INTRODUCTION
Repair of complete radial meniscal tears is a key factor in restoring the mechanical integrity necessary to maintain hoop tension in the meniscus. The primary stability of the meniscal repair is one of the most important factors for meniscal healing, but the biomechanical structural properties of different repair techniques for the complete radial meniscal tears remain unknown. We hypothesized that our novel cross-suture technique would yield greater primary stability than the double horizontal suture technique. The objective of our study was to evaluate the biomechanical properties of our suturing method in repairing complete radial tears, comparing the cross-suture technique with the double horizontal suture technique under cyclic loading conditions.

MATERIALS & METHODS
Biomechanical investigations were performed on 40 fresh human menisci (2 groups of 20 menisci each) from patients who underwent total knee arthroplasty. In the cross-suture technique group (Group A), the sutures crossed over 5 mm from the tear, 5 mm and 10 mm from the rim. In the double horizontal suture technique group (Group B), the sutures were parallel and had the same attachment points as Group A (Figure 1). We loaded the specimens onto a universal testing machine and clamped the peripheral sections of the repaired meniscus with custom-made tissue clamps (Figure 2). The specimens were cyclically loaded 500 times between 5 and 30 N and then loaded to failure after completion of the cyclic load testing at a rate of 5 mm/min. In each group, we measured ultimate failure load, stiffness and displacement after cyclic loading test and load-to-failure test. Mode of failure was determined by visual inspection. Student’s t-test were used for statistical analysis of the results, setting the level of significance at p<.05.

RESULTS
Group A had a significantly higher failure load and greater stiffness than did Group B (p<.05) (Table 1). According to the displacement, Group A had a significantly lower displacement than Group B at the end of the 500-cycles loading protocol (p<.05). No significant difference in displacement between Group A and Group B was observed after load-to-failure testing (p>0.05) (Table 1). In each group, most of the specimens failed by tissue failure, with only a few specimens failing by a suture rupture. In Group A, 17 of the specimens failed by tissue failure, and 3 failed at the knot. In Group B, 18 of the specimens failed by tissue failure, and 2 failed at the knot.

DISCUSSION
The primary stability of meniscal repair for a complete radial tear is a key factor in determining success of the repair. To reduce the risk of suture rupture or tissue failure, we focused on the orientation of the sutures relative to the meniscal tear and particularly the relationship between the orientation of the sutures and the orientation of the collagen fibers. Our study measurements of ultimate failure load and stiffness speculated that the superiority of the cross-suture technique derives from the ability of the cross-sutures to capture more strongly a greater proportion of the semi-circular oriented meniscal collagen fibers because the direction of the sutures is oblique to the meniscal collagen fibers rather than parallel to the fibers, as is the case with the double horizontal technique. Our displacement measurements after 500 cyclic loading also provide speculation that the cross-suture technique is superior to the double horizontal suture technique because cross suturing reduces the likelihood of a subsequent “cheese-cut” tissue failure.

Our study was limited by our decision to use human lateral menisci, taken from patients who received total knee arthroplasty, and to use a non-physiological method of loading. However, we proved that the cross suture technique could get the more superior stability than the double horizontal suture technique in vitro. After this, the clinical relevance of this biomechanical study is important. Clinical and animal studies with appropriate controls are recommended to validate our findings in vivo and to determine the biological sequence of cross-suture technique under clinical conditions. Nonetheless, the significant improvement in biomechanical properties that we observed in conjunction with the minor modification in technique of reorienting the sutures from parallel to cross still should provide encouragement for surgeons to consider utilizing the cross-suture technique in their clinical practice.

SIGNIFICANCE
Our cross-suture technique for repair of radial meniscal tears provide high stability and could be a promising solution in young and in active patients.

REFERENCES