

# Vertical Lasso and Horizontal Lasso Sutures for Repair of Horizontal Cleavage and Horizontal Oblique Meniscal Tears: Surgical Technique and Indications



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**Abstract:** Horizontal cleavage and horizontal oblique meniscal tears have traditionally been treated with partial meniscectomy. Recent research has shown the deleterious long-term effects of meniscectomy in these patients regarding the development of osteoarthritis. Meniscal preservation is thus the preferred method of surgical treatment in patients with these tears. However, traditional repair techniques using inside-out sutures or suture anchor–based devices do not address the horizontally aligned nature of these particular tears and thus do not compress the meniscal tissue in the correct plane. The recent development of an arthroscopic suture-passing system now allows surgeons to place arthroscopic sutures in any pattern or direction. This allows surgeons to treat tears of any type with sutures ideally placed to repair the given tears. This Technical Note describes and demonstrates 2 all-suture, all-inside, arthroscopic meniscus repair techniques to treat these challenging horizontal tear types. The repair techniques are named the vertical lasso and horizontal lasso.

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**H**orizontal cleavage tears and horizontal oblique tears of the meniscus, which divide the meniscus into superior and inferior laminae or leaves, represent 2 variations of 1 common type of meniscal tear. They tend to appear in increasing numbers among otherwise healthy young to middle-aged adults.<sup>1</sup> The presence of a horizontal cleavage tear has been shown to raise contact pressures in the involved compartment in simulated daily activities such as sitting and stair climbing.<sup>2</sup> Elevated contact pressures have been associated with degenerative changes in the knee.<sup>3,4</sup> Horizontal cleavage tears of the menisci have traditionally been managed using arthroscopic partial meniscectomy. The surgeon removes a portion of the

meniscus, often the inferior part or leaf, to “treat” the tear. However, although this may relieve symptoms in the short-term, recent research has shown the long-term detrimental effects of partial meniscectomy and the benefits of repair. Partial meniscectomy of horizontal tears has been shown to significantly increase contact pressures in the knee.<sup>5,6</sup> In addition, a recent publication by Beamer et al.<sup>7</sup> showed restoration of peak contact pressures to within 15% of normal after repair of horizontal cleavage tears with the NovoStitch system (Ceterix, Sunnyvale, CA). They showed an increase in peak contact pressures and a decrease in contact area for horizontal cleavage tears treated with inferior leaf resection.

An alternative to partial meniscectomy is meniscal repair. However, management of this pattern of tear is difficult with the most commonly used implants and techniques. Classic inside-out sutures can be placed in a horizontal mattress or vertical mattress pattern. These techniques, however, require additional large incisions along the posterior aspect of the knee, endangering vital neurovascular structures. In addition, the knots are tied on the outside of the knee joint capsule, potentially tethering the meniscus to the capsule and altering meniscal motion patterns. Moreover, the sutures cannot be ideally placed to allow compression of the superior and inferior leaves to each other because penetrating both leaves is technically challenging using rigid zone-specific cannulae.

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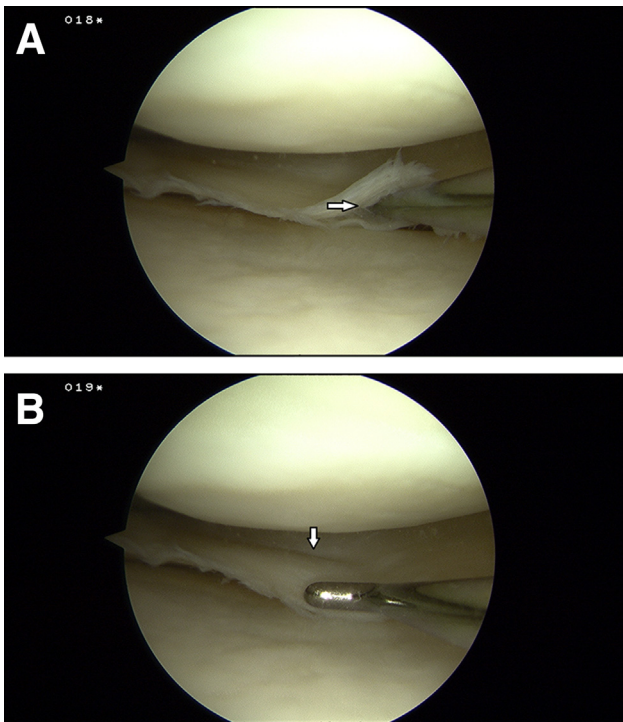
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**Fig 1.** (A) With the arthroscope in the anterolateral portal, a horizontal cleavage tear (arrow) is shown in the posterior horn of the medial meniscus in a right knee. Sufficient tissue remains to permit a vertical lasso repair. (B) The arthroscope is in the anterolateral portal. There is a vertical longitudinal component (arrow) in the peripheral zone of the posterior horn of the medial meniscus in a right knee. This, in combination with the horizontal cleavage component, indicates the need for a vertical lasso repair pattern.

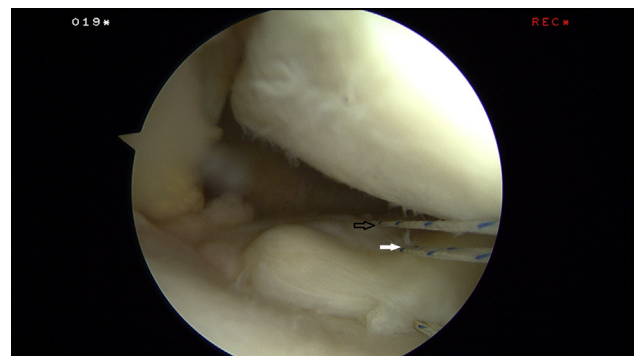
By use of “all-inside” meniscal repair techniques, buttons or anchors can be placed in a variety of repair patterns and can be passed both above and below the meniscus. Although this may seem to “repair” the meniscus by simply squeezing the meniscal tissue, there is no true compression of the superior and inferior leaves to each other. In addition, the anchors represent foreign bodies on the outside of the knee joint, potentially causing a reaction. The placement of the anchors requires the surgeon to penetrate the capsule, exposing vital extra-articular neurovascular structures to injury. Finally, if the suture is tensioned too tightly, the meniscus may be tethered to the capsule, potentially altering or constraining normal meniscal motion. This may be especially important in the lateral compartment, with the greater normal meniscal motion experienced by the lateral meniscus. The vertical lasso and horizontal lasso techniques introduced in this article not only address the limitations of the aforementioned repair methods but also provide a reproducible way in which to provide the advantage of circumferential compression (Justin Saliman, M.D., oral communication, December 2013) and repair to meniscal tear patterns typically thought to be poor candidates for repair.

## Surgical Technique

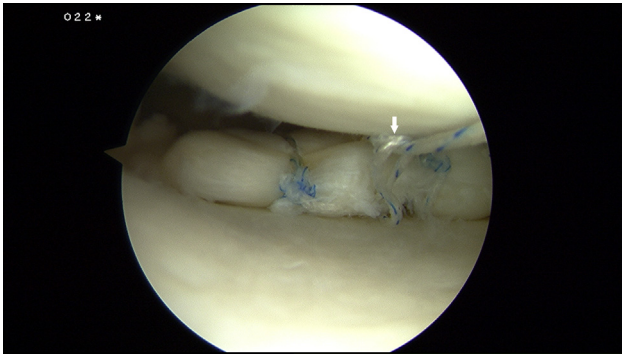
Both techniques use a unique meniscal repair system called the NovoStitch Plus (NSP; Ceterix). This system allows the surgeon to place intrameniscal sutures, which are then tied using standard arthroscopic knot-tying techniques with which an experienced arthroscopic surgeon is familiar. The NSP uses a meniscal grasping clamp with a retractable lower jaw, which advances a needle from inferior to superior through the meniscus, carrying a suture tail with it and docking the suture tail into a slot in the upper jaw. This process is repeated with the other suture tail, giving the surgeon the 2 suture tails with which to tie the knot. This is accomplished with a single pass into the joint, using a cartridge-based suture-loading implant placed within the NSP device.

### Vertical Lasso Technique

The indication for the vertical lasso technique is a horizontal cleavage tear (Fig 1). For a posterior horn tear, the NSP is passed into the joint through the ipsilateral portal, using a very low portal location, right over the anterior horn of the meniscus, to allow as direct a path as possible to the posterior aspect of the compartment. The NSP is passed deep across the entire width of the meniscus, and the needle is fired, placing the “peripheral” pass of the suture. Next, the NSP is pulled back, and the meniscus is grasped again. The needle is fired, placing the “central” pass of the suture. This creates the vertical pattern (Fig 2). The device is completely withdrawn from the joint, bringing the 2 tails and the loop out of the knee. Next, the central limb of the suture is pulled down through the loop (Fig 3). The 2 tails are then equally tensioned until the loop settles onto the surface of the meniscus (Fig 4). This creates the vertical lasso, easily visualized through the arthroscope. The 2 tails are then tied with tension, establishing the repair. The suture goes from the



**Fig 2.** The arthroscope is in the anterolateral portal viewing the posterior horn of the medial meniscus in a right knee. Placement of the central (white arrow) and deep (open arrow) passes of the vertical lasso around the vertical longitudinal tear is shown. This establishes the vertical pattern.

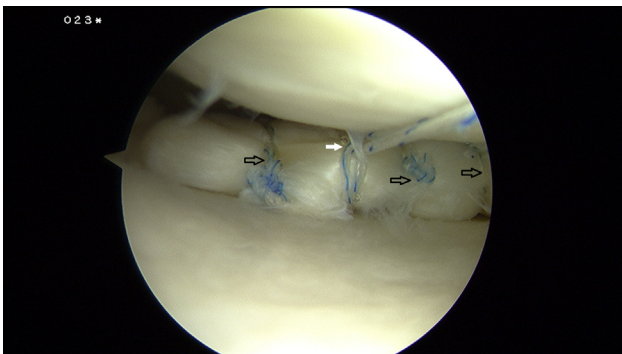


**Fig 3.** The arthroscope is in the anterolateral portal in a right knee, viewing the vertical lasso loop (arrow) within the posterior horn of the medial meniscus, with the central suture limb pulled through the inferior loop of the suture.

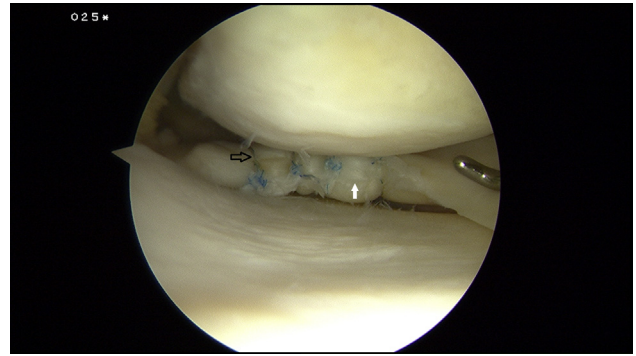
inferior surface to the superior surface, compressing the 2 leaves to each other. The lasso loop closes the “fish mouth” of the free edge and increases the compression provided by the suture passes (Fig 5). These steps are repeated until the surgeon deems the repair to be complete. One benefit of the NSP device is the use of fresh cartridges for each set of passes, ensuring a fresh needle and suture for each stitch.

#### Horizontal Lasso Technique

The indication for the horizontal lasso technique is a horizontal oblique tear, horizontal cleavage tear, or horizontal tear in a meniscus that has previously undergone partial meniscectomy (Video 1). With these tears, there is usually insufficient tissue to allow the central pass essential to the vertical lasso technique (Fig 6). However, these tears still require the circumferential compression needed to promote meniscal healing. Thus the horizontal lasso technique is used.

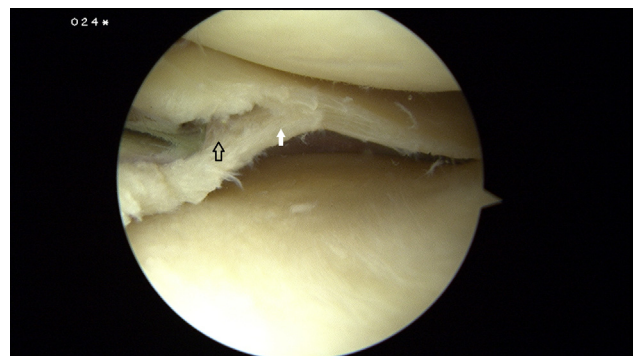


**Fig 4.** The arthroscope is in the anterolateral portal in a right knee, viewing the vertical lasso loop tensioned down to the meniscal surface (white arrow). One can already see the compression of the tear of the free edge of the meniscus. One can also see completed vertical lasso sutures, showing the circumferential compression of the horizontal cleavage tear (open arrows).

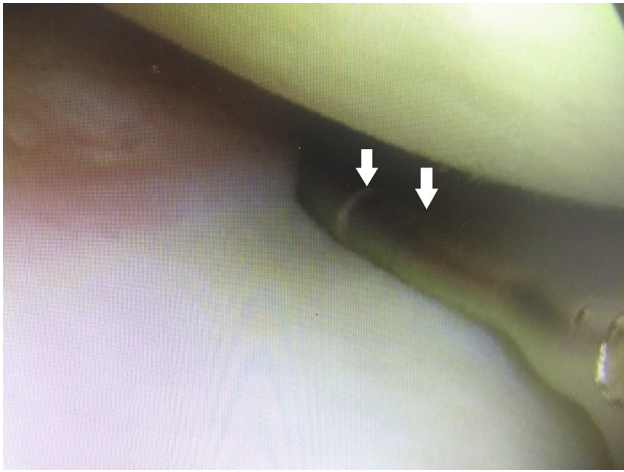


**Fig 5.** The arthroscope is in the anterolateral portal in a right knee, viewing the posterior horn of the medial meniscus. The full repair is complete, using 4 vertical lasso sutures. One should note the closure of the fish-mouth component of the tear (white arrow), as well as the compression of the meniscus in 2 planes, superior to inferior and superficial to deep (open arrow).

The NSP device is passed into the joint using a very low portal location, just over the anterior horn of the involved meniscus, to allow as straight and direct a path as possible for the device to reach the tear. The device is passed across the entire width of the meniscus to ensure that the suture will capture the inferior leaf of the tear. The meniscus is grasped, and the needle is fired, placing a peripheral pass of the suture (Fig 7). The NSP device is then moved a few millimeters to one side or the other of the first pass, depending on arthroscopic visualization and the geometry of the compartment. The needle is fired again, placing another peripheral pass. This is the horizontal pattern. The device is withdrawn from the knee, giving the surgeon 2 tails and a loop of suture (Fig 8). The second peripheral suture tail is then pulled down through the loop (Fig 9). The 2 tails are equally tensioned, bringing the loop down onto the surface of the meniscus. This creates the horizontal lasso (Fig 10). The tails are tied under tension, establishing the repair.



**Fig 6.** The arthroscope is in the anterolateral portal in a left knee. A horizontal cleavage tear (open arrow) is shown in a medial meniscus after partial meniscectomy of the white zone (white arrow), indicating the need for a horizontal lasso repair.

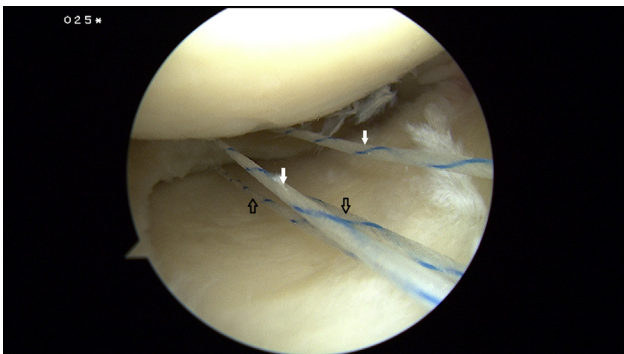


**Fig 7.** The arthroscope is in the anteromedial portal in a left knee. The upper jaw of the NovoStitch Plus is visible, showing the hash marks (arrows) between which the needle will penetrate the medial meniscus to pass the suture from inferior to superior.

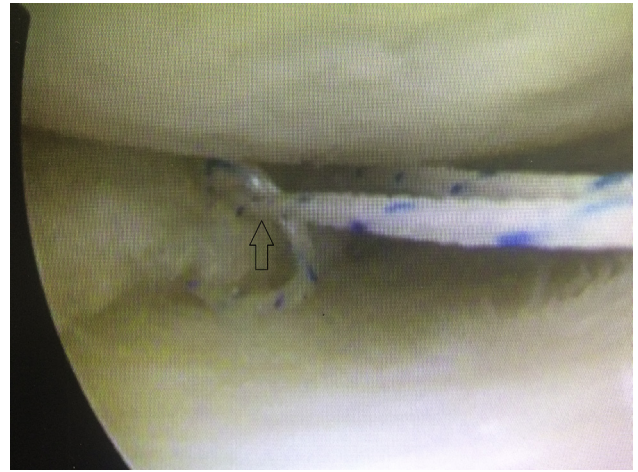
(Fig 11). The suture goes from the inferior surface to the superior surface, compressing the 2 leaves to each other. The lasso loop closes the fish mouth of the free edge and increases the compression provided by the suture passes (Fig 12). These steps are repeated until the surgeon deems the repair to be complete.

#### Joint Closure and Postoperative Management

After completion of either repair technique, I use the Nanofracture device (Arthrosurface) or a small chondral pick to perforate the bone of the lateral femoral condyle within the lateral wall of the intercondylar notch, arthroscopically anterior and superior to the anterior cruciate ligament (Fig 13), 2 or 3 times to allow extravasation of marrow content into the joint for



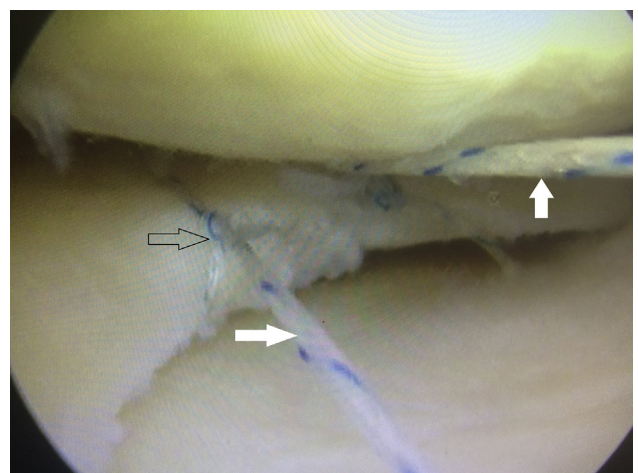
**Fig 8.** The arthroscope is in the anteromedial portal in a left knee. Both suture passes have been made in a horizontal pattern through the medial meniscus, which has undergone resection of the white zone. The 4 suture strands shown represent the 2 halves of the inferior loop (open arrows) and the 2 tails of the suture (white arrows) on the superior surface.



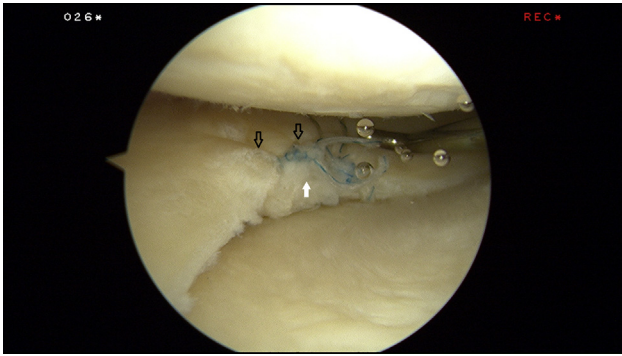
**Fig 9.** The arthroscope is in the anteromedial portal in a left knee. The horizontal lasso is shown in the medial meniscus, with the more anterior suture tail having been pulled through the suture loop (arrow).

biological augmentation of the repair, on the basis of the study by Howarth et al.<sup>8</sup> (Fig 14). Joint closure is performed as per surgeon preference. I prefer to use Monocryl subcutaneous sutures (Ethicon) and Steri-Strips (3M) because they provide reliable healing and excellent cosmesis.

Postoperative management is per my standard protocol, with a hinged locking knee brace set from 0° to 90° and locked in extension knee for ambulation, as well as touch-down weight bearing, for 4 to 6 weeks depending on tear size and repair complexity. Patients are advised that the return to full activity, including sports, may take up to 4 to 6 months.



**Fig 10.** The arthroscope is in the anteromedial portal in a left knee. The horizontal lasso is reduced down to the free edge of the medial meniscus (open arrow) on the left side of the image. The 2 remaining suture limbs (white arrows) represent the 2 tails on the superior surface, which will be tied to complete the knot.

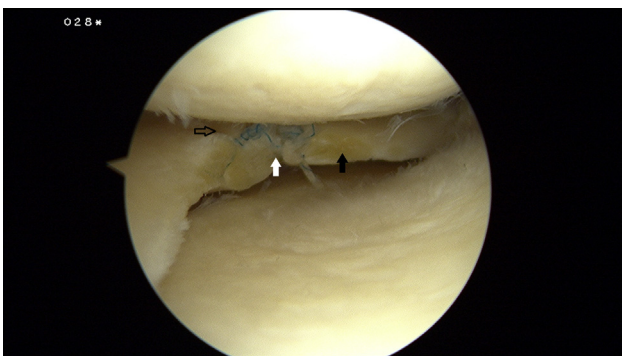


**Fig 11.** The arthroscope is in the anteromedial portal in a left knee. The medial meniscus is shown. Suture passage and knot tying for the horizontal lasso are complete. One should note the circumferential compression of the meniscal tissue along the superior surface (open arrows) and the closure of the fish-mouth component (white arrow) of the horizontal tear.

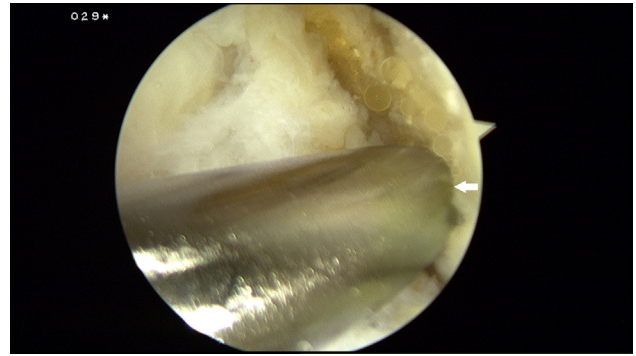
### Discussion

A growing body of literature has provided information related to the clinical results of repair of horizontal cleavage meniscal tears, challenging the notion that these tears are best treated with partial meniscectomy. A recent systematic review by Kurzweil et al.<sup>9</sup> challenged the assertion that existing clinical data showed poor results for the repair of horizontal tears. The systematic review included over 16,000 articles and found 9 studies in the literature that included at least 1 clinical outcome. These studies included repairs of 98 horizontal cleavage tears. The authors of the review noted a clinical success rate, using reoperation as the endpoint, of approximately 78%.

Another recent study was performed by Ahn et al.,<sup>10</sup> who enrolled 32 patients with horizontal cleavage tears that underwent repair. They followed up the patients for an average of 45.6 months and observed only 3



**Fig 12.** The arthroscope is in the anteromedial portal in a left knee, viewing the medial meniscus. The finished horizontal lasso repair is visible, showing circumferential compression of the meniscal tissue along the superior surface (open arrow), closure of the fish-mouth component of the horizontal tear (white arrow), and debridement of frayed free-edge tissue (black arrow) with a nonthermal coagulating device.

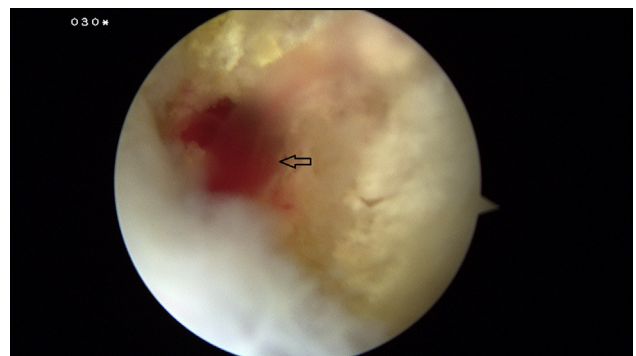


**Fig 13.** The arthroscope is in the anterolateral portal, viewing the lateral wall of the intercondylar notch in a left knee. A small chondral pick or the Nanofracture device is used to penetrate the lateral wall of the intercondylar notch into the cancellous bone of the lateral femoral condyle (arrow).

failures, thus reporting a 91% success rate. Second-look arthroscopy was performed in 11 patients, showing only 1 failure by visual assessment. In their study, patients were treated with an all-inside suturing technique augmented by marrow stimulation achieved by drilling the intercondylar notch.

Considering that horizontal tears are common in patients aged 40 years or older, in a recent study comparing the results of meniscus repair in a cohort of patients aged 40 years or older versus a cohort younger than 40 years, Steadman et al.<sup>11</sup> provided valuable evidence supporting repair. They found no significant differences in repair failure rates or outcome scores between the 2 groups, with a minimum follow-up period of 10 years and an average follow-up period of 16 years.

There are a number of advantages to the described techniques in the treatment of horizontal oblique and horizontal cleavage tears of the menisci (Table 1). Because the tear plane is horizontal, the surgeon must compress the superior leaf to the inferior leaf to maximize tissue contact and promote repair. Standard



**Fig 14.** The arthroscope is in the anteromedial portal, viewing the lateral wall of the intercondylar notch in a left knee. After removal of the chondral pick, extravasation of marrow content (arrow) is confirmed. Biological augmentation of the meniscus repair has been accomplished.

**Table 1.** Advantages and Disadvantages

Advantages	
Achieves tissue compression in the proper inferior-to-superior direction	
Achieves additional tissue compression in the central-to-deep direction	
Can be applied in medial and lateral tears	
Can be used from the ipsilateral and contralateral portals	
Can be used in patients in all age groups	
Distributes compression stress over a wider area, reducing the risk of causing an iatrogenic radial tear	
Disadvantages	
May be difficult to apply techniques in more anterior tears	
Requires the surgeon to be able to tie and manage arthroscopic knots	

arthroscopic techniques and implants can be used to create apparent compression of the meniscus by placing 1 suture limb (or needle pass with an all-inside, capsule-penetrating device) above the meniscus and one below, followed by tensioning of the suture. However, this may cause the suture to cut into the meniscus without actually compressing the 2 leaves, thereby potentially increasing the risk of causing a radial tear and failing to achieve tissue compression in the proper plane. The lasso techniques spread out the compression over a wider area, thereby broadening the area of tissue contact with each stitch. Because the suture goes from inferior to superior through the meniscus, the direction of compression will also be from inferior to superior. In addition, creating the lasso loop closes down the fish-mouth opening of the free edge, increasing the zone of tissue contact and potentially reducing the risk of tear propagation. The lasso

**Table 2.** Pearls and Pitfalls

Pearls	
The surgeon should make the ipsilateral portal low, just over the anterior horn of the involved meniscus, to enable a straight pathway to the posterior horn.	
The surgeon should use a shaver or non-thermal coagulating/ablation device to make wide open, clean portals to reduce the incidence of tissue bridging for knot tying and suture management.	
The vertical lasso should be used for tears in otherwise intact menisci to ensure there is adequate tissue to place the central pass of the suture.	
The horizontal lasso should be used for tears in intact and partially debrided menisci.	
The surgeon should perform the lasso loop outside the joint to reduce time spent on arthroscopic suture management.	
All-inside suture passage may not be possible with tears in the anterior horn or anterior half of the middle third. For these tears, inferior-to-superior outside-in suture passage, followed by making the lasso loop and knot tying, is recommended.	
Pitfalls	
A portal that is too high will not allow proper access to the posterior horn by the NovoStitch Plus device, compromising suture placement.	
Failure to open the portal may result in tissue bridges, risking suture breakage or tearing of the meniscus.	

techniques can also be applied to meniscal tears incorporating multiple tear patterns, such as vertical longitudinal and horizontal cleavage, to provide the benefits of circumferential tissue compression in multiple planes. Moreover, the lasso concept can be applied to outside-in repair methods used for tears in the anterior aspect of the middle third. One passes the suture tails through the meniscus and then retrieves the suture tails through the opposite portal. The lasso loop is made, and the tails are then tied down in the standard fashion. These techniques are straightforward to learn. Once the surgeon understands how to use the suture-passing device, the techniques become easily reproducible. These techniques allow the surgeon to repair tears previously thought to be irreparable, including those tears that have undergone prior partial meniscectomy.

There are essentially no risks or disadvantages to the lasso techniques in the treatment of horizontal cleavage and oblique meniscal tears. One critical aspect of these techniques is the importance of establishing wide open portals before suture passage. Tissue bridges may otherwise occur during knot tying, and they can cause a significant waste of time and resources. That said, once the surgeon becomes familiar with the NSP device (or similar device) and assuming that the surgeon is capable of performing arthroscopic knot tying, these methods of meniscus repair may be applied in a number of circumstances. The techniques can be applied in the medial and lateral compartments, in intact menisci and in those that have undergone partial meniscectomy, in tears located both posteriorly and anteriorly, and in patients in all age groups.

In conclusion, the 2 meniscus repair techniques presented in this report, the vertical lasso and horizontal lasso, offer surgeons the means to repair horizontal cleavage and horizontal oblique meniscal tears in both the medial and lateral compartments in a reliable and reproducible way. The 2 techniques establish circumferential compression of the meniscal tissue to maximize tissue contact (Table 2). The repair techniques are supplemented with biological augmentation by accessing the marrow space. This combination improves the biological environment and optimizes the potential for meniscal healing.

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