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Comparison of skin pressure measurements with the use of pelvic circumferential compression devices on pelvic ring injuries

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ABSTRACT

Objectives: Pelvic circumferential compression devices are commonly used in the acute treatment of pelvic fractures for reduction of pelvic volume and initial stabilisation of the pelvic ring. There have been reports of catastrophic soft-tissue breakdown with their use. The aim of the current investigation was to determine whether various pelvic circumferential compression devices exert different amounts of pressure on the skin when applied with the force necessary to reduce the injury. The study hypothesis was that the device with the greatest surface area would have the lowest pressures on the soft-tissue.
Methods: Rotationally unstable pelvic injuries (OTA type 61-B) were surgically created in five fresh, whole human cadavers. The amount of displacement at the pubic symphysis was measured using a Fastrak, three-dimensional, electromagnetic motion analysis device (Polhemus Inc., Colchester, VT). The T-POD, Pelvic Binder, Sam Sling, and circumferential sheet were applied in random order for testing. The devices were applied with enough force to obtain a reduction of less than 10 mm of diastasis at the pubic symphysis. Pressure measurements, force required, and contact surface area were recorded with a Tekscan pressure mapping system.
Results: The mean skin pressures observed ranged from 23 to 31 kPa (173 to 233 mm of Hg). The highest pressures were observed with the Sam Sling, but no statistically significant skin pressure differences were observed with any of the four devices ($p > 0.05$). The Sam Sling also had the least mean contact area (590 cm^2). In greater than 70% of the trials, including all four devices tested, skin pressures exceeded what has been shown to be pressure high enough to cause skin breakdown (9.3 kPa or 70 mm of Hg).
Conclusions: Application of commercially available pelvic binders as well as circumferential sheeting commonly results in mean skin pressures that are considered to be above the threshold for skin breakdown. We therefore recommend that these devices only be used acutely, and definitive fixation or external fixation should be performed early as patient physiology allows. There may be some advantage of use of a simple sheet given its low cost, versatility, and ability to alter contact surface area.

Introduction

The mortality rate of pelvic ring injuries varies from 5–36%.[1–9] Early mortality is usually due to exsanguination or head injury, and reduction of pelvic volume and stabilisation of the pelvic fracture should be part of the initial resuscitation. The severe bleeding associated with these injuries may arise from vascular injury, rupture of the sacral venous plexus, or soft-tissue and fracture bleeding.[10–15] There are several commercially available binder devices for the treatment of unstable pelvic injuries in the acutely injured patient. In addition, some authors have simply advocated the use of a circumferentially applied sheet.[16–19]

There have been several reports of catastrophic skin breakdown following the application of pelvic circumferential compression devices.[20–23] Some have proposed that this complication is due to pressure under the device, while others maintain that this may be the consequence of the initial soft-tissue trauma. In response to these reports, there have been studies performed examining the pressure exerted by commercially available binder devices.[22,24] Neither of these studies specifically examined the pressures imparted on the patient when adequate force to reduce the

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fracture was applied. Another recent study looked at the force necessary to obtain reduction of a pelvic fracture but did not examine skin pressure.[25]

The purpose of the current investigation was to record and compare the skin pressures exerted by various commercially available pelvic binders as well as a circumferentially applied sheet when applied with enough force to adequately reduce an experimentally produced pelvic fracture. Our hypothesis was that the device with the greatest surface area would produce the least amount of skin pressure underneath it.

Patients and methods

Five fresh, whole cadavers were obtained for the current study. The absence of pelvic pathology was confirmed by computerised tomography scans. Pfanstiel and lateral ilioinguinal window approaches to the pelvis were performed taking great care not to disrupt unnecessary tissue planes. Sensors were attached using machined polyethylene mounts and bicortically placed screws to the superior pubic ramus on each side of the pubic symphysis. (Fig. 1) Consistent osseous points on the superior aspects of each side of both the pubic symphysis and sacroiliac joints were transmitted to the motion tracking system.

Rotationally unstable (AO type 61-B-1.1), or open book injuries were created surgically by a fellowship trained Orthopaedic Traumatologist (XXX). This was done by anteriorly incising the pubic symphyseal ligaments, the pelvic floor, and the ipsilateral rectus abdominus. Posteriorly, the anterior iliosacral ligaments were disrupted. A finochietto retractor was then placed into the pubic symphysis and a diastasis of 100 mm produced. This was performed on the left side for each specimen, and consistently resulted in rotationally unstable pelvic injuries as confirmed by axial plane stress testing.

The amount of displacement at the pubic symphysis was measured using a Fastrak, three-dimensional, electromagnetic motion analysis device (Polhemus Inc., Colchester, VT). The system tracks the position of sensors within an electromagnetic field, and is accurate to 0.3 degrees. The data was collected in a personal computer and was analysed with the SPSS statistical software package. Measurements were taken prior to creation of the injury as a reference for anatomic reduction of the pubic symphysis.

A Tekscan pressure mapping system was applied around the pelvis of the cadaver. (Fig. 2) A T-POD (Bio Cybernetics International, La Verne, CA), Pelvic Binder (Pelvic Binders Inc. Dallas TX), Sam Sling (Sam Medical Products, Wilsonville OR), or a circumferential sheet with two towel clamps was applied by the same Orthopaedic Traumatologist in random order. (Fig. 3) All were placed at the level of the greater trochanters and tightened with the force necessary to reduce the pubic symphysis to less than 10 mm of displacement. The only exception was the Sam Sling

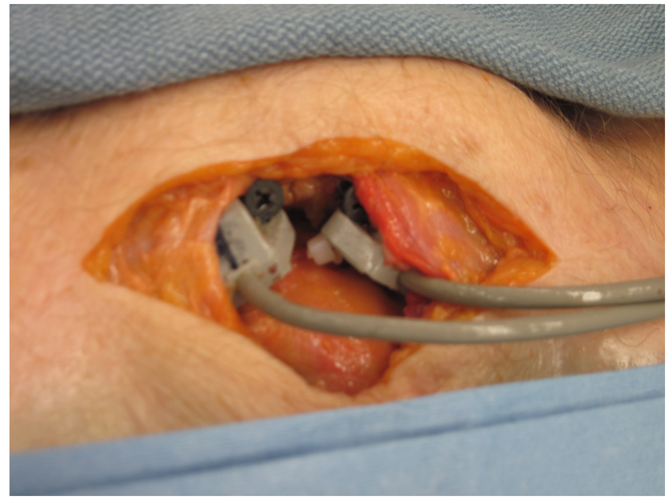

Fig. 1. Photograph of a cadaver with the sensors placed on the cephalad aspect of the left and right superior pubic ramus through a Pfanstiel approach.

which was applied according to manufacturer instructions. The sheet was applied as described by Routt et al.[18] Measurements of skin pressure, contact area, and force were recorded with the Tekscan pressure mapping system. A total of five trials with each device on each cadaver were performed.

A repeated measure ANOVA was performed to test for differences with each condition. If there were differences detected, a Tukey's post hoc comparison test was applied to evaluate pairwise differences. Statistical significance was set at $p = 0.05$.

Results

All four devices tested were able to successfully reduce the pubic symphysis diastasis to within 10 mm of anatomic. It was necessary to tighten the Sam Sling until the auto stop tension control buckle released in all trials to get a reduction within 10 mm. The maximum skin pressures measured ranged from 34 to 41 kPa (255 to 308 mm of Hg), while the mean pressures ranged from 23 to 31 kPa (173 to 233 mm of Hg). (Figs. 4 and 5) The highest values for both mean and maximum pressure (excluding the circumferential sheet) were observed with the Sam Sling, although no statistically significant skin pressure differences were detected among the four devices ($p < 0.05$) with the numbers available. The ranges for peak force applied were 17 to 24 N, and the ranges for contact area were 590 to 778 cm^2 for the devices tested. The Sam Sling also required the highest peak force (24 N) to obtain a reduction and had the least amount of contact area (590 cm^2). All data is presented in Table 1.

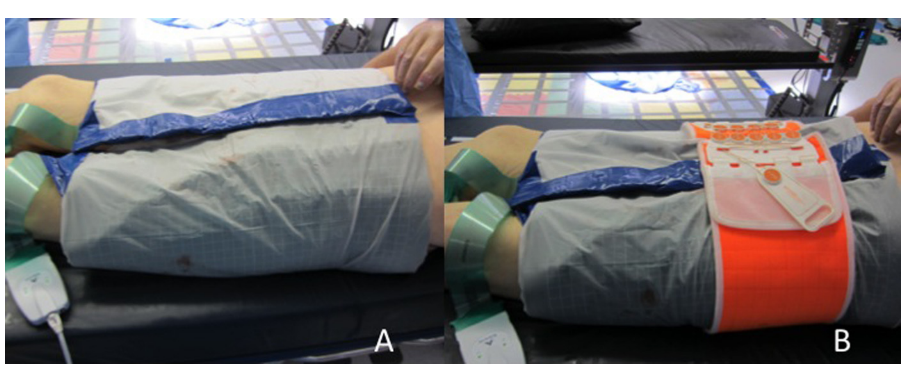

Fig. 2. Photograph of a cadaver with A) just the Tekscan pressure mapping system placed around the pelvis, and B) following application of a binder device.