EXTENDED REPORT

Influence of elastic bandage on knee pain, proprioception, and postural sway in subjects with knee osteoarthritis

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Objectives: To investigate whether a "standard" sized (that is, a size that would be prescribed by a physiotherapist) elastic bandage (S-bandage) around the knee of subjects with knee osteoarthritis (OA) would, in the short term (*a*) reduce pain, (*b*) improve knee joint proprioception, and (*c*) decrease sway in comparison with a looser (L-bandage).
Methods: In a cross over, within-subject study, 68 subjects (49 women, 19 men; mean age 67.1, range 36–87) with symptomatic and radiographic knee OA were randomly assigned to either an S-bandage or an L-bandage. Two weeks later they were assigned to the opposite bandage size. Knee pain (10 cm visual analogue scale (VAS)), knee proprioception, and static postural sway were assessed for each bandage two weeks apart. During each visit assessments were performed at baseline, after 20 minutes of bandage application, and immediately after bandage removal.
Results: The S-bandage did not have any effect on knee pain, proprioception, or postural sway. The L-bandage reduced knee pain significantly (pre-bandage application: median VAS 4.36, IQR 3.84–4.90; after 20 minutes of bandage application: median VAS 3.80, IQR 3.3–4.3, $p<0.001$), improved static postural sway (pre-bandage: median sway 4.50, IQ range 3.5–6.4; bandage applied: median sway 4.45, IQ range 3.4–6.3, $p=0.027$), but had no significant influence on knee proprioception.
Conclusions: In subjects with knee OA application of an elastic bandage around the knee can reduce knee pain and improve static postural sway. This outcome depends on the size of applied bandage.

Elastic bandages are commonly used in the treatment of various musculoskeletal disorders, including knee osteoarthritis (OA). Some patients with knee OA who use bandages report pain relief and diminution of the feeling of "giving way" and fear of falling. To date, there are few data to support this practice. Theoretically, however, a bandage might improve knee proprioception through additional skin sensory input, which in turn may improve sensation and thus lead to improved coordination.

The influence of an elastic bandage on knee proprioception has been examined in healthy subjects and in patients with various knee disorders, including knee OA. Some investigators report significant improvement in knee proprioceptive acuity in subjects with knee OA but not in healthy controls.[1] Others found that the bandage was beneficial in both groups.[2–4] However, such benefit has not been seen in subjects with localised internal derangement, such as a medial meniscus lesion[5].

Proprioceptive information is derived from at least three sources: the articular mechanoreceptors, muscle spindles, and the cutaneous touch and pressure receptors.[6–14] There are many types of cutaneous receptors,[15] but mechanoreceptors are of most relevance to joint position because they respond to movement[15] and touch.[16] Some (for example, Meissner's corpuscles and free nerve endings) are particularly sensitive to movement of light objects over the skin,[16] whereas others (for example, Pacinian corpuscles) are stimulated by very rapid movement; such receptors are spatially specific and rapidly adapting. More slowly adapting receptors (for example, Ruffini end organs) are important for detecting continuous states of deformation in joint capsules and respond to the degree of joint rotation.[16] Thus the sensory system imputes position from the distortion of mechanoreceptors both within and around the joint. Proprioception initiates reflexes that help to stabilise the limb and protect it from excessive movements via the proprioceptive stretch reflex.[17–20] In knee OA mechanoreceptors may be compromised and damaged by the accompanying anatomical change such as capsular thickening. Consequent reduced sensory input may compromise normal knee movement and impair postural and protective reflexes. The rationale of using an elastic bandage around the knee is to maximise the cutaneous contribution to joint position sense through cutaneous sensation from the area around the knee. However, whether improved proprioception is accompanied by any improvement in function, such as balance, remains unclear. Increased mechanical facilitation of the plantar surface of the foot, however, does improve postural stability in the elderly,[21] suggesting that such functional improvement may occur. Whether there is an optimal pressure or tightness at which a bandage influences proprioception has not been investigated.

This study aimed at determining the effect of two bandages of different tightness on knee pain, static postural sway, and knee proprioception in subjects with symptomatic knee OA.

PATIENTS AND METHODS

The study was approved by the local research ethics committee.

Subjects

All subjects had symptoms and signs consistent with knee OA and radiographic evidence of definite osteophyte plus definite

Abbreviations: BPM, Balance Performance Monitor; L-bandage, looser bandage; OA, osteoarthritis; S-bandage, standard bandage; VAS, visual analogue scale; WOMAC, Western Ontario and McMaster Universities (OA Index) joint space narrowing affecting at least one compartment (medial tibiofemoral or patellofemoral, or both) viewed on standard radiographs (standing extended anteroposterior and skyline 30° flexion views). No patient had symptoms, signs or *x* ray findings to suggest coexistent inflammatory or other locomotor disease, and no patients had a history of faints, vertigo, diabetes mellitus, Parkinsonism, or other condition that might impair balance. For study entry subjects had to have current pain in at least one knee measuring at least 2 cm on a 10 cm visual analogue scale (VAS) for usage, rest, or night pain, where 0 cm = no pain and 10 cm = worst pain.

Baseline assessments

Postural sway

Static postural stability was assessed with the Balance Performance Monitor (BPM) (SMS Sanders Healthcare, Harlow, Essex CM19 5TL, UK). The machine is designed to assess the weightbearing status of a subject. It consists of a feedback unit connected to two footplates. The subjects were asked to stand steadily on the footplates with their shoes on, with the position of the plates adjusted to match the position of their normal stance, arms at their sides, and eyes closed. The procedure was performed twice—the first time to acclimatise the subject and the second time for measurement. Data were acquired at 10 Hz over a period of 30 seconds and presented numerically and graphically. Graphical information is presented as a trace of the subject's weight shifts in lateral and anteroposterior directions and as a centre of gravity trace indicating the movement of the subject's centre of balance about his/her base of support during the test. The BPM data are recorded in arbitrary units on a scale from 0 to 100, from which it is possible to derive values of weight distribution (balance coefficient) and relative movement (sway coefficient). The balance coefficient is the value of the mean weight shifts during the 30 second test period in a left-right or lateral direction. The sway coefficient is the standard deviation of the balance coefficient. Greater balance and sway coefficients indicate a greater amount of postural instability.

Knee joint proprioception

Proprioceptive acuity was assessed by the subject's ability to reproduce passive positioning of the leg, using custom designed apparatus. The basic design was based on published descriptions.[1 22 23] The apparatus consisted of a chair, fitted with a device which enabled passive positioning of a subject's leg, a protractor with one degree divisions attached to the side of the chair, and a counterbalance to the weight of the subject to ensure that the leg felt weightless during the motion. The 90° flexion of the knee corresponded to 90°, and full extension of the leg to 180° on the protractor. Subjects were seated on the chair with hips and knees at 90° flexion. The leg was moved passively and positioned at a certain predetermined position (the criterion angle) and held there for five seconds. The leg was then returned passively by the examiner to the original position and the subject was asked to reproduce the criterion angle. The criterion angles were randomly selected between 90° flexion and full extension. The difference between the criterion and reproduced angle was taken as a measure of proprioceptive acuity. The procedure was performed with eyes closed and hands folded across the chest. The procedure was performed four times. The first exercise was a trial to familiarise the subject with the procedure. The average of the last three trials was regarded as the proprioceptive acuity for that leg.

Knee pain

Knee pain during various activities, stiffness, and physical function disability were assessed with the Western Ontario and McMaster Universities (WOMAC) OA Index.[24 25] In addition, the 10 cm VAS was used to assess the level of knee pain at baseline and after 20 minutes of bandage application.

Application of the elastic bandage

A randomly assigned elastic bandage size was applied to both knees. Tubigrip elastic bandages were purchased from Seton Healthcare Group (Tubiton House, Oldham OLE 3HS, UK). The following bandage sizes were used: D=7.5 cm for small knees, E=8.75 cm for medium knees, F=10 cm for large knees, and G=12.5 cm for small thighs. Very few subjects required the G size. The standard bandage (S-bandage) was applied as recommended, so that the pressure applied was not uncomfortable and did not exert pressure on the patellofemoral joint. Thus it was supportive, without slipping and without causing marked pressure as might be the case with patella taping. The L-bandage was one size looser than the S-bandage. The bandage was cut, without a window for the patella, so that it extended from the subjects mid-thigh to their mid-calf, thus replicating common usage. The order of trying the S- and L-bandages was randomised (computer generated random numbers) and the patient and observer were unaware which was used. The bandage was applied to both knees and the subjects permitted to engage in their usual degree of physical activity for 20 minutes. Then postural sway, proprioception, and self reported knee pain were reassessed in a similar fashion as above. The bandage was then removed, and immediately, the assessments of postural sway and proprioception were repeated. A second set of assessments was performed two weeks later, identical to those of the first visit, except that the second bandage size was applied.

Statistical analysis

The mean of the scores for both knees for variables of proprioception and VAS (knee pain scores) was taken as a final score and was included in the analysis together with the single value of postural sway. Analyses were performed using the SPSS version 8 program. For normally distributed data, means and 95% CI are presented. Student's *t* test was used to calculate the differences between two variables. For non-normally distributed variables, medians and interquartile (IQ) ranges are presented. The Wilcoxon signed ranks test was employed to calculate the differences between the two variables. The changes in measured variables are calculated as percentage change from baseline, adjusting for baseline.

RESULTS

The sample comprised 68 patients (49 (72%) women, 19 (28%) men) with knee OA, of whom 50 had bilateral knee pain and 18 had unilateral pain. Their mean age was 67.1 years (range 36–87), mean height 1.65 m (range 1.63–1.70), and mean weight 80.8 kg (range 76.9–84.5). Radiographic examination showed that 24 subjects had isolated tibiofemoral OA, five had isolated patellofemoral OA, and in 39 both compartments were affected. There were therefore insufficient subjects with isolated patellofemoral OA to examine possible between-compartment differences.

Influence of knee bandage on knee pain

After 20 minutes of application of the S-bandage there was a non-significant reduction in knee pain by just 6.41% ($p=0.17$), whereas application of the L-bandage produced a significant mean percentage reduction of 11.23% ($p<0.001$) (tables 1 and 2, fig 1).

Influence of the bandage on proprioception

Application of the S-bandage showed a gradual worsening of proprioceptive acuity with a mean difference from the criterion angle rising by 12.74% from baseline. Once the S-bandage was removed the mean difference from when it was applied worsened by an average of 20.04%—that is, a

Table 1 Mean (95% CI) for percentage change between assessment periods for each variable. Either Student's paired t test or the Wilcoxon signed ranks test is applied to compare each pair of variables

Variable	Bandage	Pre-bandage – bandage applied	Pre-bandage – bandage removed	Bandage applied – bandage removed
Knee pain (positive represents improvement, i.e. less pain)	Standard	6.41 (–2.46 to 15.29)		
	Loose	11.23 (5.97 to 16.48)†		
Proprioception (positive represents improvement, i.e. closer to criterion angle)	Standard	–12.74 (–25.74 to 0.25)	–25.46 (–40.51 to –10.41)	–20.04 (–32.84 to –7.23)
	Loose	–3.95 (–19.17 to 11.27)	–20.49 (–38.51 to –2.47)	–24.55 (–38.27 to 10.84)†
Postural sway (positive represents improvement, i.e. less sway)	Standard	–1.25 (–12.00 to 9.50)	–10.89 (–24.00 to 2.23)	–15.11 (–24.95 to –4.27)
	Loose	3.38 (–6.25 to 13.01)*	–8.96 (–20.44 to 2.53)	–20.62 (–32.18 to –9.06)*

*Significant at $p<0.05$; † significant at $p\leq0.001$

Table 2 Anthropometric and descriptive data for pain, postural sway, and proprioceptive acuity for the two types of bandage

Variable	Bandage	Pre-bandage	Bandage applied	Bandage removed
Knee pain 10 cm VAS (median, IQ range)	Standard	4.24 (3.75–4.74)	4.05 (3.50–4.60)	
	Loose	4.36 (3.84–4.90)	3.80 (3.29–4.32)	
Proprioception (degrees) (mean, 95% CI)	Standard	5.75 (3.70 to 9.60)	6.50 (3.67 to 10.57)	7.16 (4.20 to 10.46)
	Loose	6.33 (4.66 to 8.91)	5.83 (3.50 to 9.66)	6.92 (4.08 to 10.63)
Postural sway (median, IQ range)	Standard	4.55 (3.60–7.10)	4.65 (3.0–6.10)	4.70 (3.50–6.50)
	Loose	4.50 (3.52–6.40)	4.45 (3.42–6.27)	4.70 (3.40–7.10)

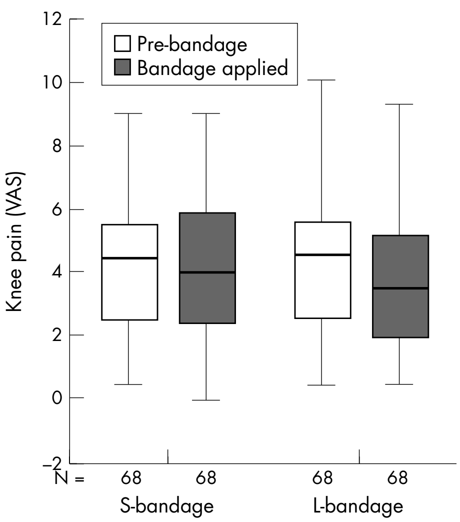

Figure 1 Box plots showing knee pain (VAS) pre-bandage application and after 20 minutes of bandage application, for an S-bandage and an L-bandage.

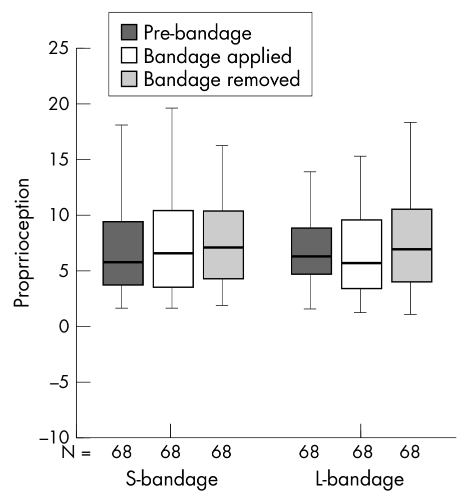

Figure 2 Proprioception assessed pre-application, after 20 minutes of bandage application, and immediately after removal of bandage, for both bandage types.

mean difference of 25.46% from baseline. None of these differences were significant (tables 1 and 2, fig 2).

Application of the L-bandage showed a mean increase in difference from the criterion angle of 3.95%. On removal of the L-bandage there was a worsening of proprioceptive acuity by a mean of 24.55% ($p<0.001$), repesenting a non-significant 20.49% difference from baseline.

Influence of the bandage on static postural sway

Application of the S-bandage had no significant effect on postural sway (postural sway became worse by 1.25% with the bandage applied, worsening by a further 10.89% on removal, to be 15.11% worse than baseline) (tables 1 and 2, fig 3).

Application of an L-bandage significantly ($p=0.027$) improved sway by 3.38%. However, on removal of the bandage, sway increased by 20.62%, ($p=0.025$) to a level which was 8.96% worse but not significantly different from baseline.

DISCUSSION

From this study it does appear that wearing an elastic bandage can influence knee pain, proprioceptive acuity, and postural sway. However, although both bandages reduced knee pain, only the loose bandage showed a significant benefit. Both proprioceptive acuity and postural sway improved with application of the looser bandage, but this benefit was lost on removal. The standard bandage had no effect on postural sway and showed a slight non-significant worsening of proprioceptive acuity while applied.

The observed improvement in postural sway in our patients is in accord with the findings in normal pain-free subjects reported by Maki *et al*.[21] They effected improvements in

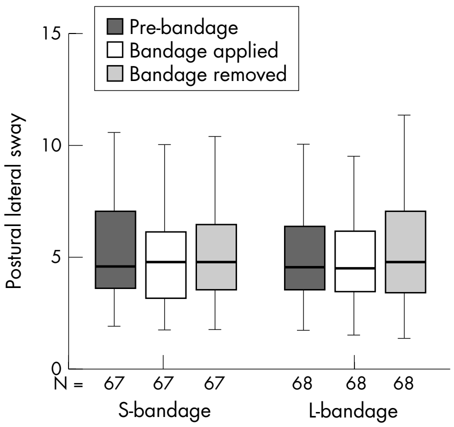

Figure 3 Postural lateral sway at pre-application of bandage, after 20 minutes of bandage application, and upon removal of the bandage, for both bandage types.

postural sway by placing a raised edge underneath the boundaries of the plantar foot surface to facilitate cutaneous sensation from the sole. However, our finding that the effect of a bandage on knee proprioceptive acuity was not significant is in contrast with most studies.[1–4] This disparity may result from differences in patient characteristics, the technique of assessment, or the pressure of bandage applied. In most previous studies subjects had disorders other than knee OA, whereas our study was confined to patients with symptomatic knee OA. Perlau *et al* used a bandage size of 10 cm,[4] whereas Barrett and Cobb selected a bandage size "as tight as comfortable".[1] The bandages used in the present study ranged from 7.5 cm to 10 cm and the standard size was assigned according to the same criterion as Barrett. However, no study has directly measured the skin pressure from such bandages. But the pressure exerted by an elastic bandage, such as those used in this study, is unlikely to alter tracking of the patella.

The possible mechanism of pain reduction seen with bandage application is of interest. Possibly, the reduction in knee pain while wearing the bandage was due to stimulation of large type Aδ sensory fibres from skin mechanoreceptors, leading to reduction in transmission of pain signals.[16] It seems unlikely that a bandage would have a direct effect through pressure in the absence of any condition that would benefit from increase in pressure or support (for example, soft tissue oedema). However, the skin receptors are very sensitive to tactile stimuli, and any movement of the bandage on the skin may influence proprioceptive acuity and subsequently result in improvement in sway. These effects might have secondary benefits on pain.

The differences between the two bandage sizes is previously unreported. The looser bandage improved sway and had a tendency towards improvement of proprioception, whereas the standard bandage did not. This may mean that the recruitment of cutaneous receptors depends on the pressure applied and the duration of stimuli. It is known that cutaneous receptors react strongly to new stimuli, such as movement of the bandage over the skin, and adapt rapidly once the stimuli become monotonous.[15 16] It has been shown that awareness of pressure on the skin sufficient to cause indentations as large as 2 mm fades within one to two minutes.[26] Therefore the more tightly applied S-bandage might have provided constant pressure to which the receptors adapted, whereas the looser L-bandage might have provided more recurrent "new" stimuli and thus elicited more continuous response from the receptors. We had expected the standard bandage possibly to yield positive results, whereas the looser L-bandage was expected to act more as a control/comparator. An important area for future study is therefore to investigate the optimal tension at which elastic bandages exert physiological effects.

There are several important caveats to the study. Firstly, it is unlikely that true blinding was achieved. Although subjects were not told the size that was being applied, they were aware that they were wearing a bandage and that the intervention might be beneficial and might have sensed the differences between the bandages even two weeks apart. Any bias introduced by these problems was unavoidable. Secondly, the Tubigrip was only available in three sizes (small, medium, and large), and the assessor had to allocate subjectively each participant's knees to one of these broad categories. Errors in assignment might therefore have been made. Thirdly, each bandage size was applied for just 20 minutes. Different results may be found with more prolonged application.

As far as we know, this is the first study to examine the effects of an elastic bandage on pain and postural sway in patients with knee OA. Although benefits were seen, further studies are needed to confirm these findings. The effect of a bandage on postural stability also needs to be tested clinically, for although the demonstrated improvement in postural sway was statistically significant, its relevance to daily function is uncertain. Whether such improvement in postural stability might reduce the incidence of falls or the subjective feeling of "giving way" was not specifically examined. However, if simple elastic bandages contribute to the control of knee OA pain and function they would be a useful addition to its management.

In conclusion, allowing for the caveats discussed, this study shows that an elastic bandage can have physiological effects by improving postural stability. This outcome depends on the size and tightness of the applied bandage. In addition, knee pain was significantly reduced after 20 minutes of application, giving some rationale to the widespread use of bandages by patients with knee OA.

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