Can the Alignment of the Knee Joint Resulting from Medial Femorotibial Osteoarthritis be Corrected by Physical Therapy?

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Abstract. The purpose of this report is to demonstrate that a patient with medial femorotibial osteoarthritis had significant pain relief after the application of a functional wrapping technique with exercise therapy. The authors also describe how to apply the wrapping to reduce the mechanical load on the medial articular cartilage of the knee joint. This report also indicates the possibility of the correction of malalignment of the knee by physical therapy, describing the mechanism of the knee joint deformity which is related to the rotational malalignment between the femur and tibia, and explains how the wrapping technique works on the knee joint. To conclude, although it is still ambiguous whether or not the knee joint alignment of the patient was corrected by physical therapy, it was indicated that the wrapping technique combined with exercise therapy was at least efficient in alleviating pain of the patient with moderate medial femorotibial osteoarthritis.

Key words: Osteoarthritis, Functional wrapping technique, External rotation of the tibia on the femur.

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INTRODUCTION

Osteoarthritis is one of the most common diseases and once a person suffers from osteoarthritis, it is persistent. Moreover, physical disabilities in bathing, negotiating stairs and housework are usually effected by the disease¹⁾, hence long periods of treatment are needed.

The lack of proper treatment in moderate or mild osteoarthritis causes the progression of the disease, and surgical treatment such as total knee arthroplasty might be required. These surgical treatments are well established and patients can return to most

previous physical activities. However such surgery is usually costly and leaves problems in terms of range of motion of the operated joints after the operation because of prosthesis functional limit. Thus the earlier the finding of the symptoms and treatment, the better and less costly it is to the patients.

Many articles have reported on the association of osteoarthritis of the knee, and obesity, disuse, abuse and quadriceps muscle weakness were regarded as risk factors^{2–6)}. Kling et al.⁷⁾ reported on the relationship between torsional deformities of the lower extremities and varus and valgus deformity in children. Eckhoff⁸⁾ also described similar

relationships related to osteoarthritis. These articles indicated femoral and tibial torsion as the main factor for knee joint deformities.

Although many articles discussed the reason why the knee joint is deformed, it is still not clear how the knee joint is deformed in either varus or valgus state. Thus it is important to know how the knee joint is deformed, and understanding this problem will lead to more effective physical therapy.

The authors have focused investigations on the gait analysis of the patients with osteoarthritis of the knee. Rotational malalignment between the femur and tibia could be the one of the risk factors in the development of osteoarthritis of the knee. The motion of the lower extremity during walking has been studied by the authors to clarify the risk factors of the deformities from kinetic and kinematic point of views⁹⁻¹³).

Rotational malalignment of the knee in the transverse plane was indicated as a factor of the deformities by the authors. When the subjects' tibia was controlled to rotate externally on the femur by an orthosis in healthy adult men, the amount of varus was significantly lower during walking as compared to walking with the tibia rotated internally¹²). Other features were also found during walking when the tibia was rotated externally on the femur as follows: displacement of the center of gravity to the stance side at the midstance phase and decrease of pelvic posterior rotation on the stance side in the transverse plane. These features could illustrate the beneficial body movements for patients with medial femorotibial osteoarthritis.

Physical therapy have been applied to remove the risk factors for patients with osteoarthritis of the knee. Even so, it has been difficult to correct deformity of the knee.

The purpose of this report is to show that a patient with medial femorotibial osteoarthritis had significant pain relief after an application of a functional wrapping technique with exercise therapy. It is also described how to apply the wrapping to reduce the mechanical load on the medial articular cartilage of the knee joint. The mechanism of the wrapping technique and possibility regarding correction of malalignment of the knee by physical therapy are also discussed.

CASE REPORT

The patient was a 72-year-old Japanese woman with a diagnosis of bilateral medial femorotibial osteoarthritis, and the grade was 2 bilaterally according to the radiographic grading system by Watanabe et al.¹⁴).

The patient had been seen by an orthopaedist from March 1989 because of pain of the left knee, with difficulty of sitting on the floor with the knees fully flexed and with the toes beneath the buttock (sitting in the Japanese fashion). Oral medication was prescribed for pain relief. Five years later, the patient was hospitalized because of shingles and facial palsy. The patient suffered from bilateral osteoarthritis four months after admission, and oral medication was prescribed for the knee joints again. After that, the patient was without pain for nine months.

Because of a recurrence of effusion on the right knee joint, the patient was referred to outpatient physical therapy to reduce pain in December 1995. At that time, the patient's chief complaint was pain while descending stairs, walking immediately after sitting or lying down for a long time and when tired.

The initial physical therapy evaluation included assessments of passive range of motion (ROM), manual muscle testing (MMT) and gait analysis. In terms of ROM, internal rotation of the hip was measured as 30 degrees in the right and 40 degrees in the left, and external rotation of the hip was 50 degrees in the right and 45 degrees in the left. In the same way, internal rotation of the knee was measured as 35 degrees in the right and 40 degrees in the left, and external rotation of the knee was 20 degrees in the right and 10 degrees in the left. Extension of the knee was observed to be lacking 5 degrees bilaterally, and flexion of the knee was measured as 145 degrees in the right and 150 degrees in the left. The MMT score was 3/5 in the hip flexor and hip adductor muscles bilaterally, 3+/5 in the hip extensor, abductor, ankle extensor, flexor muscles bilaterally and right knee flexor muscles, and 4/5 in the knee extensor muscles bilaterally and left knee flexor muscles. The gait was observed and lateral thrust of the knee and intoeing walking existed bilaterally. The clockwise rotation of patient's pelvis in the transverse plane was observed to be excessive during the stance

phase of the right lower extremity.

The patient performed exercises with resistance to strengthen the weakened muscles. The patient also performed active stretching therapy in internal rotation of the hip and external rotation of the knee to extend ROM. These exercises were done at home and two or three times a week at the department of physical therapy, since the patient took part in physical therapy as an outpatient. In addition, the emphasis of out-toeing and push-off (heel rise) during walking were advised in an attempt to regain the normal walking posture that could avoid the uneven stress on the articular cartilage of the knee joint.

The patient kept doing these exercises for two years without active stretching therapy because pain on the knee arose during the stretching. Although the patient's ROM, muscle strength and chronic pain improved, the lateral thrust of the knee and pain of the right knee remained after long walking and during walking immediately after sitting and lying down for a long time.

In October 1997, use of the functional wrapping technique on the right knee joint to induce external rotation of the tibia was started in order to reduce the lateral thrust of the knee and pain.

WRAPPING METHOD

The functional wrap used by this patient is shown in Fig. 1. The outer lining of this wrap consists of a knit fabric in order that it has elasticity, and the inner lining is made of a special rubber fabric which adheres to the skin. This wrap has good ventilation and therefore the patient's skin was rarely sweaty.

The first preparation for the wrapping was to let the patient sit on a chair properly. The patient was told to sit on the edge of the chair and instructed to move the thigh inward (i.e., combination of two motions; adduction and internal rotation of the hip) as much as the patient could do, keeping the sole in contact with the floor. The patient was also instructed to turn the toe outward as much as possible to extend the external rotation of the knee.

In terms of the rotation angle of the knee, there have been several published reports^{15, 16}. Müller¹⁷ evaluated the rotation angle of the knee as being at maximum at 45 degree flexion of the knee joint. However, in terms of this wrapping technique, the patient was given verbal directions to keep the knee

Fig. 1. Superwrap[®]. Left: Inner lining, Right: Outer lining. HENRY JAPAN CORPORATION (exclusive agency of APPLIED TECHNOLOGY LTD), 3968 Uruido, Hasudashi, Saitama 349-0013, phone +81 48-766-7111.

joint flexed at approximately 90 degrees throughout, because of the clinical simplicity and ease of understanding for the patient. In fact, this direction was effective enough for the patient to slacken the soft tissues surrounding the knee joint in order to obtain maximum external rotation of the tibia on the femur.

The wrapping was applied from the medial margin of the tibia approximately 10 cm below the tuberosity of the tibia, diagonally across to the fibula head (Fig. 2a). After a couple of rounds on the shank, pulling the wrap inward and strongly at the popliteal region to induce the tibia rotation externally, it was then wrapped up to the thigh (Fig. 2b). After a couple of rounds on the thigh, it was then wrapped down to the shank again, and ended around there. To allow comfortable knee joint flexion, a space was left around the patella (Fig. 2b).

After the wrapping was applied, the patient walked on the walking space, and gait analysis with the wrap was made in order to evaluate the effectiveness of the wrapping. This could be decided based on whether the patient was comfortable, whether the patient's head was directly above the right foot during the stance phase of the right leg, and whether the lateral thrust improved especially at the heel contact.

The wrapping was applied daily by the patient, and a physical therapist checked its effectiveness when the patient visited hospital. The patient was advised to wrap the knee at all times except when

Fig. 2. Wrapping Procedure. a: Applying from the medial margin of the tibia to the fibra head. b: After a couple of rounds on the thigh, wrapping ends around tibia. A space is made around the patella.

Fig. 3. Radiographical change of the right knee joint between two roentgenograms. Left: In September 1996, FTA=182°. Right: In December 1997, FTA=180°. Slight improvement of joint narrowing.

the patient went to bed or bathed, and it was emphasized to wrap whenever the patient went out.

RESULTS

Two weeks later, the patient reported that she was able to walk with the wrap for a long time without pain, and that even when she walked immediately after sitting or lying down for a long time, she did not feel pain.

Femorotibial angle (FTA) of the patient was

measured radiographically in December 1997, and two degrees difference was found from the radiograph that was taken in September 1996 (Fig. 3). Moreover, the joint space was slightly larger and the contact surface between the femoral and tibial articular cartilage on the medial compartment was apparently smaller in December 1997 than in September 1996.

Impairment measurements were also taken in December 1997 to determine whether they had changed from the initial visit. Regarding the ROM,

internal rotation of the hip was measured as 40 degrees in the right and 35 degrees in the left, and external rotation of the hip was 45 degrees in the right and 50 degrees in the left. In the same way, internal rotation of the knee was measured as 35 degrees in the right and 40 degrees in the left, and external rotation of the knee was 35 degrees in the right and 20 degrees in the left. In terms of extension of the knee, it was zero degrees bilaterally, and flexion of the knee was measured as 145 degrees in the right and 150 degrees in the left. The MMT score was 3+/5 in the hip extensor bilaterally; 4/5 in the hip flexor bilaterally, left hip abductor and adductor, and left knee flexor; 5/5 in the right hip abductor and adductor, knee extensor bilaterally, right knee flexor, ankle extensor and flexor muscle bilaterally. In short, it seemed that the exercise and active stretching therapy was also effective at improving the impairment of muscle strength and ROM.

The patient kept attending the hospital and kept doing exercise consistently after the change, and the patient sometimes had an ache in the knee both after she travelled and walked for a long time. However the patient said it was not as severe as before.

DISCUSSION

Many factors lead to osteoarthritis, such as obesity, muscle weakness, occupational stress and abuse of the joint, and soft tissues surrounding the knee joint which are influenced by the factors could be the source of pain¹⁸). Pain is understood as a chief complaint of the patient with osteoarthritis of the knee. Pain relief should be sought in physical therapy practice at first, and the return to previous physical activity level will be the long term purpose for patients.

In this case, although pain improved at first, the patient still had pain after she walked for a long time and when she walked immediately after sitting on a chair for a long time. As Kling et al.⁷⁾ commented, there will be a thrust in most pathological conditions that cause varus and valgus deformities such as osteoarthritis. Kling et al. also indicated that the main reason for pain of medial femorotibial osteoarthritis was lateral thrust during walking. Hence even though the patient had stronger muscles and a more balanced ROM than before, the knee joint had to be supported with

something besides muscles, because the soft tissues surrounding the knee joint were not tight enough to support the joint. Moreover, the rotational malalignment between the femur and tibia had to be corrected to reduce the abnormal uneven mechanical load on the medial articular cartilage of the knee during walking. The use of the wrap is meaningful from such points of view.

Incidentally, many researchers have reported the effect of valgus orthosis¹⁹⁻²¹⁾ for medial femorotibial osteoarthritis, and these were significantly useful for pain relief, activities of daily living and walking. However, not every patient can wear these orthoses because they are cumbersome and uncomfortable. There is also a study which reported an undesirable higher intracompartmental pressure between the femur and tibia by wearing a functional knee brace²²⁾. Thus the functional wrapping technique is still useful and meaningful for patients with mild or moderate osteoarthritis of the knee, especially those who do not want to wear cumbersome orthoses.

In general, the knee joint flexes twice after the heel contact during walking and the first flexion is considered as one of the functions of shock absorption²³⁾. However, if the toe points internally relative to the knee direction in the transverse plane, a force which thrusts the knee joint laterally could arise after heel contact¹²⁾. The converse could also happen. Similar situations could also happen to the knee joint of the patient with femorotibial osteoarthritis. If their lower extremities are not in good alignment in the transverse plane, the knee joint would have not only flexion but also abduction or adduction to absorb the force after the heel contact; the ligaments such as the medial collateral ligament, lateral collateral ligament, anterior cruciate ligament and any other soft tissues surrounding the knee joint would be then slackened (Fig. 4).

As several researchers have explained^{24, 25)}, laxity of the knee joint leads to osteoarthritis, and these small changes would be big enough to hurt the soft tissues surrounding the knee. Over a long period, cumulative small forces keep stretching the soft tissues and the alignment of the knee joint would be changed. In other words, with respect to the patient with medial compartment osteoarthritis of the knee, it could be possible that the more proper external rotation of the tibia on the femur a patient acquires, the more one can prevent the lat-

Fig. 4. The difference of shock absorption at the heel contact between three conditions. A: Tibia is rotated laterally on the femur. B: Tibia is in neutral. C: Tibia is rotated medially on the femur. After heel contact, knee bends with normal strain on the ligaments in B. With stronger strain on MCL in A. With stronger strain on LCL in C.

eral thrust.

Figure 5 shows the difference of the frontal view at heel contact before and after the patient underwent the wrapping technique. The increase of trunk inclination to the stance leg side could mean the decrease of lateral thrust on the knee at heel contact, and this perhaps explains why the patient's pain is alleviated effectively. If the amount of lateral thrust after heel contact decrease, the abnormal mechanical loading on the medial cartilage could also decrease.

In terms of articular cartilage, it is controversial if it is reversible. Because the mature articular cartilage is avascular and aneural, it has been reported that severe cartilage lesions resulting from fracture and frictional abrasion are usually irreversible²⁶⁾. Even so, according to a current study²⁷⁾, articular cartilage has an ability to regenerate which is controlled by chondrocytes. Tyler et al.²⁷⁾

noted that the success or failure of cartilage repair depends on the ability of the repair cells to reestablish a hyaline cartilage with physiological mechanical properties.

Moreover, significant radiographic change of the alignment of the knee joint after an application of orthosis to the osteoarthritis of the knee have been reported by several researchers, although whether or not the articular cartilage was regenerated was not clear^{28, 29)}. In short, the alignment of the knee joint of osteoarthritis could be changed without surgery, and it should be possible to change the FTA by physical therapy in the future.

It is also important for patients with femorotibial osteoarthritis to undertake exercise therapy as well as wrapping techniques. The muscles and the imbalance of joint mobility which affect joint stability and walking posture should be strengthened or corrected respectively. Krugh et al.³⁰⁾ reviewed the

Fig. 5. The postural difference of walking before and after the application of the wrapping technique. Left: Before the wrapping, the head and trunk inclined to left side. Right: After the wrapping, the head and trunk was just above the right foot.

relationship between skeletal malalignments of the lower quarter and correlated motions and postures from previous literature, and interpreted that genu varus could be related to internal tibial torsion and ipsilateral hip external rotation. Fukushima et al.³¹⁾ also indicated that ankle joint mobility affects the hip and knee joint movement in the transverse plane. Hence physical therapists should assess the detail of patient conditions in terms of muscle strength and joint mobility and revise the therapy according to the results in an attempt to remove the biomechanical risk factors of osteoarthritis of the knee.

In this case, it should not be reported that the alignment of the knee joint was corrected, because such a minor change should be considered as one within the range of measuring error. More accurate methods of measuring the joint space narrowing by computerized measurement were reported recently^{32–34)}. Further research is indicated to measure the joint space narrowing accurately. Moreover Jordan et al.⁵⁾ pointed out that knee pain severity is more important than radiographic knee osteoarthritis severity to determine disability. WOMAC (Western Ontario and McMaster Universities) OA Index³⁵⁾ has been well accepted as a functional assessment index of osteoarthritis involving a series of pain scales. Application of

these assessments should be considered in comprehending the functional status of patients.

To conclude, a patient with medial femorotibial osteoarthritis showed significant pain relief and improvement of walking after the application of a functional wrapping technique combined with exercise therapy. This experience indicated the possibility that this combination could be a remedy to correct the malalignment of the osteoarthritic knee joint in the future. Although the methodology of radiography and pain assessment were not accurate enough in this report, the wrapping technique could be useful and meaningful for patients with mild or moderate osteoarthritis of the knee to relieve pain and improve physical activities. This case study is a prelude to an experimental and cross sectional studies regarding biomechanical association of osteoarthritis of the knee.

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