Anterior cruciate ligament (ACL) ruptures are commonly associated with meniscus tears. The prevalence of associated meniscus injuries in patients with ACL ruptures has been found to be 65% in acute injuries and 90% in chronic injury of ACL. \(^{1,2}\) Meniscus repair performed simultaneously with ACL reconstruction can give additional stability to the knee joint. \(^{3}\) The healing rate of repaired meniscus associated with ACL reconstruction is 92%, compared to only 63% in meniscus tears not associated with ACL.
reconstruction. Generally, the treatment of a meniscus tear combined with an ACL rupture is repair rather than a meniscectomy because the bleeding and debris from the ACL reconstruction starts an inflammatory reaction that helps the meniscus’ healing phase. The other reason that repair is preferred, is that the healed meniscus can help add stability to the knee joint.

The arthroscopic meniscus repair method can be categorized as all-inside, outside-in, or inside-out. Inside-out or outside-in repair techniques require additional skin incisions and can cause neurovascular injury and soft tissue irritation. All-inside repair with meniscal implants and devices has been popularly used because of its advantages, such as its ease of use and shorter repair time. However, it has some disadvantages such as implant breakage, failure of repair, infection, and chondral injury.

The Meniscal Viper Repair System (Arthrex, Naples, FL, USA) is a new device for the all-inside suture technique, allowing surgeons to avoid the disadvantages of the outside-in or inside-suture techniques. There have been some reports regarding the results of meniscus repair using the Meniscal Viper Repair System simultaneously with ACL reconstruction.

The purpose of this study was to evaluate the results of arthroscopic all-inside repair using the Meniscal Viper Repair System on meniscus tears with ACL reconstruction through clinical outcomes and second-look arthroscopy or magnetic resonance imaging (MRI).

**METHODS**

**Study Group Collection**

From January 2010 to April 2012, there were 92 cases that underwent ACL reconstruction at Wonkwang University Hospital. Among these cases, 37 cases had meniscal tear. Out of the 37 cases, 22 cases underwent arthroscopic all-inside meniscus repair using the Meniscal Viper Repair System with simultaneous ACL reconstruction. Out of the 22 cases, the 19 cases that underwent second arthroscopy or MRI were selected for the study.

The mean age at operation time was 35.4 years (range, 18 to 45 years) with 15 men and 4 women constituting the patients. Among the 19 patients there were four cases of medial meniscus tears, 14 cases of lateral meniscus tears, and one case where both were torn.

The indications for meniscal repair in this study were: meniscal tears that were reparable using the Meniscal Viper Repair System, including tears of the middle body of the meniscus, tears approximately one-third of a posterior medial meniscal tear, and tears of the posterior half of the lateral meniscus.

We excluded isolated meniscal repair or combined knee injuries other than ACL. White-white zone tears...
were treated with meniscectomy. Also, we excluded those patients who had anterior horn tears or root of meniscus tears that were irreparable using the Meniscal Viper Repair System.

Operation Methods and Rehabilitation
The Meniscal Viper Repair System is a device that can tie a suture at the tip of a needle which passes through the meniscus. After thorough inspection of the knee joint with arthroscopy, the Viper was positioned at the posterior site of the torn meniscus and the needle was passed through the torn site. A non-absorbable suture material followed the needle and made the natural loop. The medial meniscus repair was performed prior to the ACL reconstruction.

Some cases of posterior horn tear of the medial meniscus with lax joint space were repaired using the Viper System. However, not all posterior horn tears were repaired because the Viper System could not reach area: only the posterior one-third of the medial meniscal tear was repaired with the system.

The key elements of the arthroscopic all-inside meniscus repair using the Meniscal Viper Repair System include an insertion angle parallel to the meniscus with a clear field of view. The position of the knee should be fixed during the meniscal repair. In some cases, only the torn meniscus was sutured due to incorrect positioning.

ACL reconstructions were performed using fresh frozen Achilles allograft and an all-inside meniscus repair

| Table 1. Patients’ Data |
|-------------------------|
| Patient no. | Gender/age (yr) | Tear type | Tear type/medial/lateral | Tear location | All-inside suture | Technique for femoral tunnel | Follow-up MRI | Second-look arthroscopy | Clinical result | Meniscal healing* |
|-------------|----------------|-----------|--------------------------|---------------|-------------------|-----------------------------|---------------|----------------------|----------------|------------------|
| 1           | Male/27        | O         | M                        | RR            | 3                 | AM                          | 0             | 0                    | 97             | 125              | CH               |
| 2           | Male/39        | LO        | L                        | RR            | 3                 | AM                          | 0             | 0                    | 98             | 127              | CH               |
| 3           | Male/41        | LO        | L                        | RR            | 3                 | TT                          | 0             | 0                    | 91             | 123              | CH               |
| 4           | Male/39        | C         | ML                       | RW            | 4                 | AM                          | 0             | 0                    | 93             | 129              | CH               |
| 5           | Male/16        | LO        | L                        | RW            | 4                 | AM                          | 0             | 0                    | 92             | 121              | CH               |
| 6           | Male/15        | LO        | M                        | RR            | 3                 | TT                          | 0             | 0                    | 97             | 124              | CH               |
| 7           | Male/36        | C         | M                        | RR            | 4                 | AM                          | 0             | 0                    | 95             | 125              | CH               |
| 8           | Female/18      | LO        | L                        | RW            | 3                 | TT                          | 0             | 0                    | 94             | 123              | CH               |
| 9           | Female/53      | LO        | L                        | RR            | 2                 | TT                          | 0             | 0                    | 97             | 128              | CH               |
| 10          | Male/24        | O         | L                        | RR            | 4                 | AM                          | 0             | 0                    | 92             | 122              | CH               |
| 11          | Male/32        | H         | L                        | RR            | 3                 | AM                          | X             | 0                    | 93             | 122              | CH               |
| 12          | Female/42      | C         | L                        | RW            | 3                 | TT                          | 0             | 0                    | 82             | 112              | Failure          |
| 13          | Female/50      | LO        | L                        | RR            | 2                 | TT                          | 0             | 0                    | 98             | 127              | CH               |
| 14          | Male/54        | LO        | L                        | RR            | 3                 | TT                          | 0             | 0                    | 97             | 128              | CH               |
| 15          | Female/55      | LO        | M                        | RR            | 4                 | TT                          | 0             | X                    | 91             | 123              | CH               |
| 16          | Male/17        | LO        | L                        | RR            | 4                 | AM                          | 0             | 0                    | 93             | 121              | CH               |
| 17          | Male/19        | LO        | L                        | RR            | 4                 | AM                          | 0             | 0                    | 98             | 127              | CH               |
| 18          | Female/42      | H         | L                        | RR            | 2                 | TT                          | 0             | 0                    | 94             | 129              | CH               |
| 19          | Male/22        | LO        | L                        | RR            | 4                 | AM                          | 0             | 0                    | 92             | 128              | CH               |

MRI: magnetic resonance imaging, HSS: Hospital for Special Surgery, ROM: range of motion, O: oblique tear, M: medial meniscus, RR: red-red zone, AM: accessory medial portal, CH: complete healing, LO: longitudinal tear, L: lateral meniscus, TT: transtibial portal, C: complex tear, ML: medial and lateral meniscus, RW: red-white zone, H: horizontal tear.

*MRI and second-look result.
using the Meniscal Viper Repair System by a single surgeon. All ACLs were reconstructed using the single bundle technique. A femoral tunnel was positioned in the 10:30 direction using the accessory medial portal in 10 cases, with patients who were younger, male, who played a lot of sports, and in those with a large anatomical femoral condyle. The other nine cases featured a femoral tunnel in the 11 o’clock direction using the transtibial approach.

Rehabilitation after the operation was performed for four weeks with brace protection that limited the flexion up to 60° to protect the reconstructed ACL and repaired meniscus. After 4 weeks, the range of motion (ROM) was increased every week up to 120° flexion with brace protection six weeks after the operation. Crutch walking was recommended for partial weight-bearing during the rehabilitation process.

**Clinical Evaluation**

During the last follow-up consultation prior to the second-look arthroscopy, physical exams were conducted to evaluate the patients’ symptoms (catching, locking, and giving way), including tenderness, effusion, ROM limitations, and the McMurray test. Clinical success was considered if all five categories were negative. The Hospital for Special Surgery (HSS) score was added for the analysis of functional evaluation.

![Fig. 3. Healing rates by segment according to Henning’s criteria: (A) complete healing, (B) partial healing > 50%, and (C) < 50% healing.](image)

![Fig. 4. An 18-year-old woman with a complete rupture of the anterior cruciate ligament and longitudinal tear of the medial meniscus of her left knee. (A) Arthroscopic findings of longitudinal tear of medial meniscus. (B–D) Arthroscopic findings during meniscus repair using the Meniscal Viper Repair System. (E) Arthroscopic finding immediately after suture. (F) Second-look arthroscopic findings after meniscus repair show complete healing.](image)
Magnetic Resonance Imaging and Second-Look Arthroscopic Evaluation

The mean follow-up period was 16.5 months (range, 12 to 24 months), and the second-look arthroscopy was performed at 17.3 months on average (range, 12 to 23 months; 18 patients) and the MRIs were taken at about 15.4 months (range, 12 to 24 months; 19 patients) after the first operation.

The results of MRI were evaluated with Henning’s classification, which categorizes healing states as complete, incomplete (more than 50%), or failure (less than 50%) (Fig. 3). The same surgeon who performed the meniscus repair examined the meniscus with a probe at the time of the second-look arthroscopy. The results of second-look arthroscopy were evaluated with the criteria of meniscal healing, which are classified by a residual cleft at the repair site of the meniscus; complete healing (less than 10% of residual cleft), incomplete healing (less than 50%), and failure (more than 50%).

RESULTS

Clinical Results

In 19 cases, the clinical cure rate was 94.7% with a mean HSS score of 93.9 at the last follow-up. There was one case of stiffness 12 weeks after the operation, with a ROM less than 90° on the physical examination. Passive manipulation under spinal anesthesia was performed and the ROM was increased to more than 120° at the last follow-up. There were no cases of deep infection or neurovascular injuries.

Magnetic Resonance Imaging and Second-Look Arthroscopy Results

According to Henning’s classification, in 17 out of the 18 cases performed, MRI showed complete healing (83.3%), and in 2 cases (11.1%), incomplete healing without any clinical symptoms (Fig. 4). According to criteria of meniscal healing, in 17 out of 18 cases performed, second-look arthroscopy showed complete healing (94.4%). Only one case showed failure according to Henning’s classification and the criteria of meniscal healing. Authors performed the repair with 2 notes of all-inside suture and 2 notes of

Fig. 5. A 41-year-old man with complete rupture of the anterior cruciate ligament and longitudinal tear of the lateral meniscus of his right knee. (A) Arthroscopic findings of longitudinal tear of lateral meniscus. (B, C) Arthroscopic findings during meniscus repair using the Meniscal Viper Repair System. (D) Arthroscopic findings immediately after suture. (E) Second-look arthroscopic findings after meniscus repair show complete healing.
inside-out suture during second-look arthroscopy (Figs. 5 and 6).

**DISCUSSION**

In ACL ruptures, the meniscus tear is a common associated injury. It can be associated in 65% of acute injuries and 90% in chronic injury of ACL.\(^1,2\) Higher incidence rates of lateral meniscus injuries have been reported by numerous authors.\(^22,23\) Cerabona et al.\(^24\) insisted that there is no difference in either type of meniscus tear occurrence. However, some authors reported that the medial meniscus is a much more common site of tears than the lateral meniscus.\(^23,25\) In our study, the lateral meniscus (17 cases) outnumbered the medial (4 cases) and both (1 case) meniscus tears.

A recent systematic review showed that the meniscectomy procedure is performed 2–3 times more frequently than a meniscus repair during ACL reconstruction.\(^26\) However, long-term studies have shown significantly better clinical outcomes when the menisci are repaired at the time of the ACL reconstruction.\(^27\) Bellabarba et al.\(^28\) compared the healing rate of meniscus repair with ACL reconstruction to that of meniscus repair alone and found the rates were similar.

The meniscus repair method can be categorized as all-inside, outside-in, and inside-out.\(^29\) These methods have different indications due to the site, type, and size of the meniscus tear. Each study reported various results regarding meniscus tear repair with ACL reconstruction. Gill and Diduch\(^23\) reported that in 32 patients who underwent meniscal repair using the Meniscus Arrow (Bionx, BlueBell, PA, USA) with concurrent ACL reconstruction, there was a 90.6% success rate. However, this success rate was clinically evaluated without objective methods, such as second arthroscopy or postoperative MRI. Ahn et al.\(^9\) reported on 39 patients undergoing arthroscopic all-inside suture using a suture hook for medial meniscus posterior horn (MMPH) tears with ACL reconstruction. They found that 32 (82.1%) of the knees showed complete healing and 6 (15.4%) showed incomplete healing without any positive findings of the clinical symptoms by second-look arthroscopy. In our study, the clinical cure rate was 94.7%. The MRI healing rate and second-look arthroscopic healing rate were 83.3% and 94.4%, respectively. This healing rate is comparable to those previously reported with the other techniques when the ACL is simultaneously reconstructed.\(^9,23\) The objective healing rate does not always correlate with clinical results, however. In our study, the clinical cure rate is better than the objective healing rate because a few asymptomatic patients still showed a failure of meniscal healing. In our study, one case showed failure and underwent revision repair during the second-look arthroscopy. Two cases showed incomplete healing on MRI, although they showed complete healing on second-look arthroscopy. We suggest the cause of the discrepancy is the intrameniscal tear on the MRI, which cannot be seen with second-look arthroscopy. However, there were no clinical symptoms and complete healing was seen on the second-look arthroscopy. So, the patients were not treated and could be symptomatic during the long term follow-up period.

We compared our MRI results with those of Lee et al.,\(^30\) who found that an MRI showed 25 (89%) and 24 (86%) healed menisci in the sagittal and coronal views, respectively. They also obtained similar results to our results with respect to the percentage of complete healing seen on MRI.\(^27\) Only a few reports on the Viper Repair System have been published. Chang et al.\(^19\) reported their
in vitro study which found that the Viper Repair System is an appropriate device for meniscus tears running about 1–2 mm. Gunes et al. \(^{14}\) reported that the all-inside vertical suture technique using a Viper Repair System is similar to the strength with outside-in vertical suture technique due to the high primary fixation strength compared to all-inside meniscus implants in a biomechanical study. Hagino et al. \(^{16}\) studied 57 patients with average of 19 months of follow-up and showed a 86% of cure rate in lateral meniscus tears. However, unlike the inside-out or outside-in, the Viper Repair System has low fixation power, and narrow joint spaces such as the MMPH space are difficult to repair with the system. It is also relatively more expensive than the other methods and the device is fragile. These flaws require consideration before undertaking a procedure with the equipment.

There was a case of failure in our study, which was apparent on both the 6-month follow-up MRI and the second-look arthroscopy. In this case, we repaired the re-torn meniscus using the inside-out technique during the second-look arthroscopy, and planned tear site capsule penetration by needle. In the relatively older woman, we could see degenerating changes on some meniscuses that were located in the red-white zone, which is a relatively disadvantageous zone for healing using the second-look arthroscopy.

There were several weaknesses in our study, including the number of patients. Our study examined 19 patients, and it is suggested that a large patient group should be included in future studies. A longer follow-up period may also be advantageous; our follow-up period was, on average, 17.3 months. Lastly, this study was not a comparative study with other repair methods, although it did compare previous literature.

In conclusion, arthroscopic all-inside repair using the Meniscal Viper Repair System is an effective treatment method and can be performed simultaneously with ACL reconstruction on patients.

**CONFLICT OF INTEREST**

No potential conflict of interest relevant to this article was reported.

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