Femoral Derotational Osteotomy Using a Modified Intramedullary Nail Technique

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Summary: When persistent rotation of the femur remains into adolescence, it can cause functional limitations such as fatigue, anterior knee pain, and frequent tripping. In these cases, derotation of the femur via osteotomy is often performed. We report preliminary results of bilateral derotational osteotomy for excessive femoral anteversion or retroversion using the modified intramedullary nail technique. A retrospective review of 8 patients was performed. Patients were excluded if additional procedures were performed or if the femoral osteotomy included any deformity correction other than rotation. Each patient had simultaneous bilateral femoral osteotomies for a total of 16 limb segments to review. The average age was 12 years, with 4 boys and 4 girls in the group. Seven patients had a preoperative diagnosis of femoral anteversion, and 1 had femoral retroversion. Average amount of derotation performed averaged 30 degrees. Average length of follow-up was 10 months (range, 9 to 12 mo). Average surgical time to complete the bilateral ostetomies was 139 minutes with an average total blood loss of 106 mL. The patients returned to full weight bearing with assistance at 13.75 ± 1.39 days, without assistance at 37.12 ± 5.69 days, and demonstrated full radiographic healing of the femur at 76.13 ± 20.92 days. A modified intramedullary nail technique provides a biologically sound method for rapid healing of the femoral osteotomy site by providing autograft directly to a stable osteotomy site with minimal disruption of the surrounding soft tissue envelope, resulting in faster healing and a quicker return to full, unassisted weight bearing.

Key Words: derotation—femur—osteotomy—intramedullary nail.

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Many children present to the pediatric orthopedic surgeon for an evaluation of intoeing or outtoeing. In most cases, the lower extremity rotation will gradually correct with normal growth.[1] In some children, however, substantial amounts of femoral anteversion or retroversion remains into adolescence. This persistent rotation of the femur can cause functional limitations such as fatigue, anterior knee pain, and frequent tripping.[2,3] Patients and their families also frequently have concerns about the psychological distress caused by walking differently than their peers. If the physical examination demonstrates a true discrepancy of hip internal and external rotation, then a discussion about surgical intervention is warranted.

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For reprint requests, or additional information and guidance on the techniques described in the article, please contact Christopher A. Iobst, MD, at christopher.iobst@nationwidechildrens.org or by mail at Department of Orthopaedic Surgery, Center for Limb Lengthening and Reconstruction, The Ohio State University, College of Medicine Nationwide Children's Hospital 700 Children's Drive Suite T2E-A2700 Columbus, OH 43205. You may inquire whether the author(s) will agree to phone conferences and/or visits regarding these techniques.

Derotation of the femur is performed through an osteotomy. Recent literature describes performing the derotation of the femur over an intramedullary nail.[2–5] A modification of the intramedullary nail technique, is described by Gordon in an instructional video.[6] In his technique, a closed osteoclasis of the femur is performed through multiple drill holes at the osteotomy site. This produces minimal disruption of the soft tissues at the osteotomy site. The drill holes are placed before reaming which allows autograft bone from the reaming process to surround the osteotomy. The transverse osteotomy is performed at the isthmus of the femoral canal. This location provides a friction fit of the nail in the femur and allows the patient to be immediately fully weight bearing as tolerated after surgery. The effect of these 3 factors on the postoperative healing has not previously been described.

Our hypothesis is that this combination of surgical techniques should accelerate the healing process in these patients. This study retrospectively reviews our experience using this technique in pediatric and adolescent femoral derotational osteotomies.

METHODS

After obtaining Institutional Review Board approval, a retrospective chart review was performed on all patients who underwent bilateral derotational osteotomy for excessive femoral anteversion or retroversion using the modified intramedullary nail technique. Patients were excluded if additional procedures were performed or if the femoral osteotomy included any deformity correction other than rotation. A review of each patient's chart and radiographs was performed. The following data points were collected: patient age, patient sex, etiology, surgical time, blood loss, amount of derotation performed, time to radiographic union (complete healing of all 4 cortices on anteroposterior and lateral radiographs), and time to full weight bearing (with assistance and without assistance). In addition, the charts were reviewed for complications including: infection, nonunions, delayed unions, fat embolus, hardware breakage, loss of correction, pain at final follow-up, gait at final follow-up, and patient satisfaction at final follow-up.

Surgical Technique

The patient is placed in the supine position on a radiolucent table with a bump under the hip. The patient should be placed on the edge of the table so the gluteal muscles can hang free. The patient's ipsilateral arm needs to be positioned across the chest so that it does not interfere with the reaming process. Because of these positioning requirements, it is easier to prep and drape 1 leg at a time.

As the rotational range of motion can be different with hip flexed 90 degrees and when the hip is extended it is important to check the range of motion with the hip in extension. This will be the position of the hip during the nail insertion. Therefore, before you start the procedure, flex the hip a few degrees and check the internal and external rotation of the hip in extension.

The femur is visualized with the C-arm and the narrowest portion (isthmus) of the femoral canal is identified in the diaphysis of the femur. This spot is marked on the skin. A 5-mm stab incision is made on the lateral thigh over the center of the femur at that spot. A 4.8-mm drill is passed through the soft tissues to the lateral femur and multiple drill holes are created orthogonal to the bone. A bicortical drill hole can be made through the center of the bone from straight lateral to medial. Through the same entry hole, a second hole is made in the anteromedial femur by dropping the surgeon's hand towards the floor and angling the drill tip slightly anteriorly. A third posteromedial hole is made in a similar fashion using the initial entry hole and angling the drill tip slightly posteriorly. Additional entry holes can be made in the anterolateral and posterolateral femur. A minimum of 6 holes at the same level are created circumferentially around the femur using this technique (Fig. 1).

A guide wire is then inserted into the appropriate starting position at the tip of the greater trochanter and advanced to the lesser trochanter. After checking the wire position with the C-arm, a 2-cm incision is made around the guide wire entry point through the skin in the lateral hip.

An entry reamer is then placed over the guide wire and used to create access to the proximal femur and advanced to the level of the lesser trochanter.

A ball-tipped guide wire is then inserted and advanced to the center of the distal femoral metaphysis but proximal to the distal femoral physis.

Sequential reaming is then performed over the ball-tipped guide wire. Most manufacturers recommend reaming 1.5 mm larger than the size of the nail to be inserted. Reamings can be seen on fluoroscopy passing out of the osteotomy site drill holes and accumulating around the femur at that level (Fig. 2). The appropriate sized nail is then inserted and passed to the level of the osteotomy site.

If desired, a 5-mm half pin can be percutaneously inserted posterior to the nail at the level of the lesser trochanter parallel to the floor and orthogonal to the bone. The threads on the half pin prevent the pin from losing position during the remainder of the surgery. A second 5-mm half pin can be inserted parallel to the first pin just distal to the ball-tipped guide wire but proximal to the distal femoral physis. These 2 half pins can be used to

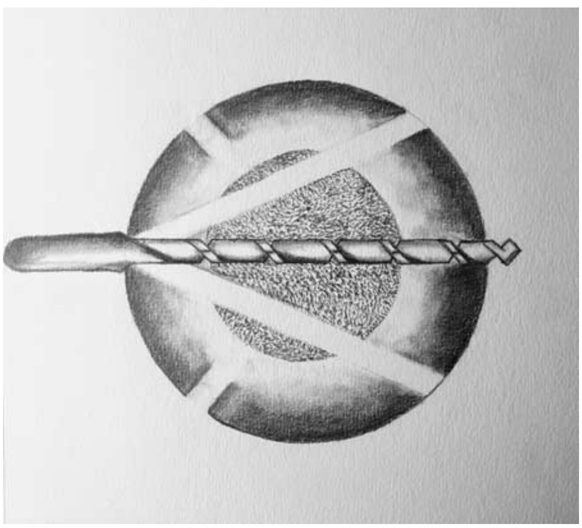

FIGURE 1. Drilling of the venting holes before the reaming.

FIGURE 2. First postoperative radiographs of right (A) and left femur (B) ~2 weeks after surgery. Note the autograft bone that is present around the osteotomy site from the reaming process.

document the amount of rotation achieved by measuring the position of one relative to the other.

The osteoclasis requires 2 people. One person holds the nail that is still exposed proximally (not the insertion device) while the second person applies a valgus force to the femur until it breaks. A C-arm can be used to confirm complete separation of the proximal and distal femoral fragments.

The nail is then passed into the distal fragment and advanced to the appropriate levels proximally and distally.

An acute derotation of the femur is performed until the desired amount of correction is attained. The patella should be rotated until it is in-line or slightly externally rotated relative to the anterior superior iliac spine. The goal is to correct the rotation to about 45 to 50 degrees of external rotation and 40 to 45 degrees of internal rotation. The half pins can be used to help gauge the amount of rotation achieved. As the osteotomy was performed at the narrowest portion of the femoral canal, there should be a tight friction fit between the nail and the bone that provides some additional stability when attempting to determine the correct amount of derotation.

After the appropriate amount of rotation is obtained, interlocking screws are placed distally and proximally to lock the rotation in place.

As the osteotomy is transverse, the patients are allowed to advance to weight bearing as tolerated immediately after surgery. They can discontinue their crutches as soon as they feel comfortable.

RESULTS

Eight patients were found to have undergone the modified intramedullary nail technique. Each patient had simultaneous bilateral femoral osteotomies for a total of 16 limb segments to review. The average age was 12 years, with 4 boys and 4 girls in the group. Seven patients had a preoperative diagnosis of femoral anteversion, and 1 had femoral retroversion. Preoperatively the anteversion patients had an average of 75 degrees of internal rotation and the retroversion patient had 80 degrees of external rotation. The average amount of derotation performed was 30 degrees such that the average postoperative internal rotation was 45 degrees and external rotation of 50 degrees. The average length of follow-up was 10 months (range, 9 to 12 mo). The average surgical time to complete the bilateral osteotomies was 139 minutes with an average total blood loss of 106 mL. The patients returned to full weight bearing with assistance at 13.75 ± 1.39 days, without assistance at 37.12 ± 5.69 days, and demonstrated full radiographic healing of the femur at 76.13 ± 20.92 days (Table 1). Radiographs at 2 weeks postoperative (Fig. 2) show autograft bone at the osteotomy site. Radiographic at 64 days postoperative (Fig. 3) demonstrate complete healing of the osteotomy.

There were no infections, no delayed or nonunions, no hardware breakage, no cases of fat embolism, or loss of correction in this series. In addition, none of the patients reported discomfort, limping or dissatisfaction with their correction at the time of final follow-up.

DISCUSSION

Derotation of the femur may be necessary in children who have persistent femoral anteversion or retroversion that interferes with function. Multiple fixation techniques for this procedure have been described in the literature, including cross pinning, plating, external fixation, and intramedullary nailing.[1–9] This study reports the results of an intramedullary nail technique that utilizes a minimally invasive incision with closed osteoclasis as the femoral osteotomy method. As outlined in the surgical technique, there are 3 main principles to this method that seems to make it an appealing choice for these patients. One, by using multiple drill holes and closed osteoclasis, there is minimal soft tissue disruption at the osteotomy site. Two, by drilling the holes at the osteotomy site before reaming, autograft bone is inherently deposited around the osteotomy during the reaming process. This is also an important safety measure, as it provides a mechanism for venting the femur and decreases the risk for fat embolism.[10] Finally, by creating a transverse osteotomy at the isthmus of the femoral canal, the nail has a tight fit and allows immediate full weight bearing. Each of these components theoretically contributes to promoting faster and more effective healing of the femoral osteotomy.

TABLE 1. Days to Major Postoperative Milestones

Patients	Days to Full Weight Bearing (With Assistance)	Days to Full Weight Bearing (Without Assistance)	Days to Healing of the Femur
1	15	35	62
2	13	34	117
3	16	44	92
4	15	36	64
5	13	34	76
6	13	34	76
7	13	32	74
8	12	48	48
Mean	13.75	37.12	76.13
SD	1.39	5.69	20.92
Median	13	34.5	75
Range	12-16	32-48	48-117

Healing data (time to full weight bearing with assistance, without assistance, and time to healing of the femur) obtained for the 8 patients who underwent the modified intramedullary nail technique. Each procedure was bilateral for a total of 16 osteotomies.

FIGURE 3. Radiograph at 64 days after surgery demonstrating complete healing of the femoral osteotomy site of the right (A) and left (B) femurs.

The results of this study demonstrate that the patients had faster radiographic healing times and faster return to unassisted full weight bearing than previously reported in the literature. Using this modified intramedullary nail technique, the patients returned to full weight bearing with assistance at 13.75 ± 1.39 days, without assistance at 37.12 ± 5.69 days, and full healing of the femur (determined by radiograph) occurred at 76.13 ± 20.92 days (Table 1). In the recent literature performing femoral derotation over intramedullary nails, the patients of Gordon et al[3] were walking by 6 weeks (42 d) and those of Pailhe et al[4] were walking at 2.6 months (78 d). The patients in this study, therefore, were walking 12% to 53% sooner than patients in their series. In the study of both Pailhe and colleagues, and Gordon and colleagues the vent holes were not drilled before reaming. In addition, Pailhe and colleagues describe using a distal metaphyseal osteotomy site and do not use the closed osteoclasis method. This difference in technique may have contributed to the longer time to regain full, unassisted walking in each series.

The time to radiographic union was also less using the modified technique. Gordon et al[3] did not report this data but Pailhe et al[4] describe an average union time of 3 months (90 d). Stevens et al[2] describe a technique similar to the one proposed in this article but they did not perform a closed osteoclasis of the femur. Their reported union times were 3 to 4 months (90 to 120 d). Skiak et al[9] reported performing derotations using an external fixator. Their average fixator removal time was 90 days. Haefeli and colleagues describe performing fixing the femoral derotations with a locking compression plate. Their average time to union was 40 weeks (280 d).[7] Therefore, depending on the technique used, time to full radiographic healing was 15% to 73% sooner in this series compared with the other techniques. The autograft surrounding the stable, minimally disrupted soft tissue envelope appears to facilitate faster healing when using the modified intramedullary nail technique.

One of the technically challenging portions of this technique is to determine the correct amount of rotation. The goal is to achieve 40 to 45 degrees of internal rotation and 45 to 50 degrees of external rotation after derotation. By performing the osteotomy at the isthmus of the femur the rotation can be performed in a controlled manner. As the femur is derotated over the nail, the drill holes tend to cause a "clicking" sensation as the femur is being rotated. The surgeon can let go and check the rotation without fear of losing alignment due to the tight friction fit of the nail at the osteotomy site. The patella should be positioned in-line or slightly externally rotated relative to the anterior superior iliac spine. The half pins placed proximal and distal to the osteotomy site can be used to double-check that the anticipated amount of derotation has been accomplished. Placing the distal screw first allows the surgeon to make final adjustments by rotating the distal segment and nail as a unit, if necessary. It is easier to place the final screw through the guide arm proximally than to try to freehand the distal interlocking screw at an odd angle. Once both interlocking screws are placed, the hip should be internally and externally rotated in extension to confirm the rotation has been corrected in a satisfactory manner.

There were no perioperative or postoperative complications such as infection, nonunion, delayed union, broken implants, or loss of correction in this series. In addition, none of the patients reported discomfort, limping or dissatisfaction with their correction at the time of final follow-up. In the Pailhe et al[4] series 1 patient experienced early varus displacement and required revision surgery. Skiak et al[9] reported 1 hypertrophic nonunion and Haefeli et al[7] had 2 implant failures. Stevens et al[2] had 2 nonunions and 23 broken screws in their series. Mei-Dan et al[5] describe a percutaneous method using an intramedullary saw with an expandable intramedullary nail. They report 1 nonunion in their series but provide no additional data about healing times.

By demonstrating faster healing times and an earlier return to full, unassisted weight bearing this technique allows the patients to return to school more quickly. Decreasing the duration of school absence allows children to have a better chance to stay on track with their grade level and helps to minimize the psychological stress of being separated from their friends. In addition, for households with single parents or parents who both need to work, a faster recovery time means less time away from work.

This study is limited by the relatively low number of patients (8 patients, 16 osteotomies) included in the series. Future studies with greater number of patients will be necessary to confirm these promising early results. A multicenter prospective study comparing this technique with an open osteotomy may provide a higher level of evidence than this level 4 retrospective study.

In conclusion, this modified intramedullary nail technique theoretically provides a biologically sound method for rapid healing of the femoral osteotomy site by providing autograft directly to a stable osteotomy site with minimal disruption of the surrounding soft tissue envelope. The results of this study demonstrate that not only is the technique safe, but it produces faster healing and a quicker return to full, unassisted weight bearing than previously reported in the literature.

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