Placement of a Compass Knee Hinge

Surgical Technique

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Introduction

The Compass Knee Hinge can be a useful part of the treatment regimen for highly unstable knee dislocations.

The Compass Knee Hinge is a hinged external fixator that provides multiplanar fixation across the knee joint while allowing sagittal plane motion. It can be utilized to provide stabilization of the knee in the setting of dislocation, fracture-dislocation, and multiple-ligament injuries, as opposed to using a fixed external fixator or knee brace alone.

Dislocation of the knee most frequently occurs from high-energy blunt trauma but may also result from an athletic competition injury. Knee dislocations are defined as multiple-ligament injuries, which typically involve the two cruciate ligaments. The injury may also involve the collateral ligaments and in most cases spontaneously reduces prior to presentation to the emergency room¹⁻³. Treatment of these injuries has evolved as surgeons have attempted to balance the goal of achieving ligamentous stability with that of not sacrificing knee range of motion. Clinical outcomes following knee dislocations are frequently poor, with arthrofibrosis, stiffness, pain, and recurrent instability being the most frequent complications⁴⁻⁹. Most authors believe that a stiff painful knee leads to more long-term morbidity and dysfunction than an unstable knee. As a result, many contemporary authors have strongly advocated early operative treatment and aggressive motion and rehabilitation despite the risk of failure of ligament repairs or reconstructions^{5,7-12}.

The Compass Universal Hinge (Smith & Nephew, Memphis, Tennessee) external fixator was originally developed for use at the elbow joint to allow early motion without increasing stress on articular and/or ligamentous repairs. The modifications used to create the Compass Knee Hinge consist of two carbon fiber 5/8 rings bolted to multi-hole Rancho Cubes (Smith & Nephew) that connect to 5 or 6-mm external fixator Schanz pins. The rings are connected by two calibrated hinges that are placed on the medial and lateral sides of the joint. The rings are

available in various sizes and can be selected before application of the hinge in order to be large enough to provide 3 to 4 cm of clearance from the soft tissues on either side of the patient's thigh. The placement of the entire apparatus is based on a centering wire that is temporarily placed at the isometric point on the femur. The hinge is centered by holes that accommodate this wire. Application of the Compass Knee Hinge (Fig. 1) is relatively straightforward, but requires attention to detail and adequate fluoroscopy.

The necessary steps for placement of the Compass Knee Hinge are described (Video 1).

Step 1: Initial Alignment of Wires

Make sure to place the centering wire at the isometric point of the knee.

- With the patient supine and a roll of sterile sheets under his or her knee, determine the desired isometric point with fluoroscopy, making sure to obtain a perfect lateral view of the knee. Locate the isometric point where a line drawn along the anterior aspect of the posterior femoral cortex intersects with the Blumensaat line¹³ (Fig. 2) and place a threaded 2.5-mm wire at this point (Fig. 2).
- Bring the tail of the wire in parallel with the fluoroscope so that it appears as a single dot. Use a mallet to tap in the wire, seating it in the lateral condyle.
- When the wire is well seated and parallel, drill it all of the way across the knee.
- Check an anteroposterior view of the knee to confirm parallel placement to the joint line (Fig. 3). If the wire is not parallel, remove it and insert it again.
- Malalignment of the wire and subsequently the entire apparatus can occur if the surgeon is not careful. It is worth the time and effort to obtain

a quality fluoroscopic view and be precise with placement of the wire.

Step 2: Placement of the Compass Knee Hinge

Take the necessary steps to place the Compass Knee Hinge over the wire.

- After the centering wire has been placed, complete the hinge by placing the external fixator pins into the femur and tibia. Initially place the Rancho Cubes facing proximally in the most posterior hole on the medial and lateral sides of the proximal ring on the hinge.
- Use a one-hole cube medially and a three-hole cube laterally. (Two different-size cubes are utilized to ensure that the pins do not cross the same point within the femur.) Then place the hinge on the centering wire about the knee and drill the femoral pins, using the triple trocar guides provided with the system (Fig. 4).
- A trocar system for drilling through the Rancho Cube is included in the system. Use a number-10 blade to make a skin incision and a hemostat clamp or similar instrument to bluntly dissect down to the bone.
- Remove the center portion of the trocar system, and use a 4-mm drill-bit to drill bicortically across the femur. Then place one pin (6 mm) posteromedially and one pin posterolaterally in the femur.
- Drive the pins until two threads are past the far cortex. Then place a centering sleeve and nut (provided in the system) over the pins within the Rancho Cubes, locking them into place.
- Place three pins (5 mm) in the tibia through the distal ring in a similar fashion; three-hole, four-hole, or five-hole Rancho Cubes are typically used. Place the pins anteromedially, anteriorly, and laterally in the tibia (Fig. 5).
- Hold both rings perpendicular to the shaft of the long bones when the pins are drilled. Of note, always place the femoral pins proximal to the proximal ring and the tibial pins distal to the distal ring to ensure that no pins enter the joint.
- Carefully evaluate the pin sites with the knee in $\geq 90^\circ$ of flexion (Fig. 6).
- If there is any area of skin tension around the pins, release it.
- Finally, tighten all bolts and recheck them, and carefully evaluate the final range of motion.

Step 3: Application of the Compass Knee Hinge with Concurrent Procedures

If repair or reconstruction of either the posteromedial or the posterolateral corner is part of the planned surgical procedure, place the centering wire prior to the repair or reconstruction of the injured corner.

- A critical issue in placing the Compass Knee Hinge in a patient with a multiple-ligament knee injury is the timing of the application steps.
- If repair or reconstruction of either the posteromedial or the posterolateral corner is part of the planned surgical procedure, place the centering wire prior to the repair or reconstruction of the injured corner. This is important because the wire is placed through the area of the corner repair or reconstruction, often requiring a number of passes to get the position exactly right. The potential to damage a repair of the posterolateral corner is unacceptably high if the centering pin is placed following repair and, depending on the choice of the posterolateral corner reconstruction technique, there may be hardware present that would block the wire placement. In these cases, therefore, the application must be completed in two phases.
- Place the centering wire first, mount the hinge, and place two femoral external fixation pins through the Rancho Cubes. Detach the Compass Knee Hinge from the pins, leaving the pins and Rancho Cubes in place in the femur only (Fig. 7).
- Place the remainder of the Compass Knee Hinge on the back table until the completion of the remainder of the reconstructions (Fig. 8).
- Remove the centering wire and perform the remainder of the repair and/or reconstruction of the knee. Following closure of all wounds at the end of the operation, remount the Compass Knee Hinge on the two femoral pins through the same holes, ensuring an isometric placement on the knee.
- Place the tibial pins to complete application of the hinge. Do not place the tibial pins until the end of the operation because they may be in the way during the ligamentous reconstruction/repairs.

Step 4: Postoperative Protocol

Postoperatively, use progressive protocols to enable the patient to regain knee motion following the application of the hinge.

- The Compass Knee Hinge is worn for approximately six weeks.

- Weight-bearing is as tolerated with the knee initially locked in extension for the first week, with progressive range of motion as quadriceps function returns.
- Continuous passive motion machines are used beginning on postoperative day one.
- Rehabilitation includes progressive increases in range of motion along with quadriceps and hamstring strengthening.
- Ask the patient to lock the hinge in full extension and maximum flexion for at least one hour each day—as pain allows—with a range of motion during the remainder of the day.
- Pin site care is similar to that provided for any external fixator.

Results

The above technique was used to treat fifty-five patients with a total of fifty-six knee dislocations who had various concurrent ligamentous reconstructions¹⁴. Forty-six patients with a total of forty-seven dislocations were followed for a mean of thirty-five months (range, twelve to eighty-six months). Seven (15%) of the forty-seven reconstructions (eleven [7%] of the 157 individual reconstructed ligaments) failed. Functional outcomes scores were improved overall, with a final mean Lysholm knee score of 87.2 (range, 69 to 100). The mean visual analog scale (VAS) score was 2.8 (range, 0 to 8); 73% of the patients returned to full-duty work, 9% returned to light duty, and 18% did not return to work. Knee range of motion was good at the final evaluation, with a mean arc of motion of 2° to 124°.

What to Watch For

Indications

- Indications for use of the Compass Knee Hinge include any knee dislocation, fracture-dislocation, or multiple-ligament injury when stability of the knee before or after ligamentous reconstruction is a concern.
- We typically consider placement of the hinge as an adjunct to ligament reconstruction in the setting of Grade-IV or Grade-V dislocation¹⁵, fracture-dislocation, chronic dislocation, or flexion deformity of >15°.

Contraindications

- Fractures of the femur or tibia that preclude proper pin placement.
- Patients who are unable or unwilling to tolerate a fixator in place for an extended period of time.

Pitfalls & Challenges

- The primary pitfall is inaccurate placement of the initial centering wire. If this wire is placed improperly, the entire hinge will not function as intended.
- It is vital that the surgeon obtain excellent fluoroscopic views and be precise with placement of the wire at the isometric point.
- Fracture-dislocations can also present challenges with pin placement if hardware is utilized for fracture fixation prior to placement of the Compass Knee Hinge or ligament reconstructions. This is overcome by adjusting the size and location of the Rancho Cubes to avoid any hardware when the pins are placed.

Clinical Comments

- Multiple-ligament knee injuries are frequently associated with unsatisfactory outcomes^{4,6,16}. Failure of ligament repairs or reconstructions with chronic instability and the need for revision is common.
- Arthrofibrosis, pain, and loss of motion are severe problems^{5-8,17} that are more likely following high-energy trauma.
- Early, aggressive physical therapy may overcome loss of motion and arthrofibrosis but also increases the risk of recurrent ligamentous laxity.
- The Compass Knee Hinge provides rigid stability in all planes of motion except the sagittal plane, allowing the patient to obtain flexion and extension.
- Minimal rotational stress is placed on reconstructed ligaments when the hinge is in place, thus allowing for a more aggressive physical therapy regimen postoperatively.
- There are some disadvantages to using the Compass Knee Hinge, which must be balanced against the improved stability. The device is expensive, takes approximately thirty minutes to apply, and occasionally causes pain at the femoral pins with flexion beyond approximately 60°. Past approximately 60° of flexion, there can sometimes be increased pull on the femoral pins, which can result in discomfort for the patient. We attempt to mitigate this by placing the pins along the intermuscular septum to minimize their pull through the quadriceps muscle itself. Overall it is rarely a major issue, and the discomfort does not occur with every patient. One must weigh the disadvantages of using the Compass Knee Hinge against the benefits of more aggressive therapy and overall stability.

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Figures

Fig. 1

Intraoperative photograph demonstrating placement of the Compass Knee Hinge with a centering wire placed directly through the isometric point on the femur. (Reproduced, with permission, from: Stannard JP, Schmidt AH, Kregor PJ. Surgical treatment of orthopaedic trauma. New York: Thieme; 2007. p 702-3.)

Fig. 2

Fig. 2-A Radiographic identification of the isometric point. **Fig. 2-B** Illustration exhibiting the isometric point, determined by a line extending from the posterior femoral cortex to the Blumensaat line. (Reproduced, with permission, from: Stannard JP, Schmidt AH, Kregor PJ. Surgical treatment of orthopaedic trauma. New York: Thieme; 2007. p 702-3.)

Fig. 3

Anteroposterior fluoroscopic image demonstrating the reference wire parallel to the knee joint. (Reproduced, with permission, from: Stannard JP, Schmidt AH, Kregor PJ. Surgical treatment of orthopaedic trauma. New York: Thieme; 2007. p 702-3.)

Fig. 4

Drilling of the posteromedial pin into the femur for the Compass Knee Hinge after placement of the hinge on the centering wire. The arrow points to the Rancho Cube. (Reproduced, with permission, from: Stannard JP, Schmidt AH, Kregor PJ. Surgical treatment of orthopaedic trauma. New York: Thieme; 2007. p 702-3. [Arrow added.]

Fig. 5

Intraoperative view from the lateral side demonstrating the placement of the three tibial pins.

Fig. 6

Intraoperative view demonstrating knee flexion following placement of the Compass Knee Hinge.

Fig. 7

Intraoperative view demonstrating femoral pins left in place with the Compass Knee Hinge removed, to allow for posteromedial or posterolateral reconstructive procedures.

Fig. 8

Intraoperative view of the Compass Knee Hinge.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8