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Y. Katsuragawa · N. Fukui · K. Nakamura

Change of bone mineral density with valgus knee bracing

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Abstract We assessed the clinical knee score and bone mineral density of the proximal tibia in an attempt to evaluate the efficacy of valgus knee bracing. The knee score improved after 3 months, and increases in bone mineral density were seen more in the lateral tibial condyle than in the medial. These results suggest that the brace acts by transferring the forces across the knee joint from the medial to the lateral side.

Résumé Pour apprécier l'efficacité d'une genouillère valgusante du genou, nous avons étudié le score clinique et la densité osseuse du tibia proximal. Après 3 mois de traitement, le score clinique est significativement amélioré de même que la densité osseuse et ceci plus au niveau du plateau tibial externe que du plateau tibial interne. Ces résultats confirment que la genouillère réduit les contraintes en compression du compartiment fémoro-tibial interne en déplaçant les forces vers le compartiment externe.

Introduction

Osteoarthritis (OA) of the knee is extremely common, and in Japan the medial compartment is the most commonly involved site. Valgus knee braces are used in the conservative treatment of OA of the knee. [1]. Theoretically the brace stabilizes the knee joint and reduces the load on the medial compartment [3]. The purpose of this study was to determine the change in bone mineral density (BMD) around the knee during treatment with a valgus knee brace.

Y. Katsuragawa · N. Fukui · K. Nakamura
Department of Orthopaedic Surgery, Faculty of Medicine,
The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku,
Tokyo, 113-0033 Japan

Y. Katsuragawa (✉)
Department of Orthopaedic Surgery,
International Medical Center of Japan, 1-21-1 Toyama,
Shinjuku-ku, Tokyo, 162-8655 Japan
e-mail: katsura@air.linkclub.or.jp
Tel.: +81-3-3202-7181, Fax: +81-3-3290-2110

Patients and methods

The patient group consisted of 3 males and 11 females aged 57 to 80 years (average 69 years). All suffered from medial compartment OA of both knees. The valgus knee brace Unloader (Generation II Orthotics, Vancouver, Canada) was prescribed for the most affected knee (Fig. 1), and these were worn for a period of at least 3 months each time the patients walked. Compliance was ascertained by bi-weekly visits to hospital. During this study no other treatment was offered except for the application of poultices, which is popular in Japan.

Clinical assessment was performed every 4 weeks. The functional efficacy of the brace was assessed according to the knee

Fig. 1 The valgus knee brace (Unloader) used in this study

Table 1 Criteria for evaluating osteoarthritis of the knee

Items	Points
<i>Pain on walking</i>	
Walking 1 km or more usually with no pain, without regard to mild pain, rarely felt, with certain activities	30
Walking 1 km or more regardless of pain	25
Walking 500 m or more, but less than 1 km without regard to pain	20
Walking 100 m or more, but less than 500 m without regard to pain	15
Walking indoors or nearby, but less than 100 m, without regard to pain	10
Inability to walk	5
Inability to stand	0
<i>Pain on ascending or descending</i>	
No pain	25
Pain; relieved by using handrails	20
Pain with handrails, but no pain with step by step ambulation	15
Pain with step by step ambulation, pain relieved by using handrails	10
Pain even with step by step ambulation and handrail use	5
Inability to ascend or descend due to pain	0
<i>Range of motion</i>	
Squatting	35
Sideways or cross-legged sitting	30
Flexion or arc of motion of 110° or more	25
Flexion or arc of motion of 75° or more	20
Flexion or arc of motion of 35° or more	10
Flexion or arc of motion less than 35° including ankylosis or severe flexion contracture	0
<i>Joint effusion</i>	
No edema, no swelling	10
Occasional puncture required	5
Frequent puncture required	0
<i>Total score</i>	100

scoring system of the Japanese Orthopaedic Association (Table 1) [4]. A dual energy X-ray bone densitometer XR-30 (Norland, Wis., USA) was used to measure BMD. The protocol used for measurement analysis was research scan mode with scan speed set at 45 mm/s and point resolution set at 1 mm.

For the measurement each patient was placed in a supine position on the scanning table. Where there was a flexion contracture of the knee joint, the leg was fixed to a custom-made foot cage to standardize the alignment of the tibia and knee (Fig. 2).

Two regions of interest (medial and lateral) were determined on the anterior posterior view of the knee; each was 2 cm thick, just below the joint line. Three variables were calculated; BMD of the medial tibial condyle (M), BMD of the lateral tibial condyle (L), and the ratio of the BMDs of these two condyles (L/M). The clinical scores and the three variables were compared in each knee immediately before using the brace and 3 months later.

A paired *t*-test was performed using Stat View software (Abacus Concepts, Berkeley, Calif., USA) on a personal computer (Macintosh Centris 660AV). The statistical significance was set at *P* less than 0.05.

Results

All changes in clinical and BMD data are shown in Table 2. Clinically, the braced knee showed significant improvement; the average score rose from 60 ± 8 to 71 ± 9 . Clinical changes in the unbraced knee were slight; the change of average score from 80 ± 15 to 83 ± 12 (Fig. 3).

Fig. 2 The foot cage used for bone mineral density (BMD) measurement. The cage can hold the foot in a reproducible position

Fig. 3a,b Change of Japanese Orthopaedic Association score. **a** Braced knees; **b** Unbraced knees

In the braced knees, the treatment increased BMD in the medial condyle (M) from an average of 0.86 ± 0.20 g/cm² to 0.89 ± 0.20 g/cm², while BMD in the unbraced knees increased from an average of 0.80 ± 0.13 g/cm² to 0.82 ± 0.13 g/cm².

The BMD in the lateral condyle (L) of the braced knees increased significantly from an average of 0.58 ± 0.14 g/cm² to 0.62 ± 0.12 g/cm², while in the unbraced knees BMD changed from an average of 0.61 ± 0.12 g/cm² to 0.63 ± 0.12 g/cm².

As a result of these changes the ratio (L/M) in the braced knees increased from an average of 0.69 ± 0.12 to 0.71 ± 0.13 , and in unbraced knees from an average of 0.76 ± 0.10 to 0.77 ± 0.10 (Fig. 4).

Table 2 Clinical and bone mineral density data before and after treatment with the knee brace

No	Age (years)	Sex	Side/brace	Pre-treatment				Post-treatment			
				Score	M	L	L/M	Score	M	L	L/M
1	62	F	Left+	55	0.791	0.659	0.833	70	0.853	0.708	0.830
			Right-	45	0.725	0.634	0.874	60	0.765	0.651	0.851
2	64	F	Right+	65	0.773	0.569	0.736	75	0.888	0.664	0.748
			Left-	70	0.717	0.579	0.808	75	0.835	0.703	0.842
3	65	F	Right+	65	1.196	0.808	0.676	70	1.192	0.872	0.732
			Left-	85	1.062	0.741	0.698	85	1.083	0.822	0.759
4	73	F	Right+	55	0.475	0.337	0.709	65	0.507	0.400	0.789
			Left-	95	0.614	0.493	0.803	95	0.561	0.459	0.818
5	75	F	Right+	55	0.868	0.483	0.556	65	0.937	0.548	0.585
			Left-	90	0.823	0.529	0.643	90	0.814	0.507	0.623
6	80	F	Left+	55	1.264	0.511	0.404	65	1.336	0.557	0.417
			Right-	70	0.595	0.420	0.706	70	0.639	0.491	0.768
7	71	F	Right+	60	0.678	0.408	0.602	60	0.790	0.545	0.690
			Left-	65	0.707	0.464	0.656	65	0.794	0.556	0.700
8	63	M	Right+	75	0.997	0.675	0.677	90	1.036	0.711	0.686
			Left-	90	1.003	0.668	0.666	90	1.047	0.701	0.669
9	71	F	Right+	50	0.705	0.487	0.691	60	0.799	0.543	0.680
			Left-	90	0.729	0.576	0.790	90	0.786	0.608	0.774
10	80	M	Left+	55	0.949	0.619	0.652	70	0.937	0.592	0.632
			Right-	75	0.839	0.693	0.826	80	0.820	0.656	0.800
11	57	F	Right+	75	0.853	0.803	0.941	85	0.791	0.773	0.977
			Left-	100	0.924	0.831	0.899	100	0.861	0.773	0.898
12	69	M	Right+	50	0.947	0.731	0.772	65	0.935	0.727	0.778
			Left-	95	0.811	0.771	0.951	95	0.795	0.789	0.992
13	65	F	Right+	60	0.779	0.563	0.723	80	0.766	0.581	0.758
			Left-	65	0.861	0.583	0.677	80	0.874	0.607	0.695
14	71	F	Left+	65	0.777	0.531	0.683	80	0.731	0.500	0.684
			Right-	80	0.779	0.494	0.634	85	0.810	0.511	0.631

M, Medial condyle; L, lateral condyle

Fig. 4a,b Change of bone mineral density (BMD) ratio. **a** Braced knees; **b** Unbraced knees. The ratio increased significantly in braced knees ($P=0.0176$), while it was not significant in unbraced knees ($P=0.1233$)

Discussion

This study suggests that valgus knee bracing for medial compartment OA improved the symptoms and the BMD of the proximal tibia predominantly in the lateral condyle; M and L increased by 3 and 7%, respectively, and the L/M ratio increased by 3%.

Reduced pain and improved stability by bracing might allow increased daily activities in these patients, resulting in an increase in BMD in both condyles. Furthermore, the brace might transfer load from the medial to the lateral aspects of the knee. These results are essentially similar to the changes of BMD after high tibial osteotomy reported previously. However, some biases can be assumed in the osteotomy studies. Firstly, the BMD of the proximal tibia after osteotomy may be affected by the compressed trabeculae or sclerotic changes at the osteotomy site; and secondly, after osteotomy a period of non-weight bearing is required, resulting in loss of BMD. In our study such problems were excluded, and the changes of BMD reflect the change of the loading across the knee.

There are several methods of evaluating such changes of bone quality, among which dual-energy X-ray absorptiometry (DEXA) is accurate and easy to measure. As for the precision of bone densitometer XR-30, the coefficient of variation for BMD is less than 1% [2].

The results of bone mineral measurement suggest that valgus knee bracing can improve loading in medial compartment OA. With an increasingly aged population, non-operative treatment for osteoarthritis including the use of an orthosis is of importance. The present study confirmed the clinical efficacy of valgus knee bracing, and showed that the BMD measurement could be a useful guide when seeking to evaluate other orthoses.

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