

The Effects of Increasing Mass Unloader Knee Orthosis and Two Kinds of Silicon and Polyethylene Pad on Pistoning Movement during Walking

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ABSTRACT

Introduction: Knee orthosis is used in different cases and can be seen pistoning movement in all orthosis. The purpose of this study was to evaluate the effects of increasing mass knee brace and two kinds of silicon and polyethylene (PE) pad on pistoning movement during walking, on health subject.

Material and Methods: A total of 20 healthy volunteers, including 10 men and 10 women, with an average age of 24.65 years, participated in this study. Subjects used unloader knee brace with PE and silicon pad, with and without weights in four phases, and at each phase, they engaged in 10 minutes' walk. Before and after each phase, using a video camera, the brace displacement on limb was measured with a marker. Finally, the pistoning movement of the orthosis on the knee was measured using the Kinovea software.

Results: This study showed significant differences between the four tests ($P < 0.050$). The mean migration of the orthosis with silicon pads in both genders was lower, compared to the average migration of the orthosis in the three other cases (0.65 cm), and the amount of migration knee brace with silicon pad with weights, PE pad, PE pad with weights was 4.1 ± 1.6 , 3.1 ± 1.4 , 6.3 ± 1.8 cm, respectively. An inverse relationship existed between the level of comfort and orthosis migration. Orthosis with silicon pad demonstrated the highest level of comfort and orthosis with PE pad, with weight showing the lowest level.

Conclusion: The results showed that the use of silicone pads inside the brace construction, as well as lighter than knee brace, reduced migration, and increased comfort level. Moreover, compliance to knee braces was improved.

Keywords: Silicon pad; Polyethylene pad; Pistoning movement; Knee brace

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Introduction

The human knee is considered as the largest and most complex joint collection and one of the most vulnerable joints (1). Normal knee function requires a careful balance between stability and movement which is dependent on the stability of ligaments, joint surfaces, and the muscle covering the joints (2). Any impairment in the structure of knee leads to a loss of function or change in the mechanics of the knee joint (1). Abnormal rotation, depending on the changed position of contact joint, may lead to osteoarthritis of

the knee (3-6). When the knee orthosis is used, in theory, the complementation of the movement range should be allowed without any restriction, except when the orthosis is prescribed in order to limit the range of motion or enhance the stability in soft tissue under malfunctioning conditions. However, the truth still remains that, available orthosis are far from the ideal situation. It is necessary to carry out the kinematic, kinetic and position of ligaments, since the normal, natural and detailed rotation axis of the knee and the orthosis joint are closely located (7, 8). Because of the

mismatch between knee orthosis and anatomical mobility, this leads to a shear force on the soft tissues, change in joint kinematics, decreased ability of orthosis for the control of anterior tibial displacement and also limitation in the normal range of motion and subsequent remedial actions and appearance of unwanted forces and limitation in joint forces, orthosis displacement to distal (pistoning moves of the limb orthosis) and condylar separation, eventually leading to osteoarthritis of the knee (1, 9, 10). When knee orthosis is used, a number of inconsistencies occur resulting in the application of the forces through the knee orthosis, while the limiting and unwanted forces lead to the displacement of orthosis and its pistoning movement on the extremity of the body. The pistoning movements are considered as up and down movement or longitudinal components of orthosis on the lower limb segment. Limiting forces of the orthosis have three-dimensional natures, this implies that the components can either be in the longitudinal (upper, lower), anterior-posterior and internal-external directions. Limiting powers in the anterior-posterior and internal-external directions are used especially when the orthoses are applied to compensate for the incompetence of the soft tissues. Limiting forces in the longitudinal direction lead to unwanted pistoning of the components of the orthosis during movement.

Pistoning forces prevent the normal range of motion and also cause skin irritation due to the pressure on the bony prominences in the suspended points (11). The distal or slip displacement of orthosis is a common problem in the use of functional knee orthosis (12-15) and may simply lead to failure of orthosis to match the soft tissue of the foot during the repetitive muscle contractions, during activities (15), and this ultimately reduces the convenience and acceptance of orthosis by the patients (12). Van Leerdam (16) stated that slipping of the brace occurs due to four reasons: gravity, lack of friction, the cone-shaped foot, mismatched axis of rotation of the anatomical knee and orthosis, and dynamic forces. Moreover, he stated a new theory that the main reason of disability of the knee brace is the stretched anterior skin of the limb when bent, because several times after bending the knee, this phenomenon leads to the displacement of the brace on the limb. Although studies have reported slightly different levels of orthosis displacements during activities (12, 14, 15, 17-19) between 0.25 mm (12) and 10.83 cm (19), however, it is believed that distal movement occurs in all orthosis. Since the functional orthosis is primarily used for defects in anterior cruciate ligament, the designs having Hing-Post-Shell may cause less displacement compared to the Hing-Post-Strap, due to their increased hardness and strength, as well as provision of more contact with the soft tissues (13, 19-21). Lewis et al. (9) found that an improvement in the design and

manufacture of knee braces and corresponding closeness of their movements to the natural knee joint resulted in a reduction of the limitations of movement and discomfort often associated with pistoning. Although many manufacturers of the knee braces have tried to prevent the displacement of brace on the limb by improving the designs of the orthosis for better fit on the body; however, the clinical experiences suggest that a large part of the problem still remains (22). The proximal and distal shells of the knee orthosis can be made from different materials, such as polypropylene, polyethylene (PE), nylon, carbon or fiberglass, with thermosetting or thermoplastic resin and rigid foam made of ethyl vinyl acetate, or polyurethane plastozote. Silicones are adequately thick and soft which can lead to the comfort of patients through the use of orthosis. Since silicones have adhesion properties in the coating pads of the orthosis, they are applied to prevent the slipping and displacement of the orthosis on the limb, and also prevent the inflammation of skin by preventing the displacement of orthosis. However, according to the disadvantages of the pistoning movements on the limb, and also since this movement can influence the acceptance of the orthosis by the patient, then the present research aimed to evaluate and compare the effects of the construction factors on the orthosis, including increased mass of orthosis, PE pads, and silicone pads inside the knee orthosis, to prevent the pistoning movements in the traditional orthosis.

Materials and methods

This intervention - quasi-experimental research was conducted to assess 20 healthy volunteers (10 women and 10 men), having a mean age of 1.08 ± 24.65 and body mass index (BMI) of 1.08 ± 22.42 . Samples were collected by non-probability method among the students of the Faculty of Rehabilitation of the Medical University of Iran, who had the inclusion criteria, and were willing to participate in the study. The Ethics Committee of the Medical University of Iran (on 2/07/2014 with registration number of 5121/105/D/93) was approved, and consents were obtained from the participants. Criteria for inclusion in the study included students without any congenital hip problem, no history of any damage or failure in the lower extremities, as well as a body size index within the normal range. Exclusion criteria included pain in the knee joint during walking and the unwillingness of people to continue with the test. All assessments were carried out during a meeting, using an unloader knee orthosis with the single upright. Orthosis evaluations were performed in four states of orthosis with PE padding, orthosis with PE padding with the weights, orthosis with silicone pads, and orthosis with silicone pad with a weight and randomly, while the mass of weights added to the orthosis was 450 g. Before starting to walk, the anterior superior iliac spine and



Figure 1. The pictures relevant to the dynamometer and the pads inside the shells of orthosis

the upper edge of the upper shell of orthosis, together with the lower edge of the lower shell and ankle of the participants, were remarked and eventually, participants were asked to walk for 10 minutes on a flat surface and also walking up and down the stairs. The pulling force of the straps was measured by the dynamometer of model ISF-F500 and each participant was filmed at the beginning and end of each 10 minutes. Finally, the distal migration of the orthosis on the knee was measured by the Kinovea 0.8.15 software (Copyright © 2006-2011- Joan Charmant & Contrib. Kinovea is subject to the terms of the Gnu General Public License version 2). The Kinovea software can view the videos according to the angle and distance analysis of the markers. This application is highly reliable and valid, according to studies conducted by Balsalobre-Fernandez et al. in 2014 (23) and Ogueta-Alday in 2013 (24). At the end of the test, the comfort of the knee orthosis was easily evaluated in four modes, including orthosis with PE pads, orthotics with PE pads with weights, orthosis with silicone pads, and silicone pad orthosis with weight, using a visual analog scale.

Figure 1 shows silicone and PE pads, as well as the force-displacement measuring instruments of the orthosis.

Figure 2 shows pictures before and after the orthosis with silicone pad.

In this study, statistical analysis was performed by Statistical Package for Social Sciences software (version 21; SPSS, Inc., Chicago, IL, USA). To accommodate the data distribution with the normal theoretical distribution of the data, the Kolmogorov-Smirnov was used. Analysis of variance test with the repeated observations was used to compare the amount of displacement between the four modes of the orthoses. Finally, the Bonferroni test was used for pairwise comparison. In addition, the relationship between the type and level of comfort of orthosis was measured using the Wilcoxon test. A significance level of < 0.050 was considered in the statistical tests.

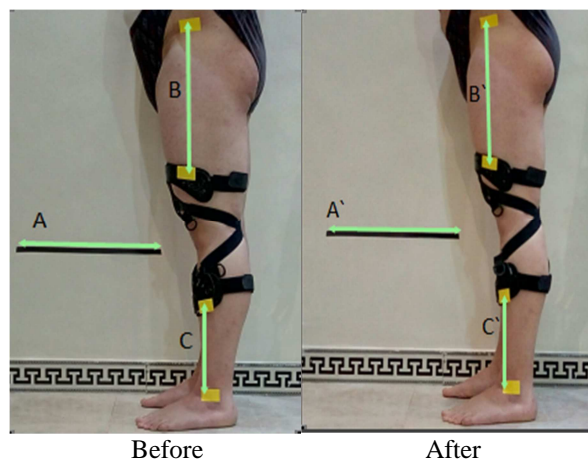


Figure 2. The method to measure the displacement of the knee orthosis with silicone pad before and after the walking, A & A': Calibrate line (Before and After), B & B': Distance markers to upper edge orthosis (Before and After), C & C': Distance markers to ankle (Before and After)

Results

About 20 healthy volunteers consisting of 10 men and 10 women participated in this study. The normality of the distribution of variables was obtained using a non-parametric Kolmogorov-Smirnov test.

Table 1 shows indicators of central tendency and dispersion for age, gender, height and BMI in four modes of the knee orthosis.

The movement of orthosis in four modes, orthosis with PE padding, orthosis with PE padding with weights, orthosis with silicone pads, orthosis with silicone pad and weights is shown in table 2.

Table 2 compares the displacement of four orthosis.

The orthosis migration amount is shown in table 2 for four modes, including orthosis with silicone pad, orthosis with silicone pad with the weight, orthosis with PE pads, and orthosis with PE pads with the weight.

Table 1. Demographic characteristics of participants

Variable	Mean \pm Standard deviation	Minimum	Maximum
Age (years)	24.650 \pm 1.089	23	26
Height (cm)	171.1500 \pm 9.9328	155.00	189.00
Weight (kg)	66.025 \pm 10.029	52.00	87.00
BMI (km ²)	22.4230 \pm 1.0840	20.63	24.89

BMI: Body mass index

The mean migration of the orthosis with silicon pads in both genders was lower compared to the average migration of the orthosis in the three other cases (0.65 cm). In both groups of male and female, the mean migration of the orthosis with the PE pads with the weights was higher than the three other modes and given as 6.31 cm.

Discussion

This study aimed to investigate the effect of increasing the mass of orthosis and both PE and silicone pads on the pistoning movement of the knee orthosis with the single upright. The results of the study supported the hypothesis on the effect of weight gain orthosis and the use of silicon pad. Although studies have reported slightly different amounts of migration during daily activities, such as walking on a flat surface or a treadmill, and during exercise (12, 14, 15, 17-19) as 0.25 mm (12) and 10.83 cm (19), the results of all studies indicated distal migration of the orthosis and patient complaints. In a study conducted in 2000 by Rast, the magnum lite pads which were made of neoprene brace had a linear migration and rotational migration more than two C.Ti Edge and C180 orthosis, which were made of silicone and acrylic resins, respectively. However, C.Ti and C180 orthosis had no significant difference in migration (19), and this was consistent with the results of the present study in the field of orthotics which demonstrated less displacement with silicone pad. Greene et al. (14) used different orthosis and the orthosis made of Donjoy Legand, which were very light and had their inside covered by

pneumatic pads made from Kraton, resulting in an internal-external migration which was less than the other orthotics. Wojtys and Huston (18) used two types of orthosis, including the brace with custom fit and prefabricate braces both of which were of the Donjoy braces and were both made of neoprene, but finally, it was observed that the migration of the Custom Fit Orthosis was 18.6 mm and the prefabricate orthosis migration was 5.4 mm (18). The results of this study are consistent with the results of the studies of Greene et al. Orthosis used in this study was far lighter than the others, that it improved the movement of the orthosis on the limb. Furthermore, the use of silicone pad also influenced the amount of migration of the knee orthosis on the limb.

Conclusion

The results showed that the use of silicone pads inside the brace construction, to cause contacts with the patient's skin, influenced the reduction in the amount of the orthosis migration on lower limb, as well as increased the comfort of the patient when using the orthosis during walking, moreover less orthoses weight, as much as possible, will prevent the orthosis migration. Finally, in this study, the minimum migration level and maximum of comfort belonged to the orthosis with silicone pad; in contrast, the maximum amount of migration and minimum comfort level of orthosis was obtained by PE pad together with the weight. However, more and more detailed studies with more diverse instruments, as well as more samples, are needed to prove the results of the study.

Table 2. Comparison of the migration level of the orthosis in four modes

Type 1	Type 2	Mean difference	Standard error	Significance
PE	PE with weight	-3.1475	0.45685	< 0.001
	Silicon	-2.516	0.45685	< 0.001
	Silicon with weight	-0.9925	0.45685	0.198
PE with weight	PE	3.1475	0.45685	< 0.001
	Silicon	5.6635	0.45685	< 0.001
	Silicon with weight	2.155	0.45685	< 0.001
Silicon	PE	-2.516	0.45685	< 0.001
	PE with weight	-5.6635	0.45685	< 0.001
	Silicon with weight	-3.5085	0.45685	< 0.001
Silicon with weight	PE	0.9925	0.45685	0.198
	PE with weight	-2.155	0.45685	< 0.001
	Silicon	3.5085	0.45685	< 0.001

PE: Polyethylene

Conflict of Interests

Authors have no conflict of interests.

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