Effect of a Patella-Stabilizing Brace on Lateral Subluxation of the Patella

Assessment Using Kinematic MRI

Frank G. Shellock, PhD

ABSTRACT: This study investigated the effect of a special patella brace on patients with lateral subluxation of the patella using kinematic magnetic resonance imaging (MRI). Fifteen patients were assessed with and without application of the brace (Shields Patella Stabilizing Brace, Hely & Weber, Santa Paula, Calif) using active-movement, against-resistance kinematic MRI of the patello-femoral joint. Kinematic MRI examinations were evaluated using previously described qualitative criteria to determine patello-femoral relationships. Eleven (73%) patellofemoral joints had improvement (55%) or correction (45%) of lateral subluxation of the patella. The brace failed to alter the position of the patella in four (27%) patients who had patella alta (two patients) or were extremely overweight (two patients). This study provided objective findings that application of the brace improved or corrected lateral subluxation of the patella in the majority of patients. This information has important implications for the conservative treatment of patients with this form of patellar malalignment.

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INTRODUCTION

Malalignment of the patella relative to the femoral trochlear groove is the primary cause of anterior knee pain and functional instability of the patellofemoral joint.[6-8,11] The use of standard radiography for diagnostic evaluation of the patellofemoral joint has many recognized limitations and, as such, is considered to be unreliable and relatively insensitive.[3,4,6,7,14,22,30,32] In 1988, a kinematic magnetic resonance imaging (MRI) procedure was developed to provide diagnostic information pertaining to patellar alignment during the initial increments of joint flexion, when subtle position-related abnormalities are the most apparent.[28] Since then, many investigations have reported kinematic MRI of the patellofemoral joint is a sensitive and useful technique for assessment and characterization of aberrant positions of the patella.[3,4,12-14,25-27,29,32,33]

Diagnosis of patellar malalignment by physical examination alone is often difficult because the physical findings may mimic internal derangement of the knee.[4,7,22] A comprehensive evaluation that includes diagnostic imaging (eg, kinematic MRI) for precise characterization of patellar alignment and to rule out other causes of anterior knee pain permits selection of the proper therapeutic method for patients with patellofemoral abnormalities.[4,6,7,22]

Because patellar malalignment may be a dynamic phenomenon,[1,3,20,25] the kinematic MRI examination evolved to the current state-of-the-art diagnostic procedure whereby the patellofemoral joint is imaged during active movement, against resistance.[4,22,25] Importantly, this type of kinematic MRI examination improves the diagnostic yield compared to the incremental passive positioning technique.[4,22]

Many different physical rehabilitation and surgical protocols have been used to manage patients with patellar malalignment syndromes.[2,5-10,13,15-19,21,24,31-33] Initially, nonoperative regimens are used to treat these patients, including the use of bracing or taping.[5-7,9,10,19]

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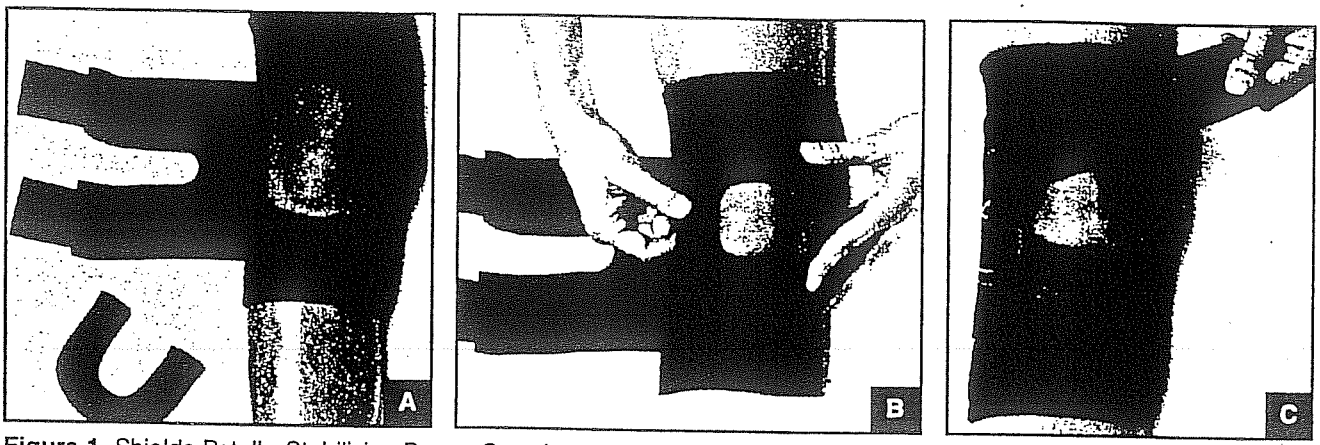

Figure 1. Shields Patella Stabilizing Brace. Care is taken to ensure the patella is centrally located in the brace (A). The patella is palpated, and the U-shaped buttress is placed directly against the lateral side of the patella (B). Next, the buttress is pushed medially while the straps are applied, pulled firmly, and attached to the medial side of the brace, creating a counterforce acting on a laterally subluxated patella (C).

Few investigations have objectively assessed the effect of bracing to improve or correct patellar malalignment.[5,13,24,32,33] Therefore, this study used active-movement, against-resistance kinematic MRI to evaluate the effect of applying a special brace to patients with lateral subluxation of the patella.

MATERIALS AND METHODS

Study Population

Fifteen patients (10 women and 5 men; age range: 31-71 years old; height range: 61-74 inches; weight range: 119-275 lb) participated in this investigation. Each patient was selected for inclusion in this study based on the presence of the hallmark signs and symptoms of patellar malalignment, as assessed by an experienced orthopedic surgeon. Physical findings and symptoms for these patients were typical for pathology of the patellofemoral joint[6,7,11] including: chronic pain (n=15), positive apprehension sign (n=15), lateral patellar facet pain (n=11), sensation of "giving way" (n=12), crepitus (n=9), swelling (n=8), history of prior lateral dislocation of the patella (n=8), and increased pain while ascending or descending stairs (n=15). Three of the patients had prior surgical procedures (lateral retinacular release [n=2] and medial transposition procedure [n=1]).

Because the primary goal of this study was to determine if wearing the brace could produce an effect on the position of a laterally sublimated patella, only patients with this type of abnormal patellar alignment were included in this investigation.

Patella Brace

A Shields Patella Stabilizing Brace (Hely & Weber, Santa Paula, Calif) was worn by the patients in this study. This specially designed brace consists of a neoprene cuff (held together using hook-and-loop fasteners) with a posterior cut-out, a U-shaped buttress, and two neoprene straps (Figure 1). Hook-and-loop fasteners are used on the cuff, buttress, and straps to maintain the brace in a properly fixed position. The appropriate size of this brace was selected for each patient.

The brace was applied with the patient seated with the affected knee relaxed in a fully extended position to permit "free" movement of the patella. The cuff was placed securely around the patellofemoral joint and fastened above and below the joint via the hook-and-loop fasteners. Care was taken to ensure the patella was centrally located in the brace (Figure 1A). The patella was palpated, and the U-shaped buttress was placed directly against the lateral side of the patella (Figure 1B). Next, the buttress was pushed medially while the straps were applied, pulled firmly, and attached to the medial side of the brace (Figure 1C). This created a counterforce acting on the laterally subluxated patella.

Kinematic MRI

Active-movement, against-resistance kinematic MRI of the patellofemoral joint was performed on the patients in this study.[22,24,25] Briefly, a commercially available positioning device (General Electric Medical Systems, Milwaukee, Wis) was used to apply resistance to the patellofemoral joint during dynamic movement through a range of motion from approximately 45° of flexion to extension.[22,24,25]

Magnetic resonance images were obtained using the transmit and receive, quadrature body coil of a 1.5-T 64-MHz MR system (General Electric Medical Systems, Milwaukee, Wis) and a fast spoiled gradient recalled acquisition in the steady state pulse sequence.[22,24,25] The following imaging parameters were used: axial plane; repetition time, 30 msec; echo time, 7 msec; flip angle,

30°; number of signal averages, 1; matrix size, 256×128; field of view, 36-40 cm; and section thickness, 7 mm.[25] Six images were obtained at three different section locations (total number of images=18) of the patellofemoral joint to assess the entire excursion of the patella in relation to the femoral trochlear groove during dynamic joint movements from 45° of flexion to extension.[22,25]

Display and Qualitative Analysis of the Kinematic MRI Examination

All kinematic MRI examinations were reviewed in a blinded fashion by an experienced interpreter. The kinematic MRI studies were viewed in a cine-loop format (ie, paging the six different images obtained at each section location forward and backward at the rate of two images/second), as previously described.[22,24-28] The cine-loop display of the kinematic MRI procedure optimally shows the pattern of patellar alignment compared with evaluation of individual MRI.[4,24-28]

A qualitative method was used to analyze the kinematic MRI studies because of the known limitations of using quantification schemes.[4,6,22,24-30] These limitations include:

- The majority of the techniques were designed for use with plain radiographs obtained at a single increment of joint flexion, usually >30°. These measurement techniques are not practical or helpful with kinematic MRI examinations, whereby multiple images are obtained of the patellofemoral joint during the earliest increments of joint flexion.
- Abnormal patellofemoral joints often have associated anatomic irregularities (eg, dysplastic patellae, dysplastic bony anatomy, patella alta, and patella baja). These conditions preclude an accurate assessment of patellar positions using quantification schemes because there are no consistent landmarks for proper measurement of patellofemoral relationships. For example, in patella alta, where the patella articulates above the femoral trochlear groove during the earliest increments of flexion, there is no way to properly determine the position of the patella (ie, it is not possible to measure patellar tilt or displacement because the femoral trochlear groove landmarks are not present on the section location showing the patella).
- There is no agreement on the usefulness of any particular quantification technique for determining patellofemoral relationships.
- A recent investigation by Staubli et al[30] reported that radiographic indices developed for descriptions of osseous contours of the patellofemoral joint using conventional radiography and computed tomography do not provide the specific relationships of the surface geometry of the articulating cartilaginous surfaces, as visualized using MRI.
- The quantitative assessment of patellofemoral incongruency has never been used by orthopedic surgeons or other clinicians to guide surgical or rehabilitation procedures designed to treat patellofemoral joint abnormalities.

In view of these problems and considerations associated with measurements of patellofemoral relationships, several investigators believe it is appropriate and practical to use qualitative criteria to describe patellofemoral relationships viewed on kinematic MRI examinations.[4,6,22,24-29] In further support of this analysis technique, several articles have used this methodology for evaluation of kinematic MRI examinations of the patellofemoral joint.[4,22,24-29] This qualitative technique is used for the interpretation of kinematic MRI examinations in the clinical setting.

The following criteria were used to describe the position of the patella relative to the femoral trochlear groove[4,22,24-27]:

- *normal patellar alignment*—the central ridge of the patella is positioned in the center of the femoral trochlear groove and, this orientation is maintained throughout the range of motion evaluated using kinematic MRI, and
- *lateral subluxation of the patella*—a form of patellar malalignment in which the central ridge of the patella is laterally displaced relative to the femoral trochlear groove or the centermost part of the femoral trochlea and the lateral facet of the patella overlaps the lateral aspect of the femoral trochlea.

In addition to the above, a qualitative comparison was made between the patterns of patellar alignment seen with and without the brace applied to the patellofemoral joint[24] as follows:

- improvement in lateral subluxation of the patella was indicated if there was a decrease in the relative displacement of the patella,
- correction of lateral subluxation of the patella was indicated if there was centralization of the patella in relation to the femoral trochlear groove,
- no change was indicated if the brace did not produce an observable change, and
- worsening was indicated if the position of the patella relative to the femoral trochlear groove was further displaced in an abnormal manner.

Exercise

To determine the influence of physical activity on the position of the brace as well as the painful patellofemoral joint symptoms, an additional kinematic MRI examination was obtained immediately after exercise. Physical activity consisted of having each patient walk on a level surface (6 minutes) and up and down stairs (6 minutes), for a total of 12 minutes of exercise.

Subjective Perceptions of Pain

Patients were questioned regarding their subjective

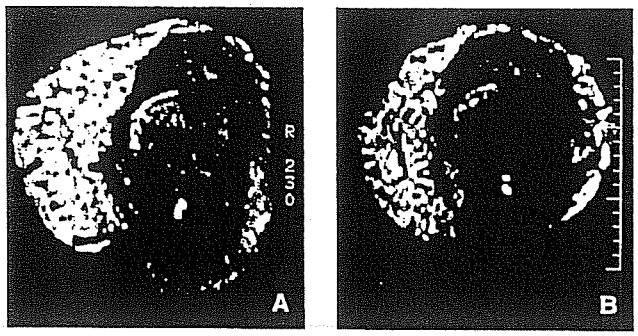

Figure 2. Patient with lateral subluxation of the patella examined without (A) and with (B) application of the patellar brace. Axial image obtained using active-movement, against-resistance kinematic MRI of the patellofemoral joint (joint angle, approximately 22°). Note the presence of lateral subluxation of the patella with the central ridge of the patella laterally displaced relative to the femoral trochlear groove and the lateral facet of the patella overlapping the lateral aspect of the femoral trochlea (A). Note the correction (ie, centralization of the patella in relation to the femoral trochlear groove) of lateral subluxation of the patella produced by bracing (B).

perceptions of painful symptoms while wearing the brace during exercise. Patients were interviewed immediately after performing exercise to determine if the brace decreased their overall painful patellofemoral joint symptoms. Specifically, patients were asked the question, "How does the brace make your joint feel during exercise compared to how it typically feels when you do the same activities?"

RESULTS

Technically acceptable MRIs were obtained for the kinematic MRI examinations in all cases. Every patient included in this study had lateral subluxation of the patella demonstrated by the kinematic MRI examination of the patellofemoral joint.

Eleven of 15 (73%) patients had an improvement (6/11 [55%]) or correction (5/11 [45%]) in lateral subluxation of the patella with the brace. Kinematic MRI examinations performed after exercise showed the same findings for the patella position compared with those kinematic MRI examinations performed before exercise. Each patient who had improvement or correction of lateral subluxation of the patella reported a reduction in subjective perceptions of painful symptoms while wearing the brace during exercise. Figure 2 shows an example of a patellofemoral joint with and without the brace studied by kinematic MRI.

Wearing the brace failed to alter lateral subluxation of the patella in four (27%) patients. Two of these patients had patella alta[23] and two were extremely overweight. Kinematic MRI examinations performed after exercise showed the same findings for the patella position compared with kinematic MRI examinations performed before exercise. Three (75%) of these four patients reported a decrease in their subjective perceptions of painful symptoms while wearing the patella-stabilizing brace during exercise.

DISCUSSION

Malalignment of the patella causes decreased patellofemoral contact surface area, increased shearing force, and increased surface-to-surface contact stress.[3,6,7,11] These mechanisms eventually result in the destruction of articular cartilage.[3,6,7,11] A slight patellar displacement can alter the load distribution of the patellofemoral joint and produce painful symptoms in the absence of a detectable cartilage lesion.[6,7,11] Understandably, treatment methods that are intended to centralize or improve patellar subluxation are believed to be beneficial for the management of patients with patellofemoral malalignment.[1,2,5,6,7-9,19,24,31-33]

Many different types of patella braces are available. Cherf and Paulos[5] reported the uses and designs of most of these orthotics are unclear and frequently lack a biomechanical foundation. Theoretically, the primary function of a patella brace is to reduce a malaligned patella, with secondary functions that include providing warmth to the tissues, changing the tension of soft-tissue structures, and reducing sensations of joint instability.[5] Unfortunately, few studies have been conducted using objective criteria to determine the practical biomechanical function of patella braces with regard to changing the position of a malaligned patella.[5,13,24,32,33]

Koskinen and Kujala[13] were the first to report objective data obtained by using kinematic MRI that showed the influence of a patella brace on patellofemoral relationships. Likewise, Worrell et al[32,33] reported that bracing patients with patellofemoral joint pain generally changed the position of the patella, based on findings from kinematic MRI. Unfortunately, these investigators used the incremental, passive-positioning kinematic MRI technique that has inherent limitations compared with the active-movement, against-resistance kinematic MRI method.[4,22]

In a previous study, Shellock et al[24] studied patients with and without a specialized, sleeve-type patella brace using the active-movement, against-resistance kinematic MRI technique. The results indicated the brace improved or corrected patellar malalignment for most of the patients.[24] The brace did not alter the patellar positions for patients who had dysplastic patellofemoral osseous anatomy, patella alta, or both.[24]

The present study was conducted on another patella

brace because its design features were capable of producing a counterforce to a laterally subluxated patella. The findings indicated that for most of the patients studied, wearing the brace influenced the position of a laterally subluxated patella as shown by the active-movement, against-resistance kinematic MRI examination. The use of kinematic MRI with and without treatment provides empirical evidence for the specific type of patellofemoral joint pathology that is present and justification for using a particular form of therapy.[4,6,22,24]

The fact that use of the patella brace failed to correct or improve the lateral subluxation of the patella in four patients who had patella alta, were overweight, or both is not unusual. Patellar realignment surgical procedures also have been unsuccessful in the presence of patella alta, dysplastic bony anatomy, or both.[6,7] Failure of a brace to change the position of the patella in overweight patients (ie, one with excessive subcutaneous fat) has not been reported previously. Externally applied force produced by the functional components of the brace are unlikely to work if the anatomy does not permit repositioning or if the U-shaped buttress of the brace is unable to "interact" with the patella to move it.

When conservative treatment such as bracing is used in patients with patellar malalignment, it is beneficial to quickly determine if there has been improvement in displacement of the patella relative to the femoral trochlear groove. Otherwise, valuable time may be wasted. Or, in a worst case scenario, unwanted cartilage contact stress may be induced that creates another problem for the patient (eg, if bracing moves the patella in an inordinate or unacceptable manner).

All of the patients who had an improvement or correction in the position of the laterally subluxated patella reported subjective perceptions of decreased patellofemoral pain related to wearing the brace during physical activity. Three of the four patients who had no effect produced by wearing the brace also reported decreased pain. This suggests either the brace functioned by some mechanism other than repositioning the patella to decrease the symptoms or the use of symptom-related information is a rather insensitive criterion to determine the effectiveness of bracing. Unfortunately, the design of the present investigation and relatively small sample size for the two groups of patients (ie, those who had a positive response and those who had no response) does not permit clarification of this issue.

According to Worrell et al,[32,33] information is needed regarding the effect of exercise on the capability of bracing to alter the position of the patella. The present study indicated 12 minutes of physical activity did not change the altered position of the patella achieved by the immediate application of the brace. These data, while limited in scope, nevertheless represent the first evaluation of the combined effects of bracing along with exercise on the ability of a given brace to maintain its influence on the position of the patella. Additional studies are warranted to determine the effectiveness of bracing with regard to maintaining the improved or corrected position of the patella in association with more vigorous, long-term exercise.

One possible limitation of this investigation is a relatively small number of patients were studied. However, other previously published reports pertaining to patellar-tracking abnormalities or the effect of braces on patellofemoral relationships similarly examined small numbers of patients.[13,14,32,33]

Another possible limitation of this study is there was no statistical analysis of the data. However, it is not always crucial to apply inferential statistical analysis to data. Notably, a close evaluation of the peer-reviewed radiologic literature reveals statistical analysis is not always used to express findings using diagnostic imaging.

Finally, only the acute effect of the brace on the position of the patella was evaluated. Obviously, it is desirable to obtain data using kinematic MRI and assessment of symptoms on a long-term basis. Additionally, evaluation of the patient's symptoms with the brace applied during exercise did not use any particular survey or other tool, like previous studies.[32,33] Nevertheless, the findings obtained serve to encourage and warrant future studies on the effects of bracing for patients with patellofemoral malalignment.

CONCLUSION

Application of the patella brace improved or corrected lateral subluxation of the patella in the majority of patients. These findings were based on objective data obtained using active-movement, against-resistance kinematic MRI of the patellofemoral joint. This information has important implications for the conservative treatment of patients with lateral subluxation of the patella.

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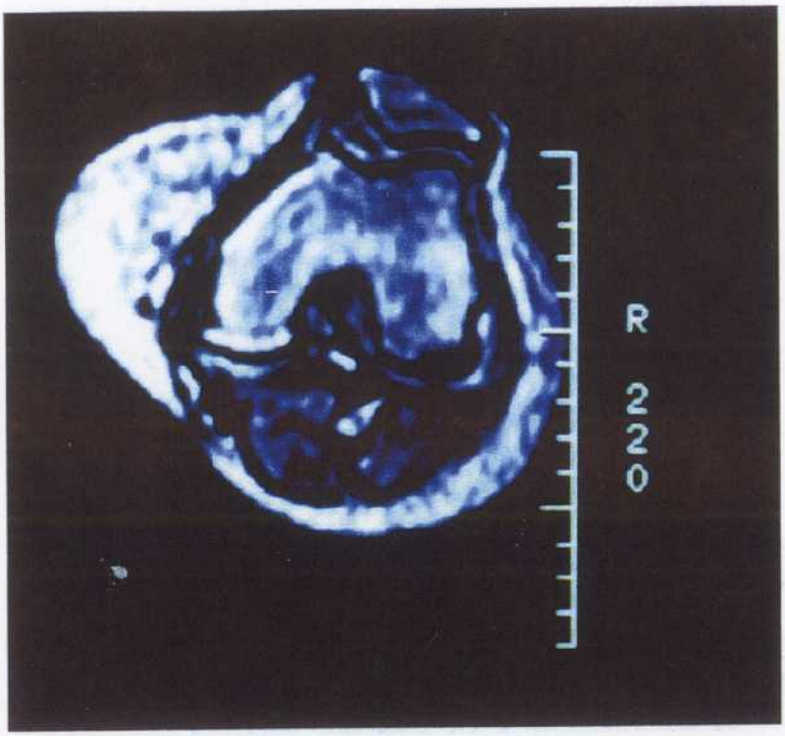
LATERAL PATELLAR TILT, WITHOUT SHIELDS BRACE

KINEMATIC MRI OF THE PATELLOFEMORAL JOINT,
ACTIVE-MOVEMENT AGAINST RESISTANCE TECHNIQUE*



NORMAL ALIGNMENT OF THE PATELLA, WITH SHIELDS BRACE

KINEMATIC MRI OF THE PATELLOFEMORAL JOINT,
ACTIVE-MOVEMENT AGAINST RESISTANCE TECHNIQUE*

*Kinematic MRI studies performed by Frank G. Shellock, Ph.D., FACSM; Adjunct Clinical Professor of Radiology, University of Southern California, School of Medicine.