design of the study was a prospective randomised trial. Over a period of 16 months, 30 consecutive Tscherne C1 tibial-shaft fractures were randomised into two groups. Randomisation was based on hospital numbers. Patients with even numbers were recruited into the 'traction group' ($n=16$); those with odd numbers were recruited into the 'traction-free group' ($n=14$). Mean patient age in the 'traction group' was 37.5 (range 21–90) years and in the 'traction-free' group was 36 (range 18–55) years. There were 11 men and five women in the traction group, and 12 men and two women in the traction-free group.

The operative protocol was standard for all patients. The procedure was performed under general anaesthesia. Cefra-

S. Kutty · A. J. Laing · C. V. R. Prasad · J. P. McCabe
Department of Trauma and Orthopaedics,
Merlin Park Regional Hospital,
Galway, Ireland

S. Kutty (✉)
46 The Old Forge, Lucan,
Co. Dublin, Ireland
e-mail: kuttysatish@hotmail.com
Tel.: +353-1-6105621
Fax: +353-1-6105621

Table 1 Traction group. *Ant* anterior compartment, *Per* peroneal compartment, *S. post* superficial posterior, *D. post* deep posterior, *RTA* road traffic accident

No.	Age (years)	Gender	Pre-operative compartment pressures in mm Hg				Post-operative compartment pressures in mm Hg				Mechanism of injury
			Ant	Per	S. post	D. post	Ant	Per	S. post	D. post	
1	55	Female	8	9	12	12	40	26	20	21	Slip on rock
2	23	Male	9	9	14	13	27	26	30	33	Fall from beach buggy
3	30	Male	23	18	20	20	40	40	41	30	Sports injury
4	29	Female	23	23	21	25	31	40	28	37	Fall at disco
5	36	Female	10	16	18	17	42	24	26	30	Trip over chair
6	64	Male	10	12	13	13	38	28	48	30	Fall off bike
7	90	Female	10	8	12	18	16	18	26	22	Fall off chair
8	21	Male	11	12	17	14	40	20	31	33	Sports injury
9	38	Male	15	24	21	21	41	40	42	40	Sports injury
10	39	Male	18	14	25	17	26	19	40	41	Fall in garden
11	30	Male	17	12	18	14	21	28	25	22	Fall off a wall
12	45	Female	4	5	7	4	5	11	9	14	RTA
13	30	Male	14	16	18	12	32	30	36	33	RTA
14	26	Male	10	12	14	15	30	32	28	24	RTA
15	21	Male	18	15	14	12	28	30	25	28	RTA
16	23	Male	20	18	14	17	38	35	36	39	RTA

dine intravenously was administered as a prophylaxis. Compartment pressures were measured before the application of traction and/or commencement of the procedure with the patient supine. The method described by Gulli and Templemen [1] was used to measure all four compartments. Based on the study by Heckmann et al. [2], pressure measurements were taken at a distance of 10 cm from the fracture site in all patients. The pressures were measured with a Stryker intracompartmental pressure monitor (Stryker Instruments, Michigan USA). The blood pressure was monitored simul-

taneously. Traction was applied through a calcaneal pin sufficient to align the fracture. For patients in the traction-free group, the procedure was performed with the knee flexed and supported with a folded pillow and the limb held in position with the help of an assistant. Closed ante grade nailing was performed with a longitudinal, mid-line, patellar-tendon-splitting approach. The canal was reamed to a diameter of 1.5 mm larger than the selected intramedullary nail. Russell Taylor Delta tibial nail (Smith and Nephew Richards Inc, Memphis, TN, USA) was used in all cases

Table 2 Traction-free group. *Ant* anterior compartment, *Per* peroneal compartment, *S. post* superficial posterior, *D. post* deep posterior, *RTA* road traffic accident

No.	Age (years)	Gender	Pre-operative compartment pressures in mm Hg				Post-operative compartment pressures in mm Hg				Mechanism of injury
			Ant	Per	S. post	D. post	Ant	Per	S. post	D. post	
1	37	Male	10	10	12	14	16	18	20	20	Sports injury
2	55	Male	20	18	16	14	26	20	21	18	RTA
3	22	Male	18	16	16	14	30	24	27	24	Sports injury
4	24	Female	9	8	12	10	17	14	19	16	RTA
5	53	Male	14	12	10	10	20	16	15	13	Fall off bike
6	22	Male	20	16	18	14	30	26	32	28	RTA
7	51	Male	20	14	12	12	25	26	22	26	RTA
8	49	Male	18	14	14	12	26	24	22	24	Farmyard injury
9	34	Female	16	16	14	16	24	22	23	21	Slip at home
10	41	Male	16	12	14	10	24	18	23	24	Fall off wall
11	19	Male	16	14	12	15	22	20	18	20	Sports injury
12	18	Male	20	16	14	18	22	20	18	20	Fall off bike
13	22	Male	20	14	18	16	28	24	24	22	Sports injury
14	40	Male	24	20	20	17	28	25	26	23	Sports injury

Fig. 1 Pressure values of the anterior compartment in the two groups before and after the procedure.

and locked in a static manner. In the traction group, the traction was released as soon as the nail was inserted. The compartment pressures were measured at the end of the procedure, again with the patient in a supine position and at the same point. The differential pressures (Δp) were also recorded [4]. The threshold for decompression was set at Δp less than 30 mm Hg (Δp =diastolic blood pressure–compartment pressure) [4].

Results

The raw data are shown in two tables (Tables 1 and 2). It was analysed with Student’s *t* test (two-tailed).

When the pre-operative and post-operative pressures were compared for each compartment within each group, the mean compartment pressures increased post-operatively (6.9–17.1 mm Hg; range of the difference of means). This was statistically significant at $p<0.001$ (paired *t* test). There was no statistically significant difference ($p>0.05$, two-group *t* test) in the pre-operative mean compartment pressures for both groups when all four compartments were compared individually. The mean post-operative measurements of the traction group were higher (6.8–8.5 mm Hg) in all four compartments (Figs. 1–4). This was statistically significant ($p<0.05$, two-group *t* test). None of the pressures reached the critical level, as they were more than 30 mm of Hg below the diastolic blood pressure (Δp).

Fig. 2 Pressure values of the peroneal compartment in the two groups before and after the procedure.

Fig. 3 Pressure values of the superficial posterior compartment in the two groups before and after the procedure.

Fig. 4 Pressure values of the deep posterior compartment in the two groups before and after the procedure.

Discussion

Injury, restoration of length of the fractured bone, reaming, nailing and traction are all causes attributable to rise in compartment pressures. Reaming and nailing result in a tran-

sient increase in compartment pressures [5]. This rise in pressure is not sustained, and the pressure falls after nailing. Matson and Clawson, in an experimental study on rabbits, showed a rise in compartmental pressures after application of traction in a fractured limb [6]. Shakespeare and Henderson

identified the effect of calcaneal traction on compartment pressures. They found that for every kilogram weight of traction applied, the deep posterior pressure rose by 5.7% and the anterior pressure by 1.6% [8]. Koval et al. reported that 30% of patients had neurological complications after nailing of tibial-shaft fractures [3]. The majority were neuropathies and the cause identified was traction.

Our study shows that post-operative compartment pressures in both groups significantly increased, irrespective of traction. This is due to fracture reduction and restoration of length as well as other aspects of the surgical procedure. We have shown that use of traction as an aid to nailing increases compartment pressures to a much higher level. This group of patients had low pre-operative compartment pressures and hence, when traction was applied, it did not reach a critical level to cause compartment syndrome. In a setting where the compartment pressures are high pre-operatively, close to the critical level, traction is likely to precipitate a compartment syndrome.

Intramedullary nailing, if performed without traction, avoids an unnecessary increase in compartment pressures. We advocate that the procedure be done without traction where technically feasible.

References

1. Gulli B, Templeman D (1994) Compartment syndrome of the lower extremity. *Orthop Clin North Am* 25:677–684
2. Hechmann MM, Whitesides TEJ Jr, Grewe SR et al (1994) Compartment pressure in association closed tibial shaft fractures: the relationship between tissue pressure, compartment and the distance from the site of the fracture. *J Bone Joint Surg Am* 76: 1285–1292
3. Koval KJ, Clapper MF, Brumback RJ, Ellison PS Jr, Bathon GH, Burgess AR (1991) Complications of reamed intramedullary nailing of tibia. *J Orthop Trauma* 5:184–189
4. McQueen M (1997) Acute compartment syndrome in tibial fractures. In: Court-Brown C, Penning D (eds) *Tibia and Fibula*. Butterworth-Heinemann, Oxford, pp 131–142
5. McQueen M, Christie J, Court-Brown CM (1990) Compartment pressures after intramedullary nailing of the tibia. *J Bone Joint Surg Br* 72:395–397
6. Matson FA, Clawson DK (1975) The deep posterior compartment syndrome of the leg. *J Bone Joint Surg Am* 57:34–39
7. Mullett H, Al-Abed K, Prasad CV, O'Sullivan M (2001) Outcome of compartment syndrome following nailing of tibial fractures. *Injury* 32:411–413
8. Shakespeare DT, Henderson NJ (1982) Compartment pressure changes during calcaneal traction in tibial fractures. *J Bone Joint Surg Br* 64:498–499