Rheumatol Int (2008) 28:419–428
DOI 10.1007/s00296-007-0455-x

ORIGINAL ARTICLE

Effect of a modified S-form hip brace, WISH type, for patients with painful osteoarthritis of the hip: a role in daily walking as a hip muscle exercise

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Received: 7 March 2007 / Accepted: 2 September 2007 / Published online: 21 September 2007

Abstract A hip brace designated as WISH-type of S-form hip brace was applied for 14 patients with painful hip osteoarthritis (OA), who were required to walk as an exercise at least a half hour every day. Patients were independently evaluated and serially scored using the Harris and Japanese Orthopaedic Surgery (JOA) scores. Pain relief on gait was obtained immediately and dramatically in all patients, providing high compliance. Approximately three fourths of patients acquired independence from analgesics. Both Harris and JOA scoring systems indicated significant improvement of hip function. Only two cases showed poor responses, and common factors in these cases included bilateral involvement and unsuccessfulness of daily walking exercise. The present WISH-type hip brace may be one of the most valuable treatments in the management of the hip OA. Requirements of muscle exercise around the hip girdle involving daily walking should be emphasized for maintenance of the brace effects.

Keywords Hip · Osteoarthritis · Hip brace · S-form · WISH-type · Harris score

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Introduction

Osteoarthritis (OA) is a common locomotor disorder and is more prevalent in older people. One of the most frequently affected joints is the hip. The dynamic lateral instability develops in patients in roughly the third decade of life [1]. This lateral instability is, in part, related to age-associated muscle weakness around the hip girdle since instability is also observed slightly in healthy old people [1]. Symptoms of OA of the hip, including joint pain, tenderness, limitation of movement, crepitus, limping, and variable degrees of local inflammation, are the most reported complaints at general practices. These symptoms often cause difficulties in performing normal daily activities and work engagement [2].

In clinical practice, there are a variety of conservative treatment methods available for patients with OA of the hip. These include pharmacological and non-pharmacological treatments. Non-steroidal anti-inflammatory drugs (NSAIDs) are effective in reducing pain and improving functional ability of the hip [3]. These drugs, however, must be used with caution, especially long-term use, because of the side effects [3, 4]. Although intra-articular injection of hyaluronan has recently been used for knee OA, this method has not been approved for treating OA of the hip [4].

Non-pharmacological treatments are mainly physical therapies including manual therapy and exercise therapy [5]. Manipulation and stretching techniques are included in manual therapy, which is aimed at improving the elasticity of the tissues around the joint. Although the effects of manual therapy programs on hip function have been shown to be superior to exercise therapy programs in patients with OA of the hip, manual therapy must be administered by a physical therapist with special training, requiring that patients visit the hospital frequently [6]. Exercise therapy includes active and passive exercises, and aims at improvement of muscle function, increasing the joint range of motion, decreasing pain, and increasing walking ability [6]. This therapy is provided by a physical therapist, but can, in part, be performed outside of the hospital. Exercise therapy has shown to be an effective intervention for OA of the hip [7], and is recommended by guidelines [8]. Recently a meta-analysis demonstrated evidence-based recommendations for the role of exercise in the management of hip OA [9]. Some investigators, however, have shown that by 9 months after the end of the intervention period, patients' improvements had regressed to baseline [10]. Thus, adherence is suggested to be the principal predictor of long-term outcome from exercise [9]. It is also suggested that practical aspects of long-term exercise delivery and maintenance require more attention, since increasing adherence, promoting physical activity, and the role of exercise and muscle strength in progression have not been fully addressed before [9].

Although shoes and sticks are recommended in the management of OA of the hip [3, 4], hip-brace therapy has gained little attention from medical doctors and physical therapists. An S-form hip brace of the Wakayama Medical College type has been developed for patients with OA of the hip [1]. The design concept of this brace is to reinforce the hip joint, to permit flexion, extension, and abduction, to correct inadequate position of the limb, and to prevent up and outward movement of the femoral head [1]. This brace has been shown to provide an early alleviative effect, and the author suggested a possible mechanism in which the stability obtained from the brace equipment may reduce muscle hyper contraction, leading to reduction of the intra-articular pressure [1].

It remains uncertain why the brace with such fascinating concept has not been used more widely. Based on a speculation that the reason may be due to discomfort to wear and the expense, as suggested previously [4], we improved the brace so that it is lighter and more concise, and named this version the WISH-type. Furthermore, the purpose of bracing is to provide assistance for daily walking exercise and not just as an alleviation mechanism only. Thus, the patients in this study were encouraged to walk daily as a hip girdle muscle exercise. Here we describe the modified portions of the WISH-type S-form hip brace and we showed the effect on hip function, as evaluated by Harris and Japanese Orthopaedic Surgery (JOA) Hip Score and radiological findings.

Methods

Subjects

During the period June 2004 to February 2006, patients with OA of the hip were referred to the outpatient clinic of Gunma University Hospital with complaints due to OA of the hip. Hip OA was defined according to the clinical criteria of the American College of Rheumatology [11]. Patients in whom the hip pain induced by weight bearing during gait was clearly reduced by manual pressure onto the great trochanter were recruited into this investigation. People who were on a waiting list for hip replacement or had a hip replacement were excluded. The radiological grade of OA was estimated according to Crowe et al. [14], and then most patients with radiological grades of III and IV were excluded.

The local ethics committee approved the study (Gunma University, Maebashi, Gunma, Japan), and each individual participating in the study gave informed consent.

Hip brace

The WISH-type S-form hip brace has been made on the basis of the design concept of Wakayama Medical College type, as demonstrated previously [1]. In the original Wakayama Medical College type, the pelvic potion of the hip brace holds it at the right position against pelvis to prevent rotation of the brace, and provides a fulcrum of the lever though a lateral bar. The lateral bar possess a single joint allowing hip flexion and extension near the peripheral edge. Another joint allowing hip abduction is located at the peripheral edge, and thus the combination of these two joints restricts only hip adduction. The peripheral joint provides a fulcrum between the S-form bar as a power point and greater trochanter pad as a working point. Through a universal joint, the third joint allows the pad face to trochanter correctly, and the pad then pushes the greater trochanter inward when the affected limb is abducted or bears weight. To make the weight lighter and improve the brace more concise, here we utilized Thrust Bearing Hip Joint Assembly, Variable Abduction (Fillauer LLC, Chattanooga, TN) as the lateral bar (Fig. 1). An upper extended bar was fixed inside to the lower hip joint bar. Then the greater trochanter pad as well as the universal joint were removed, and instead the greater trochanter pad was fixed directly to the upper extended bar attached to the lower hip joint bar, though a co-polymer polypropylene material.

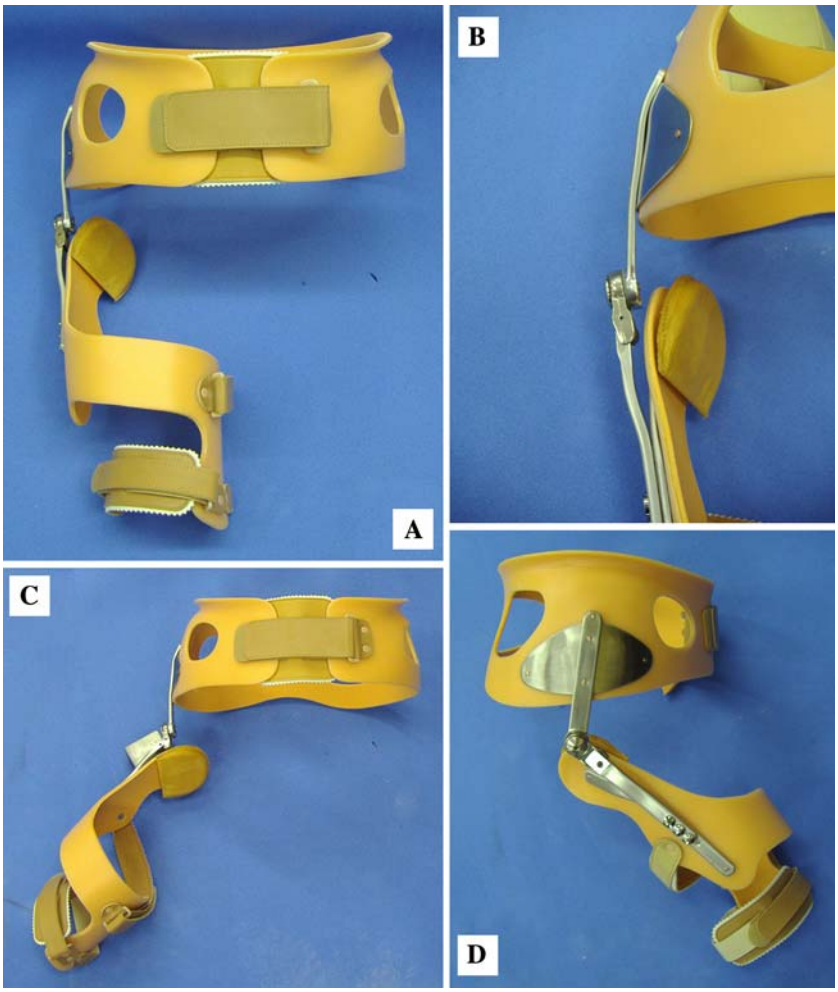

Fig. 1 WISH-type S-form hip brace consists of pelvic portion, S-form portion, and the *lateral bar* as their connection (**a**). *Lateral bar* possesses two joints (**b**), allowing the affected hip abduction (**c**) and flexion (**d**)

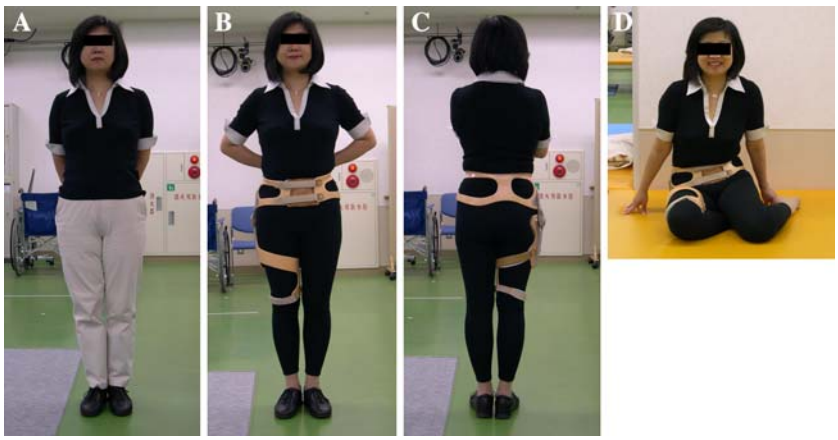

Fig. 2 Front (**b**) and posterior (**c**) views of WISH-type S-form hip brace. Few cosmetic problems were observed when pants were worn (**a**), and the brace did not restrict customary sitting positions (**d**)

Furthermore, an S-form bar holding the thigh was replaced by co-polymer polypropylene material with continuity to the greater trochanter pad. The resultant brace weighed around 0.9 kg, and the lateral prominence due to lateral bar was reduced (Fig. 2). The modified type of the brace was designated as the WISH-type, since users' hope as well as ours is "WISH" to be free from pain.

Exercise therapy

Patients equipped with WISH-type S-form hip brace were required to walk at least a half hour every day in order to strengthen muscles around the hip joint required for gait. Exercises consisting of hip muscle strengthening exercises with the use of weight were suggested as home exercise.

Furthermore, if possible, gait exercise in water was recommended additionally.

Assessments

Hip function was evaluated with the Harris Hip Score (HHS) [12] and JOA Score [13], both of which are treated as the primary outcome measure and consist of four variables: pain, functional capacity, range of motion, and deformity. The total score of the HHS is 100, and a score <70 has been reported to reflect poor functioning (poor category) [12]. The Wilcoxon matched-pairs test was used to analyse dependent variables within individuals. Hip function responses to the brace were also compared by using the χ^2-test for a categorized variable. A P value of <0.01 was considered statistically significant.

Results

Patient characteristics and follow-up

During the period from June 2004 to February 2006, 15 patients were recruited, and one male patient dropped out from the follow-up 3 months later. The details of the remaining 14 patients are given in Table 1. Since manual compression onto the great trochanter had little effect in patients with severe dislocation, most of who were registered into a hip arthroplasty waiting list, radiological grades in the present study included ten in grade I, three in II and one patient in III. All patients were female, and the right side was dominantly affected. Range of age was between 36 and 73, and the average was 52 years old. Five patients had bilateral involvement, and four radiologically showed dysplastic roof in the contralateral hip. The period of follow-up ranged from 6 to 28 months, the average being 15.8 months. Intermediate assessments at 3 and 6 months could not be performed in one patient (case 3).

Compliance of the WISH-type hip brace

Pain relief on gait was obtained immediately and dramatically after equipping all patients. This encouraged patients to actively walk daily. Also, there were few cosmetic problems and pants could be worn, and the brace did not restrict customary sitting-position (Fig. 2). These characteristics resulted in good compliance of this brace equipment. One month later, all patients wore the brace consistently in the daytime. One patient (case 1) was completely free from the brace after 15 months use. Four patients used the brace in the case of pain due to hard activity such as climbing, resulting in the temporal equipment once or a few times per month at the last follow-up period. On the other hand, eight patients depended on the brace every day, and four of them wore the brace all day.

Dependence on analgesics

Thirteen out of 14 patients were dependent on analgesic drugs when the brace was applied for the first time (Table 1). All drugs taken by the patients were NSAIDs. The drugs were used on an as-required basis. In three patients (cases 7, 8, and 13) this resulted in continuous use throughout this investigation period. Also one patient (case 6) required analgesics before the application of total hip arthroplasty (THA). However, six patients were completely free from the drugs, and they were taken once or twice a month for the remaining four patients, resulting in brace-based acquisition of independence from analgesics in 10 out of 14 patients (71.4%). Fortunately there were no gastrointestinal side effects in this study.

Performance of muscle exercise of daily walking

At the final assessment, daily walking exercise could be performed by 12 out of 14 patients, as shown in Table 1. Style of exercise varied among patients. Most cases walked at the same time in the same course every day for 30 to 60 min. Case 7, an elementary school teacher, was required to walk so much during her job that she was able to integrate her walking exercise during her job. All patients who improved also performed stretching exercises at home in addition to other exercise. There was a tendency of increase in duration of the exercise, leading to a trial of mountain climbing. However, two subjects (case 6 and 13) had to abandon the exercise program because of exercise-induced pain (Table 1), although the equipment allowed them to perform activities of daily living by alleviating pain.

Scoring assessments

It is noteworthy that the Harris scores were improved in all patients at 1-month follow-up assessment. The range of the improved score was between 10 and 39.3, and the average was 21.6 points, indicating significant improvement ($P < 0.002$) according to the Wilcoxon matched-pairs test. Furthermore, significant improvement was also found at the latest post-equipment assessment, i.e., average Harris hip scores were 58.15 versus 90.35 ($P < 0.01$), at first vs last assessments, respectively. Thirteen patients out of 14 showed poor hip function at first assessment, and the equipment of the brace resulted in significant reduction (only 2 out of 14, cases 6 and 13) in the number of patients with poor hip function, i.e., below 70 Harris score points ($P < 0.001$) according to the χ^2-test. The time courses of the individual scores are shown in Fig. 3a. Although for most

Table 1 Patient characteristics

Case	Age/sex	Site of OA hip	Radiological grade[a]	Contra-lateral	Follow-up period (Mo)	Time at the evaluation[b]	Brace quipment		Analgesics			Walking exercise
							Duration[c]	Final status	Drug at beginning	Duration[c]	Final status	
1	47/F	R	I	Dysplasia	28	1,3,6,12,24	15	CR	Loxoprofen sodium	3 Mo	1 Day/Mo	Yes
2	52/F	R	II	Dysplasia	27	1,3,6,12,24	12	1 Day/Mo	Loxoprofen sodium	1 Mo	CR	Yes
3	65/F	R	I	Normal	23	1,12	3	Work and walk only	–			Yes
4	57/F	R	I	Dysplasia	18	1,3,6,12	12	1 Day/Mo	Loxoprofen sodium	4 Mo	CR	Yes
5	51/F	L	II	Dysplasia	17	1,3,6,12	17	CD	Lornoxicam	1 Wk	1 Day/Mo	Yes
6	36/F	R	I	OA	17	1,3,6,12	13	THA[d]	diclofenac sodium	13 Mo	CR[e]	No
7	49/F	R	I	OA	14	1,3,6,12	6	Outside only	Loxoprofen sodium	14 Mo	CD	Yes
8	47/F	L	I	Normal	14	1,3,6,12	6	Work only	Loxoprofen sodium	14 Mo	CD	Yes
9	48/F	R	I	Normal	14	1,3,6,12	3	1 Day/Mo	Loxoprofen sodium	1 Mo	CR	Yes
10	49/F	R	II	Normal	13	1,3,6,12	11	Outside only	Loxoprofen sodium	7 Mo	1 Day/Mo	Yes
11	40/F	R	I	OA	12	1,3,6,12	10	2–3/Mo	Loxoprofen sodium	1 Mo	CR	Yes
12	44/F	L	III	OA	9	1,3,6	9	CD	Loxoprofen sodium	5 Mo	CR	Yes
13	70/F	R	I	OA	9	1,3,6	9	CD	Lornoxicam	9 Mo	CD	No
14	73 F	R	I	Normal	6	1,3,6	6	CD	Loxoprofen sodium	1 Wk	1 Day/Mo	Yes

Mo month, *Wk* week, *F* female, *M* male, *R* right, *L* left, *CR* complete release, *CD* contenously daily

[a] Radiological grade was evaluated according to Crowe et al. [14]

[b] Months after equipment of the brace

[c] Duration until release from the daily drug administration or persistent equipment

[d] Total hip arthroplasty was performed 13 months after the brace equipment

[e] Analgesics were required consistently before THA

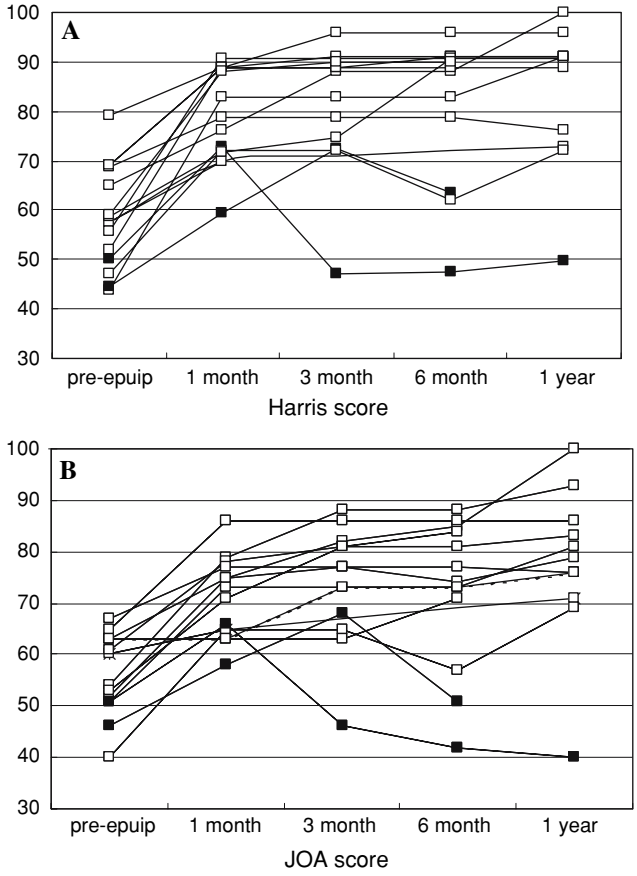

Fig. 3 Time course of the Harris (**a**) and JOA (**b**) scores of individual patients showing results of poor category (*closed square*) and fair or better categories (*open squire*) in final Harris score assessment

patients the improvement was kept at the follow-up assessment (open square), the increase in the score was diminished in two patients (case 6 and 14, closed square). In case 6, the hip brace provided a dramatic effect on pain, reflecting on the 23 total points improvement at 1-month follow-up assessment. Unfortunately, the patient felt so well that she walked a long distance at a big play land with her children for a whole day, causing severe coxalgia to develop. Total Harris score decreased under the first score point (49.6), which was the worst score point at 1-year follow-up assessments, and resulted in THA 13 months after the equipment of the brace. Although her condition did not improve, the hip brace was applied every day because the equipment relieved her pain. The common factors in these two cases with negative effect included bilateral involvement, unsuccessfulness of daily walking exercise, and therefore continuous dependence on analgesics and the brace.

The time course of the scoring points evaluated with the JOA score system was similar to that with Harris score (Fig. 3b). Average JOA score at the first assessment was 57, ranging from 40 to 67, and those at the 1-month assessment and the last review were 72 and 77.5 with significant difference ($P < 0.01$ and $P < 0.01$, respectively), confirming the functional improvement as shown in the Harris scoring system. Again, cases 6 and 13 did not show increase in the score points. In case 6, JOA scoring points decreased gradually until THA operation and then reached the worst score at 1-year follow-up assessment, in contrast to the time course of Harris scoring points (Fig. 3). The factors influencing the reduced point were pain development and progression of ROM restriction in both assessment systems. In contrast, points relating to ADL recovered. The discrepancy between the time courses of the total points of both scoring systems may be due to the different percent in score points relating to ROM, e.g., 5 maximum points for Harris score and 20 for JOA, respectively.

To evaluate variables contributing to total score improvement, average scores were compared between those of pre-equipment and those obtain 1 year after brace equipment in ten patients with improved scores (Fig. 4). The hip brace significantly improved the total score approximate 1.5-fold in both Harris and JOA scores ($P < 0.01$ for

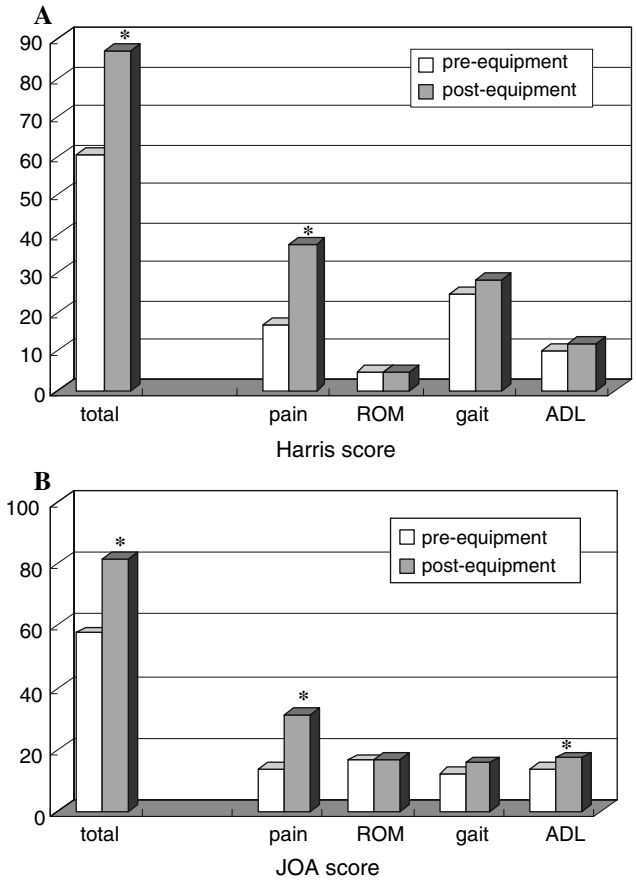

Fig. 4 Comparison of average scores of each variable between those of pre-equipment and those obtain 1 year after brace equipment in ten patients with improved scores. *Asterisk* indicates significant difference with *P* value less than 0.01

both). Variables influencing the improvement were related to pain-related points, which increased two-fold ($P < 0.01$ for both coring systems). ADL-related points were only improved significantly using the JOA scoring system, while other variables did not have a significant contribution in either the Harris or JOA system.

Radiological evaluation

As shown in Fig. 5, radiological changes were not found in patients with improved complaints and scores, even at 2-year follow-up assessment. Interestingly the brace showed positive effects on hip function scores in patients with radiological grade III (Fig. 6). On the other hand, Fig. 7 demonstrated the radiological changes in case 6, who developed pain and disability in daily life, and resulted in THA. Again the radiological findings showed negligible changes throughout the follow-up period. It was noteworthy that few direct changes from the brace were found (Fig. 7b).

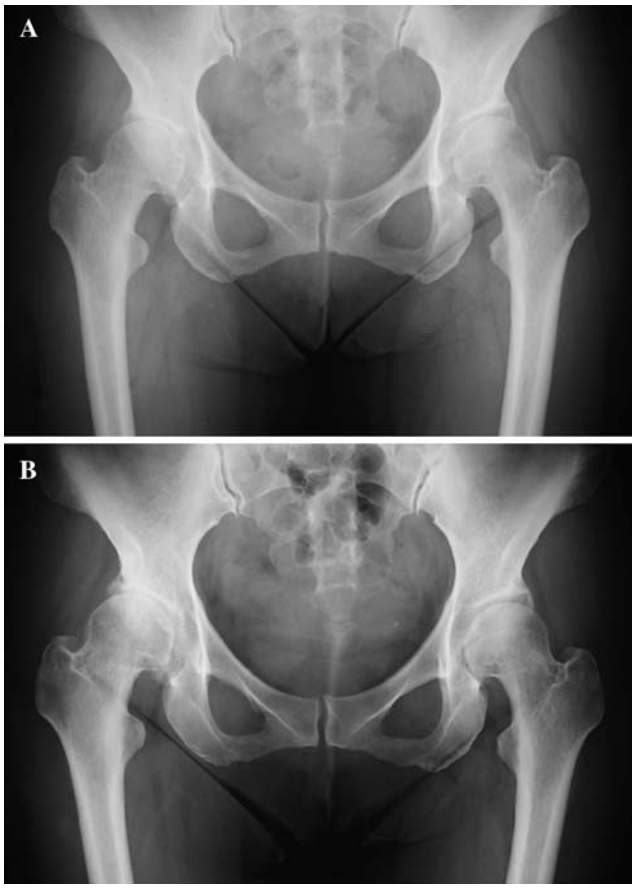

Fig. 5 Representative radiographies of hip joints with improved hip function. Antero-posterior views of hip joints in case 1, were taken just before the equipment (**a**) and 2 years later (**b**)

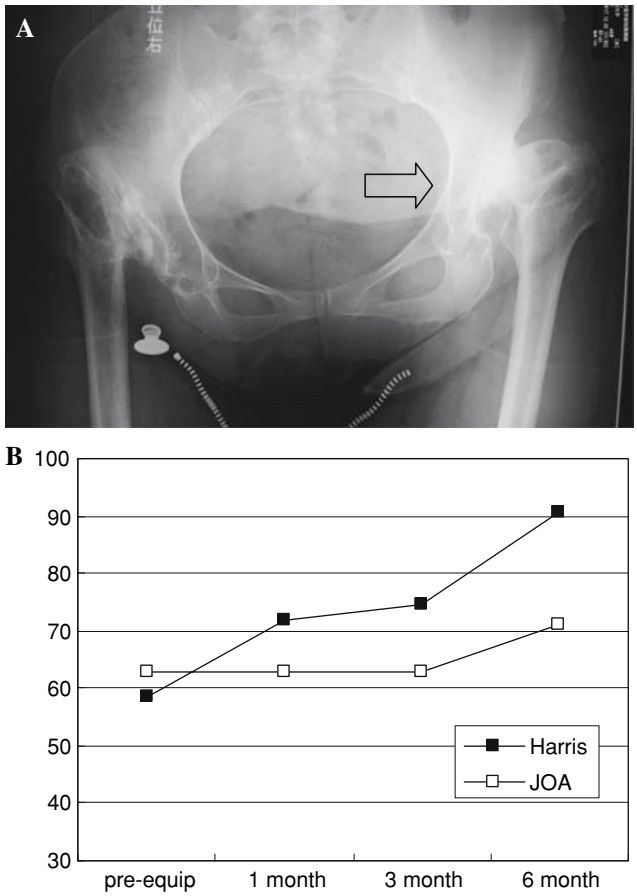

Fig. 6 Radiograph showing grade III of OA in case 12 (**a**). WISH-type S-form hip brace was applied for her left side (*arrow*), then improved her hip function scores (**b**)

Discussion

In the present study, high compliance of the WISH-type brace equipment was obtained with successful response of the patients with painful OA of the hip. This was the case even for a patient with progressive pain complaints, resulting in THA, by palliative effects. Most patients were able to stop taking analgesics. The pain control effects encouraged patients to perform daily walking exercise. This exercise outcome was not temporal. Harris and JOA scoring systems revealed these positive effects of the brace quantitatively.

Pain relief on gait was obtained immediately and dramatically after the initial use of the WISH-type S-form hip brace in all patients. Also 1 month later, all patients used the brace consistently in the daytime with improved scores by both Harris and JOA scoring assessments. The original S-form hip brace was developed with a design concept to reinforce the hip joint, permit flexion, extension, and abduction, to correct inadequate position of the limb, and to prevent up- and outward movement of the femoral head [1].

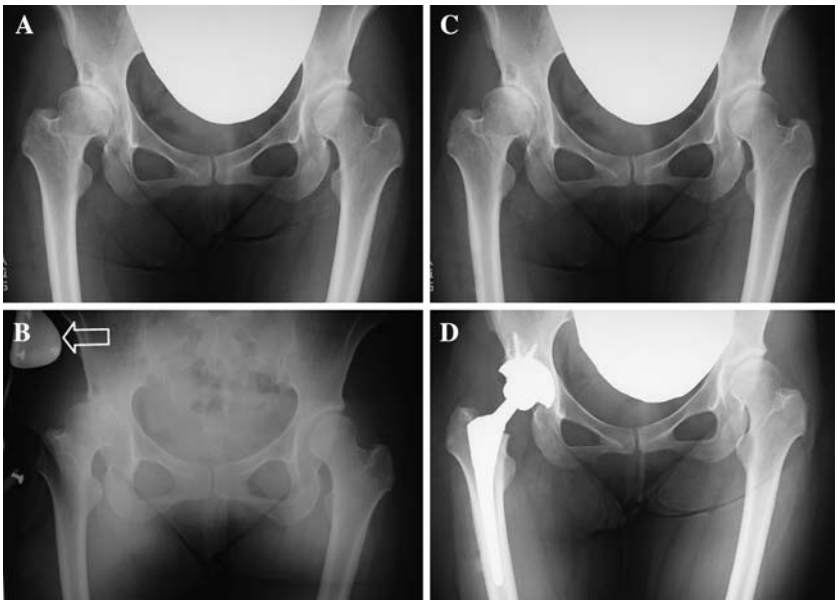

Fig. 7 Serial radiographies of case 6, in which the brace did not provide long-term efficacy, were taken at the first use of the equipment with (**b**) or without (**a**) WISH-type S-form hip brace, and just before (**c**) or after (**d**) total hip arthroplasty

The original brace provided pain reduction on gait [1]. The main improved portion of the present WISH-type hip brace was removal of the universal joint, leading to lighter weight and fewer cosmetic problems. The improvement in the WISH-type hip brace maintained the advantage of the original S-form hip brace by removing pain and dependence on analgesics. Furthermore, the WISH-type hip brace allowed patients to move actively and even sit in the traditional Japanese style. It is therefore suggested that the improvement of the WISH-type hip brace may contribute to high compliance in the daily use.

NSAIDs were required for 13 out of 14 patients for controlling their pain before the use of the brace. The analgesics have been shown to be effective in reducing pain and improving functional ability of the hip [3]. These drugs, however, must be used with caution, especially for long-term use because of their side effects [3, 4]. Serious risks of the analgesics involve gastrointestinal ulceration [15], coronary heart disease [15, 16], and deterioration in renal function [17]. In fact, most present patients were concerned about the continuous dependence on the oral drug, although palliative effects were realized completely. However, approximately three fourths of patients using the hip brace obtained independence of the analgesics. These results indicate a direct effect of the brace on pain control in the OA hip, and suggest that the brace may play an important role in the reduction of drug-induced side effects in the management of hip OA.

Two independent measures were used in the present study, since it has been suggested that the different hip scores often give contrasting measures of success in the same patient [18]. The therapeutic effects of the present hip brace were confirmed by both Harris and JOA scoring systems, demonstrating a steady improvement during the first month and a sequential recovery tendency in most patients. The most important factor contributing to the improvement of score points was pain. This was well correlated with the acquisition of independency of the analgesics, which reflected well on the Harris score [12]. On the other hand, pain variable, which does not include the assessment of analgesics [13], also showed significant improvement in the JOA scoring system. Interestingly ADL-related points were improved significantly in JOA only. Pain reduction likely induced by the present hip brace may contribute to Japanese style activities of daily living, such as squatting, which is only assessed in JOA scoring system [13].

It is noteworthy that continuous performance of daily walking exercise corresponded completely with final outcome of hip function at latest review, i.e., patients performing daily exercise obtained resultant categories of fair or better, while two patients, in whom hip function scores were poor result, could not perform the daily exercise. Based on these results, daily walking exercise may be associated with the improvement of hip function obtained from the hip brace equipment. Muscle dysfunction plays an important role in the pathogenesis of OA [19, 20]. These background exercise therapies, which aim at improvement of muscle function, increase of joint range of motion, decrease of pain, and increase of walking ability [6], are provided by physical therapist, but can be performed independently of the hospital. Exercise therapy has been shown to be an effective intervention for OA of the hip [7], and is recommended by guidelines [8, 9]. Some investigators, however, have shown that by 9 months after the end of the intervention period, patients' improvements regressed to baseline [10]. Thus adherence is suggested to be the principal predictor of long-term outcome from exercise [9]. Daily walking exercise in the present study showed high

adherence for patients with fair or better results. Possible factors contributing to the high adherence may be the relatively light road of the exercise, allowing patients to perform exercise with pleasure. It is likely that an ideal cycle, in which pain reduction induced by hip brace progresses active performance of daily walking and vice versa, may be constructed, and that an effect of the S-form hip brace might be temporal if daily exercise was not applied.

Kawamura described the positive effect of the original S-form hip brace on the radiological features [1]. However, no improvement in radiological findings was shown in patients with evident effect on hip function. Direct changes were not detected when the brace was applied, either. Negligible correlation between radiological findings and functional disability was suggested in hip OA [21]. Probably improved findings suggesting cartilage repair may not be expected radiologically, even in patients with improved hip function.

Complications in this series were few. On the other hand, two patients did not respond positively to the brace. The common factors in these two cases included bilateral involvement, unsuccessfulness of daily walking exercise, and therefore continuous dependence on analgesics and the brace. The notion that too much walking could induce persistent pain and interfere with the maintenance of the exercise should be considered, although the exact mechanisms are unknown at present.

Limitations of the present study may be the relatively short follow-up periods, since the conservative treatments consisting of analgesics, physical therapy, and bracing, are not radical. Hip arthroplasty could not be avoided in severe cases. Survival of the primary hip arthroplasty is not long, and resultant revision surgery is required for many patients [22, 23]. Thus from a time-saving point of view before operation, conservative treatments play an important role, especially for younger patients. Further studies with longer follow-up will be necessary. Another limitation is the lack of an approach addressing the mechanisms in which the bracing reflect on the gait for patients with hip OA. Kawamura reported enhanced pressure on the great trochanter by the original S-form hip brace [1]. Now a gait analysis for patients with hip OA, using the present brace is in progress.

In summary, the present WISH-type hip brace should be considered before performance of THA, especially for patients requiring analgesics with mild OA showing radiological grades I and II. Requirements of muscle exercise around the hip girdle involving daily walking should be emphasized for maintenance of the brace effects.

Acknowledgments We thank for Dr. Akitaka Ueyoshi, Kawasaki College of Medical Technology, for his kind suggestion, and Drs. Kiyoshi Mimura and Kunio Kamatani for their valuable discussion. This work was supported in part by a Grant of Japan Sports Medicine Foundation, Inc, in 2003 (HW), and by Grant-in-Aid for scientific research (C) 16591472 (H.W.) from the Japan Society for the Promotion of Science.

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