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REHABILITATION USING 13-DEGREE FORWARD BENDING POLES FOR PATIENTS WITH RHEUMATOID ARTHRITIS AFTER A TOTAL JOINT REPLACEMENT

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Abstract : Here we evaluate the usefulness of 13-degree forward bending pole-assisted walking to promote the early discharge of rheumatoid arthritis patients after a total joint arthroplasty. We evaluated two male and six female rheumatoid arthritis patients with an average age of 64 who received a total hip or knee arthroplasty. We required them to perform pole-assisted walking five times a week for 20 minutes a day. Rehabilitation lasted 4-6 weeks until discharge. Clinical follow-up included mobility, physical strength and flexibility assessments. After 1 year of pole-assisted walking, two patients can play golf without the assistance of a cane. Patients who performed pole-assisted walking improved their walking speed 1 year after surgery by 5 seconds compared with speeds measured 4 weeks after surgery. Chair stand repetitions also increased over that time. Pole-assisted walking improved the stability and safety of the ambulation of rheumatoid arthritis patients after surgery. Patients also reported improved arm and leg strength. No falls were reported 5 years after surgery. This clinical trial is thought to be specific to patients with severe pain in many joints including knees and hips.

Key words : pole-assisted walking, total knee arthroplasty, total hip arthroplasty, rheumatoid arthritis, thirteen-degree forward bending pole

INTRODUCTION

We recommend the early discharge of rheumatoid arthritis patients who can easily walk around a flat barrier-free corridor after a total knee or total hip arthroplasty. This is in part

because we have a financial motive to reduce hospital stays. However, early discharge is not always ideal for all patients. Despite their improvement as inpatients, two of our patients fell in their homes after their discharge. One broke her leg as a result of her fall. We therefore began to ask our patients to use medical poles with a 13° forward bend (Kizaki Inc. Komoro, Japan) for walking after discharge, and promoted additional training with these poles during their outpatient rehabilitation. Here we report our experience of medical poles during the post-operative follow-up.

METHODS

Our cases included two male and six female rheumatoid arthritis patients with an average age of 68.8 ± 8.3 years who had undergone either a total hip or total knee arthroplasty. Two patients had diabetes mellitus. No patients had a history of deep vein thrombosis of the lower extremities. No cases had postoperative limb-length discrepancy of more than 1 cm. One patient received bilateral THAs, two patients received a single THA, three patients received bilateral TKAs and two patients received a single TKA.

Rehabilitation Technique with Medical Poles

After patients fully mobilized with a walker, we required them to train with medical poles five times a week for 20 minutes a day over a 4–6 week period after discharge. We evaluated each patient's mobility, efficiency, physical strength and flexibility. There are five different types of rubber pads that can be attached to the bottom of the poles. We chose to use rubber pads with flat bases (Fig. 1). Five different rubber pad designs were registered with the Japan Patent Office.

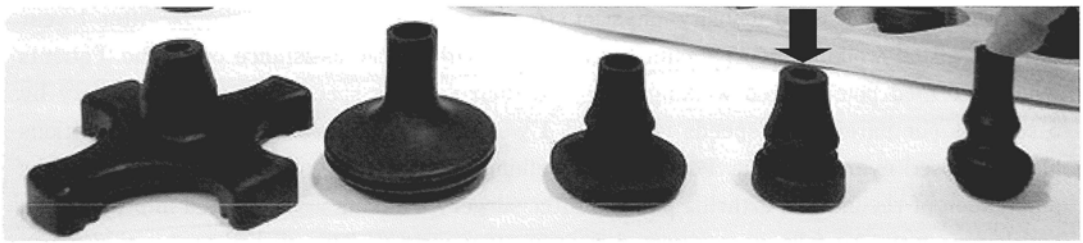

Fig. 1. Five types of rubber pads. The arrow indicates our choice of rubber pad for this study.

When we produced those forward bending poles, we instructed the 5 volunteers who were gathered to walk with poles that had curve angles of 10, 11, 12, 13, 14, 15, 16, 17, and 18 degrees for 60minutes each. And we checked their wrist pain and decided to choose the pole with the 13-degree bend for the best grip. This 13-degree forward bending pole design was registered with the Japan Patent Office.

Immediately after the arthroplasty, we adjusted the medical poles to be shorter than usual to aid walking without a change in walking speed. We initially recommended patients to use the medical poles in front of their weightbearing foot when they walked on the flat basement floor.

After discharge, we recommended patients to use the medical pole behind their weightbearing foot.

We performed physical strength evaluations 4 weeks and 1 year after the arthroplasty using the chair stand [1] and 10 m walking tests [2]. We also administered a subjective symptom questionnaire. Clinical exams included a shoulder stiffness evaluation, a deep breathing assessment, auscultation of the heart, evaluation of the upper and lower extremities for swelling, attitude assessment, weight measurement, an evaluation of the patient's overall appearance, gait assessment to measure staying power, balance and walking stability, a patient self-reported health evaluation, determination of the patient's fear of falling, how often the patient goes out and any self-reported increase in upper or lower extremity strength (Table 1.)

Table 1. Questionnaire on subjective symptoms

Questionnaire
1, shoulder stiffness
2. deep breath
3. palpitation of the heart
4. swelling of upper extremities
5. swelling of lower extremities
6. relaxed and feeling calm
7. maintaining of the proper weight
8. good appearance
9. increase of staying power
10. self-rated health
11. stable walk
12. well balanced
13. existence of fear to fall
14. the frequency of going out
15. increase of upper body strength
16. increase of low body strength
Answer choice
・improved
・no change
・take a turn for the worse
・no symptom from the firs

The chair stand test (30 seconds) is typically used to evaluate patients who have undergone orthopaedic operations such as anterior cruciate ligament reconstruction[1]. The 10 m walking test was performed with and without the medical poles. The 10 m walking test is typically performed to evaluate the mobility and respiratory status of patients with chronic obstructive pulmonary disease (COPD)[2] or other chronic lung diseases. As we did not have COPD patients in this study, we did not recommend patients to perform "Nanba-style walking", a traditional Japanese walk which involves rapid side to side foot motion typically used during this exam. Nanba-style walking is typically chosen by COPD patients because it allows the movement of the chest to synchronize with the movement of the pelvis, permitting easier breathing[3].

All patients were pre-measured for pole length and grip, which were critical to training success. Patients were introduced to the Nordic-style of walking during their rehabilitation through standardized lessons. The pole length was decided as follows. First, we can approximately calculate the pole length by multiplying the patient's height by 0.63. The patients

stand straight and put the pole in front of them. Then they put four fingers through the fixed pole strap with the middle finger staying at the height of their navel. The patients should bend their elbows to grasp the grip at a right angle. The instructors can then adjust the pole length according to the patient's body type and the way they walk.

Each lesson began with free walking for 10 minutes. The patients were then divided into three groups. Patients in Group A can walk well without the audible sound of squeaking shoes. Patients in Group B make squeaking sounds when they drag their feet during ambulation. These sounds can be improved by teaching these patients to use a wider upper arm swing with an easy twist. Group C included patients who struggle with pole-assisted walking. Many of these patients spontaneously corrected their walk when the instructor taught them to walk with their chin up.

The instructor needs to teach only elbow movement, not lower limb movement, to allow the patient to walk rhythmically. The patient should be instructed to walk leading with their arms instead of their feet.

Instructors should only use poles to demonstrate exercises, not to show the patients how to walk. At first, we tell patients to walk while concentrating on swinging their arms rhythmically. After 5 minutes the instructors can teach them to move their arms only in a horizontal manner, like a level boxing punch. This should permit a patient from Group B to join Group A. The instructors should walk side-by-side with the patient holding the poles in their hands but not using them for walking.

Patients should be encouraged not to engage in Nanba walking. Correction is permitted following the 10 minutes of free walking at the beginning of each session. Consistent reinforcement should be given while the instructor walks side-by-side with the patient. Patients should be taught by example, and with video recordings. Video recordings also allow patients to clearly recognize changes in their walking styles before and after each lesson.

During pole-assisted walking the instructor should apply gentle but firm pressure to the patient's back. This lesson will correct their posture for pole-assisted walking, allowing them to walk faster and much more easily.

To help patients to practice their horizontal arm swinging, the instructor should push the elbow gently. If the patient is right handed, the instructor should push the patient's left elbow because the swinging movement of their weaker hand is not long enough. About 10 pushes on the patient's elbow is enough for them to increase their elbow stroke. Instructors should avoid pushing the patient's elbow upward or downward. The strength balance required to push the patient's arm is about 80% forward and 20% backward.

RESULTS

Most patients did not have an initial interest in using the medical poles. However, all patients agreed to walk with medical poles after observing some patients had improved their walking and posture after using the medical poles,. Two patients suffering from rheumatoid arthritis (RA) with Steinbrocker stage II[4] and four patients with stage III disease chose to use the side strap grip (Kizaki Inc). This type of grip is good for promoting a natural walking rhythm

because the patient's thumbs are placed on the top of the hand-grip. Patients with Steinbrocker stage IV disease chose the wrist strap grip (LEKI Lenhert GmbH, Stuttgart, Germany). These patients had severe thumb deformities and were therefore unable to keep their thumbs on the top of the hand grip.

To allow the patients to walk as comfortably as possible, we initially allowed them to walk independently with the medical poles. We then taught them additional walking techniques using these poles, first demonstrating the four-point weightbearing walk as shown in Fig.2. After 1 year of therapy, all patients could walk with the pole held in the hand opposite their weightbearing leg. No patients chose to walk in the "Nanba style", which is with the medical pole held on the same side as the weightbearing leg.

Fig. 2. Four-point weight bearing, called "rehabilitation walking"

When walking times were compared 4 weeks after arthroplasty among patients with medical poles, T canes and free walking without an assistive modality, no differences were noted. One year after arthroplasty, the walking time for all three walking modality groups was faster (pole-assisted walking by 4.6 ± 1.2 seconds and free walking by 4.8 ± 1.5 seconds) comparing with the times measured 4 weeks after their surgeries.

The muscle strength of the patients' lower extremities improved after walking with a medical pole. Eight patients answered that long distance walking and walking up or down slopes became much easier with medical poles. The chair stand test after 1 year of walking with medical poles was greatly improved, by 5 ± 1.2 repetitions comparing with the results measured 4 weeks after the arthroplasty. When the results of the chair stand test improved by more than 20 repetitions, patients were more likely to return to all activities of daily living and recreational sports (Table 2).

Changes in patients' postoperative active range of motion (ROM) were measured using a fixed-angle device with five-degree intervals. In two cases, the active external and internal

Table 2. Rheumatoid arthritis patients cases. Preoperative demographics and postoperative activity

Case	1	2	3	4	5	6	7	8	Ave±Stand	P value
Gender	F	F	F	F	F	F	M	M		
Age	73	53	69	73	74	63	65	80	68.8±8.3	
S. stage	II	III	III	II	IV	III	III	II		
AngleR.	8	9	8	3	18	17	8	11	10.25±5.01	
AngleL.	8	8	7	9	14	9	4	15	9.25±3.62	
procedure	L.TKA	B.TKA	B.TKA	R.TKA	B.TKA	B.TKA	L.TKA	B.TKA		
UW4W	18.24	12.87	16.36	16.89	16.46	17.76	16.24	14.22	16.1±1.8	N.S.
PW4W	19.93	11.01	18.12	16.34	17.24	18.46	17.44	12.38	16.4±3.1	
UW1Y	13.67	5.82	13.31	10.78	13.88	14.21	10.68	7.98	11.3±3.1	N.S.
PW1Y	14.4	5.82	13.42	11.24	14.67	14.69	10.76	8.89	11.7±3.2	
CS4W	10	14	10	12	10	8	12	12	11±1.9	< 0.01
CS1Y	12	23	14	20	12	12	17	18	16±4.2	
Activity		Trip		Golf				Golf		

L:Left R:Right B:Bilateral THA:Total hip arthroplasty TKA:Total knee arthroplasty UW: Unassisted walking PW: Pole-assisted walking 4 weeks after surgery. 4W: 4 weeks, 1Y: 1 year, CS : Chair stand test (for 30 seconds) Angle: Radio carpal angle S.Stage: Steinbrocker Stage

rotation of the hip joint improved 1 year after the arthroplasty comparing with measurements 4 weeks after surgery. Two patients could play golf and perform the chair stand test effectively 1 year after surgery.

Subjective symptoms were also improved by pole-assisted walking. In six cases, patients reported improvement of their posture and easiness of walking on a downward slope. These six patients also reported improvement of long distance walking. Two patients were able to restart playing golf. Two patients could walk with longer strides and two patients noted diminished stiffness of the shoulder and neck regions. One female patient reported an increase in overall muscle mass, while her body weight decreased 2 kg. One patient reported the ability to return to work in her garden using a hoe.

Several cardiovascular and health benefits of medical pole-assisted walking were noted. Walking with medical poles increased patients' heart rates from 5 to 30 beats per minute. The rate of oxygen intake and the number of calories burned increased by 20%. All patients reported an increase in staying power, self-rated health, stable walking, and balance. They also all denied a fear of falling

Case presentation 1: Total Knee Arthroplasty

An 80-year-old RA patient presented to our group with Steinbrocker stage II hand changes and bilateral varus knee deformities with an FTA (Femoro Tibial Angle) of 200 degrees. We performed a left total knee arthroplasty that left the patient's left lower extremity 2.5 cm longer than his right extremity, disrupting his ability to walk. We therefore planned to perform a right total knee arthroplasty 4 months after the left TKA.

We used a 22-degree wedge-type metal augmentation for knees[5,6] to restore the deformity (Fig. 3). The patient could walk with medical poles three weeks after the surgery. The patient was capable of rigorous rehabilitation because the lengths of his left and right lower extremities were equalized.

After discharge the patient continued to walk with medical poles with the goal of improving

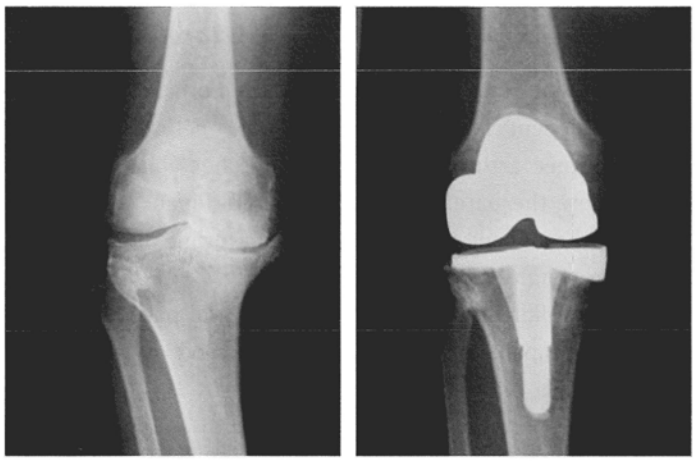

Fig. 3. Wedge Third 22° implant for defective portion for TKA. a) Preoperative radiograph, b) Immediately postoperative radiograph

his posture and the physical strength of his lower extremities. His chair stand test improved from 12 to 26 repetitions. The patient was able to return to his agricultural work and golf 1 year and 3 months after his second arthroplasty.

Case Report 2: Total Hip Arthroplasty

A 73-year-old man presented to our group with Steinbrocker stage III hand deformities and an inability to walk independently without the assistance of a T cane. We performed an arthroplasty of his right hip to improve his activities of daily living. However, he was afraid to walk with the medical poles days before his discharge, 1 year after discharge the patient could swing a golf club and displayed a significantly improved posture and lower back muscle strength. The patient's chair stand test also improved from 12 to 20 repetitions (Fig. 4).

Fig. 4. Seventy-three-year-old man who underwent right THA. He can play golf very well.

Case Report 3: Total Knee Arthroplasty

A 53-year-old female presented to our service with Steinbrocker stage IV hand deformities and an inability to walk independently because of the varus deformities of both knee joints. We performed bilateral total knee arthroplasties to improve her ability to perform the activities of daily living and to allow the patient to travel around Japan. We recommended that she walk with medical poles throughout the winter season. During the winter season she walked with medical poles using rough soled, non-slip shoes (Fig. 5). Her chair stand test improved from 14 to 23 repetitions. Walking was possible using medical poles both indoors and outdoors throughout the year. She is capable of walking in an aggressive style, but chooses to utilize the defensive style to prevent falls.

Fig. 5. Fifty-three-year-old woman who underwent bilateral TKAs., She cautiously practiced walking with medical poles 2 days before discharge.

DISCUSSION

The Nordic walk (NW) involves walking with poles in both hands to support a comfortable posture. A German study by Hagen et al[7] evaluating the advantages and disadvantages of NW found that it decreased the stress placed on the lower extremities during walking and increased the load on the upper extremities during running. It was demonstrated that NW training improved both the strength and walking speed of elderly patients compared with the improvements associated with traditional walk training[8]. Many authors have found that NW reduces the load and impact on patients' knees[9-11].

Walking with medical poles not only increased the patients' overall strength compared with traditional walking, but was also easier than walking without poles. Walking with medical poles decreases the patient's subjective motor strength but increases their heart rate by five to 30 beats per minute and their hydration uptake and calorie consumption by about 20%. These benefits may explain why the 53-year-old patient discussed in Case Report 3 lost two kilograms

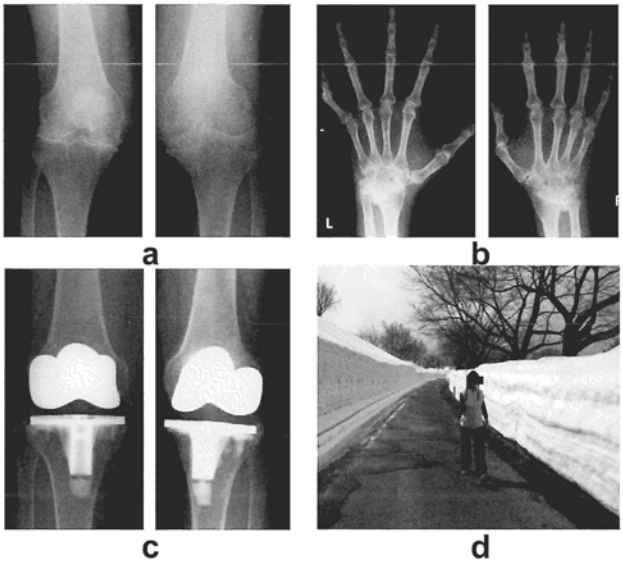

Fig. 6. a) Varus deformities of bilateral knees before surgery, b) The right radiocarpal angle was 9 degrees. The left radiocarpal angle was 8 degrees. c) Bilateral TKAs d) A 53-year-old woman could walk with poles in the winter time.

of body weight while gaining lower back muscle strength (Fig. 6).

Medical pole-assisted walking also helps to increase patients' walking balance, walking speed and walking posture. Pole-assisted walking also makes the upper body muscles work harder, which may explain the subjective decreases in shoulder stiffness reported. Stress on the lower extremities decreased when ambulating downslope with poles. This technique appears to be beneficial for rehabilitation after either total knee replacement or total hip replacement, increasing the patient's physiologic demands without increasing the subjective perception of effort[12].

On the biomechanical level, NW has an increased rate of displacement because of the longer strides permitted by NW compared with traditional walk training along with the increased movement of the upper limbs during NW. Ground reaction forces are also higher while a reduction in planter pressure is found in the central metatarsals[13]. There are 3 styles of NW (Fig. 7). We recommend the defensive style for ordinary patients to protect their bodies while walking to strengthen the muscles of the upper limbs, lower limbs and lower back equally.

We recommend that patients above 40 years of age use medical poles in the defensive style. As they progress through rehabilitation and can demonstrate the ability to walk with poles naturally with good posture while in the defensive style, at that time the patient can begin walking with the poles using the standard style (Fig. 7b). We recommend that the special aggressive style (Fig. 7c) be reserved for professional athletes. In Case Report 3 a 53-year-old female was capable of walking in an aggressive style 1 year after her arthroplasty, but chose to always walk in the defensive style to prevent a fall (Fig. 7a).

Ordinary men and women may be attracted to the aggressive style, but the general implementation of this technique may be very dangerous. If an ordinary person walking using

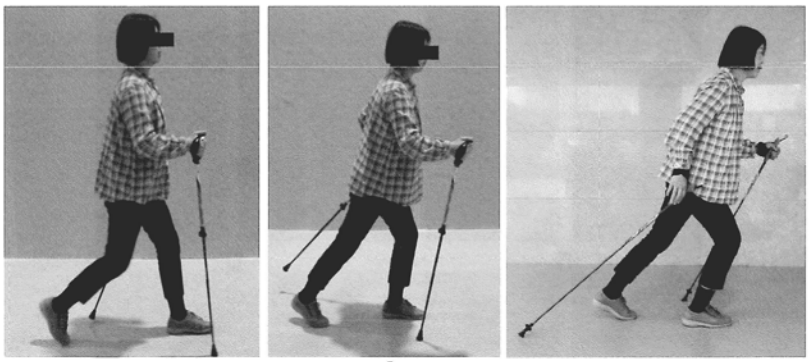

Fig. 7. Three styles of Nordic walking demonstrated by case No.2, six years after surgery. She is using cam lever style poles. a) defensive style b) standard style c) aggressive style using LEKI type poles.

the aggressive style accidentally fell forward, the poles would not be able to stop their fall like they would in the defensive style. We therefore strongly recommend that ordinary people who begin NW start with the defensive style.

The Kizaki medical poles are used by our group because they have two distinctive features. The first is the shape of the top of the hand-grips (Fig. 8a). The design of these grips was inspired by the Canadian gold medalist mogul skier Jean-luc Brassard, who grips his poles with his thumbs placed on top of the hand grips, using them in an alternating pattern[14]. The placement of the patients' thumbs on top of the handgrips helps them to quickly and easily adapt to the alternating patterns used in pole-assisted walking. Placing the thumbs on the grips also prevents the patient from putting excessive pressure on the hands, increasing the range of motion of the arms, shoulders and upper body. By lightly gripping the handgrips the pressure on the wrists is also reduced. If the patient has a thumb deformity and cannot place his or her thumbs on the top of the poles, they can grip the handle lightly and place their thumbs beside their index fingers in the shallow grooves of this grip.

The second distinctive feature of Kizaki medical poles is the 13-degree curved pole angle (Fig. 8b), which is based on ideal comfort and reduced pain after long-term pole use. The shaft of the pole is curved to match the natural angle of the human wrist[10] to make it easier to accommodate arm swing. Arm swing is important to allow for proper shoulder blade movement. This curve is particularly effective for people who suffer from stiff shoulders or wish to correct their hunched postures.

The abduction of the wrist is no more than 15 degrees. The adduction of the wrist joint is 40 to 45 degrees[15]. The middle of this ROM is a point 13–13.5 degrees flexed and 15 degrees adducted. We believe that this justifies why a pole grip bent 13 degrees forward is advantageous. The radiocarpal angle is about 15 degrees (Fig. 8c), measured using the radiocenter and right-angle reference lines. The radiocarpal angle is the angle formed between the right angle line and a line drawn from the tip of the radial styloid to the tip of the ulnar styloid[16]. We believe that a pole bend must also be around 15 degrees to maximize wrist comfort.

The medical pole grip is curved to match the natural angle of the human wrist to easily permit arm swing. This curve is particularly important for those patients who suffer from stiff shoulders or wish to correct their hunched posture. We can walk naturally with medical poles for longer durations than without poles[17]. We therefore strongly recommend medical poles for rehabilitation after THA or TKA.

An additional advantage of these poles is that they are telescopic and can be collapsed to 58 cm in length. This length is convenient for travel. (Fig. 8d).

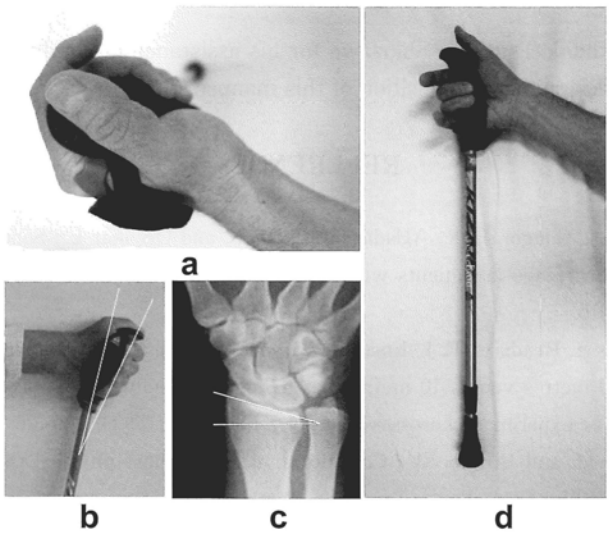

Fig. 8. Medical poles produced by Kizaki a) Thumb up b) Three-step telescoping style pole c) 13-degree forward bending pole d) Radiocarpal angle is 15 degrees.

The original aim of pole-assisted walking was not to encourage our patients to walk faster but to be able to ambulate in a stable and safe manner. Therefore, it is unsurprising that some of our patients are unable to walk faster now than they did prior to their surgery. However, they do report an increase in arm and leg strength, which may have contributed to our patients not sustaining a single fall for 5 years after their surgery.

During the same period we performed total joint arthroplasties on 148 osteoarthritis patients without pole-assisted walking. They are 121 female and 27 male osteoarthritis patients with an average age of 68.3 ± 11.6 who have undergone either total hip or total knee arthroplasty. Among them, five patients (4 female and 1 male) fell and needed femoral fracture operations. Osteoarthritis patients' muscles are usually stronger than rheumatoid arthritis patients' muscles, but they fell within 5 years of having surgery. So we recommend pole-assisted walking to the patients who will receive total knee or hip arthroplasty operations.

CONCLUSION

Walking with 13-degree forward bending poles significantly and safely improves the walking

balance, speed and posture of patients after total knee or total hip arthroplasties.

Improvements in quality of life scores following rehabilitation with medical poles were not affected by the patient's age, sex or Steinbrocker stage. However, they were affected by improvements in the chair stand test by more than 20 repetitions.

We recommend patients use Kizaki ® medical poles in the defensive walking style, as these poles have ergonomic features and the defensive style is safer than other walking methods.

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