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SYMPOSIUM: RECENT ADVANCES IN FOOT AND ANKLE SURGERY

Endoscopic Gastrocnemius Recession for Treating Equinus in Pediatric Patients

John F. Grady DPM, Carolyn Kelly BS

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Abstract Gastrocnemius recessions have been performed as open or endoscopic procedures. Most of the literature describes the outcomes of these procedures in children with specific neurologic limitations. We report an alternative approach to endoscopic gastrocnemius recessions in neurologically healthy pediatric and adolescent patients whose gastrocnemius equinus could not be corrected nonoperatively. We prospectively followed 23 patients (16 boys, seven girls) who underwent 40 procedures for equinus deformity (n = 22) or osteoarthritis (n = 1). All patients had been directly referred for surgical treatment because all previous nonoperative treatments (stretching, night splints, orthotics, nonsteroidal anti-inflammatory drugs, and physical therapy) had failed. The indications for surgery were patients age 18 years or younger experiencing symptomatic equinus unresponsive to nonoperative care. Pre- and postoperative ankle dorsiflexion were measured. The minimum followup for study inclusion was 1 year (mean, 2.9 years; range, 2–5.1 years). For every patient, dorsiflexion range of motion improved (mean, 15°; standard deviation, 4°). No patient had diminished nerve sensation postoperatively. This technique can be used to correct gastrocnemius equinus in otherwise healthy children who have not benefited from prior nonsurgical treatment.
Level of Evidence: Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.
Each author certifies that his or her institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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Introduction

Many studies describe the surgical correction of gastrocnemius equinus contracture [5, 7, 11]. A gastrocnemius equinus is typically characterized by less than 10° of ankle dorsiflexion with the knee extended [9, 10]. Less than 10° of dorsiflexion can lead to various compensations in the lower extremity that ostensibly cause secondary problems [7], including Achilles tendinosis [7], flatfoot [7, 9], lower back pain or strain [9], knee hyperextension (genu recurvatum) [9], plantar fasciitis [3, 6, 7], midfoot pain or arthritis [2], or lateral foot pain [6]. Some nonoperative methods for treating limited dorsiflexion include gastrocnemius stretching [3, 4], orthoses [4], and nonsteroidal anti-inflammatory drugs (NSAIDs) to limit the amount of inflammation [3] of the foot and ankle. Limited dorsiflexion has also been surgically treated with Achilles tendon lengthening procedures and open gastrocnemius recession techniques [14]. Recently, several authors have described endoscopic gastrocnemius recessions [1, 14, 17]. This method is reportedly associated with fewer complications [17] and less likelihood of poor cosmesis [14, 15]. Pinney et al. [11] suggest endoscopic gastrocnemius recession (EGR) is indicated in adults demonstrating gastrocnemius equinus or in those adults exhibiting less than 10° of dorsiflexion with the knee extended and an increase in ankle range of motion with the knee flexed.

One study suggested the amount of dorsiflexion in children may differ from that of adults [13]. Children, specifically child athletes, require a certain degree of motion, flexibility, and strength in daily functioning, just as adults do. In addition, adolescent athletes may require different baselines of dorsiflexion to function normally [13]. Providing an EGR to children and adolescents with gastrocnemius equinus may allow them the opportunity to overcome their physical limitations and any current or future lower extremity pathology related to their equinus [17]. In addition, this provides a surgical option where nonoperative methods have failed in the past.

We therefore describe a new technique of EGR to be used on otherwise healthy pediatric patients with gastrocnemius equinus. We then asked whether this technique would (1) increase ankle dorsiflexion range of motion adequately and (2) avoid injury to the sural nerve.

Patients and Methods

We prospectively followed 23 patients (40 procedures) in which we performed EGRs from 2003 until 2008 (Table 1). The procedure was performed bilaterally on 17 of 23 patients. This procedure was indicated for these patients because they had attempted nonoperative treatment under the care of previous physicians that had proved unsuccessful. Twenty-two of the patients were diagnosed by us as having idiopathic equinus and one having osteoarthritis. All patients initially presented with pain that had lasted at least 1 year. Pain was generally located along the lateral or plantar aspect of the foot. The pain caused the patients to limp and limited their ability to participate in activities. These patients underwent a minimum of 6 months of nonoperative treatment including NSAIDs, stretching [4], orthoses, and physical therapy. Before surgery, the patients were experiencing various preoperative symptoms either contributing to or as a result of their equinus deformity (Table 2). As patients were referred, all nonoperative treatments were performed under the care of a previous physician, and it was ensured all patients had been treated nonsurgically for at least 6 months before surgical intervention. Indications for the procedure were: pediatric patients (younger than age 18 years) with gastrocnemius equinus who had not benefited from nonsurgical treatment, those who walked with a limp or had difficulties walking in general (antalgic gait), and those whose active lives were limited as a result of lack of range of motion and foot pain. Neuromuscular disease was a contraindication for the procedure. As a guideline for the study, we excluded any patients who did not follow up for 1 year. Because all patients met this guideline, none were excluded from our study. Eight of the 23 patients in the study were athletes or very active children whose activities were limited by their conditions. There were seven female and 16 male patients with an age range of 7 to 16 years (one patient was 17 years old at the time of second recession). The minimum followup was 1 year (mean, 2.9 years; range, 2–5.1 years). No patients were lost to followup. We discussed the risks with the patients and parents, and informed parental consent was obtained.

Before surgery, two of us (JG, EZ) assessed ankle range of motion using a tractograph with one arm placed laterally on the fibula, the axis at the ankle, and the other arm parallel to the inferior lateral aspect of the calcaneus (Fig. 1). The ankle was dorsiflexed, keeping the knee in an extended position with the subtalar joint in neutral position. Additionally, this same method was used when flexing the knee. If dorsiflexed limitation was relieved (in other words, if the measured dorsiflexion of the ankle was 10° or greater), we considered the limited motion secondary to gastrocnemius equinus as defined by the Silfverskiöld test [1]. To assess nerve sensation, we used a Semmes-Weinstein 5.07-g monofilament to test all digits bilaterally. These assessments were also followed postoperatively. All patients were screened for neuromuscular disorders because there is a higher recurrence of equinus in patients with neuromuscular abnormalities [3, 8, 17]. Each child or adolescent was assessed preoperatively for a definitive diagnosis (Table 1).

We made a 1-cm length incision at the medial aspect of the ventral gastrocnemius aponeurosis. Deep dissection was carried out bluntly with a hemostat, observing for any nerve along the way. This was carried through subcutaneous fat to the aponeurosis. We used an aponeurosis elevator to dissect across the posterior aspect of the calf anterior to the subcutaneous fat and posterior to the gastrocnemius aponeurosis. An exit wound was made laterally by a stab incision over the periosteal elevator and projecting that through. We then inserted an obturator and a cannula through the same pathway and then, inserting a 3.5-mm scope, we observed for the aponeurosis across the entire length of the slotted cannula (Fig. 2). Noting the aponeurosis, we then rotated the cannula 180° (Fig. 3). Then we identified the sural nerve. It is important to identify the sural nerve before proceeding. If it is not posterior to the cannula, it can be inadvertently cut. Next, we inserted a hook blade laterally into this same slotted cannula with the cannula now rotated anteriorly. The hook blade was used to cut from the medial aspect of the aponeurosis to the lateral aspect of the aponeurosis as we observed with a scope inserted from medial to lateral as the blade leaves our visual field (Fig. 4). We ensured we cut the aponeurosis until we gained 10° of dorsiflexion on the table with the knee extended. We avoided overcorrection (that is, gaining greater than 10° of dorsiflexion with the knee extended

Table 1. Summary of data on 23 patients undergoing EGR

Age (years)	Gender	Diagnosis	Side (R/L)	Preoperative ankle DF (°)	Postoperative ankle DF (°) at 2 weeks, 6 months, and 2 years	Number of years after initial procedure
12	F	DJD	L	0	12	5
10	M	Equinus Def	L	1	11	4
9	M	Equinus Def	R	0	10	4
12	M	Equinus Def	L	−2	9	3
13	M	Equinus Def	R	−2	10	3
12	F	Equinus Def	R	−6	10	3
16	M	Equinus Def	L	−4	10	3
15	M	Equinus Def	R	−4	12	2
14	M	Equinus Def	L	−5	9	3
14	M	Equinus Def	R	−5	10	3
17	F	Equinus Def	L	−11	10	3
16	F	Equinus Def	R	−8	10	2
13	M	Equinus Def	L	−8	10	2
12	M	Equinus Def	R	−8	10	2
13	M	Equinus Def	L	−2	14	3
13	M	Equinus Def	R	−3	15	2
9	M	Equinus Def	L	−6	10	2
13	M	Equinus Def	L	−20	10	2
12	M	Equinus Def	R	−7	10	4
12	M	Equinus Def	L	−6	10	4
7	M	Equinus Def	L	−2	12	2
7	M	Equinus Def	R	−6	11	2
16	F	Equinus Def	L	−8	10	2
15	F	Equinus Def	R	0	10	3
8	F	Equinus Def	L	−7	10	4
9	F	Equinus Def	R	−7	11	4
11	F	Equinus Def	L	0	10	2
12	F	Equinus Def	R	−2	12	2
13	M	Equinus Def	R	−2	10	4
15	M	Equinus Def	L	−1	10	3
14	M	Equinus Def	L	−5	10	4
14	M	Equinus Def	R	−5	15	3
12	M	Equinus Def	L	−4	11	2
12	M	Equinus Def	R	−2	11	3
9	F	Equinus Def	L	2	12	4
9	F	Equinus Def	R	2	12	3
9	M	Equinus Def	L	−6	10	2
9	M	Equinus Def	R	−6	10	3
12	M	Equinus Def	L	−8	10	3
12	M	Equinus Def	R	−6	11	3

EGR = endoscopic gastrocnemius recession; R = right; L = left; DF = dorsiflexion; F = female; M = male; DJD = degenerative joint disease; Equinus Def = equinus deformity.

perioperatively), and we sectioned the aponeurosis millimeter by millimeter as we concurrently dorsiflexed the foot (Fig. 5). The tension in the foot, applied to first anatomic resistance, allowed us to judge when we made a complete release. An additional cutting type of endoscopic unit can be used as well. In 15 patients, we additionally performed a subtalar joint arthrodesis, which is the insertion of an MBA implant into the sinus tarsi to correct subtalar joint

Table 2. Number of patients experiencing various preoperative symptoms

Symptom	Number of patients
Generalized foot pain	23
Ligamentous laxity	18
Flatfoot deformity	10
Achilles tendonitis	3
Arthritis	1
Tibialis posterior tendonitis	1
Sinus tarsi syndrome	1

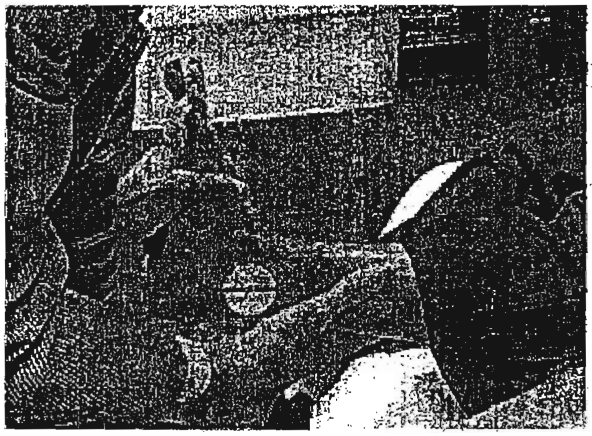

Fig. 1 Measurement of ankle dorsiflexion. The evaluator assesses ankle range of motion with the knee extended. One of the arms of the tractograph is placed on the lateral aspect of the fibula with the axis at the ankle. The other arm is placed parallel to the inferior aspect of the calcaneus. This technique represents part of the Silfverskiöld test.

instability. We then irrigated the area with saline, putting the suction tip on one end of the cannula. We closed the incisions using one simple interrupted suture of 4-0 Monocryl (Ethicon, Somerville, NJ).

Postoperatively, we applied a posterior splint keeping the foot in dorsiflexion at 10° to the leg for 2 weeks, during which time the patients were kept nonweightbearing. Subsequent to that, we had patients bear weight normally with flexibility exercises, depending on which concurrent procedures were performed. We allowed return to normal activity, including aggressive sports, no sooner than 1 month postoperatively. After that time, weakness and nerve sensation were noted for at least another 3 to 4 months. This was assessed through routine muscle strength tests such as strength of dorsiflexion and plantar flexion of the ankle to active resistance of the patient. Additionally, range of motion of the ankle was assessed.

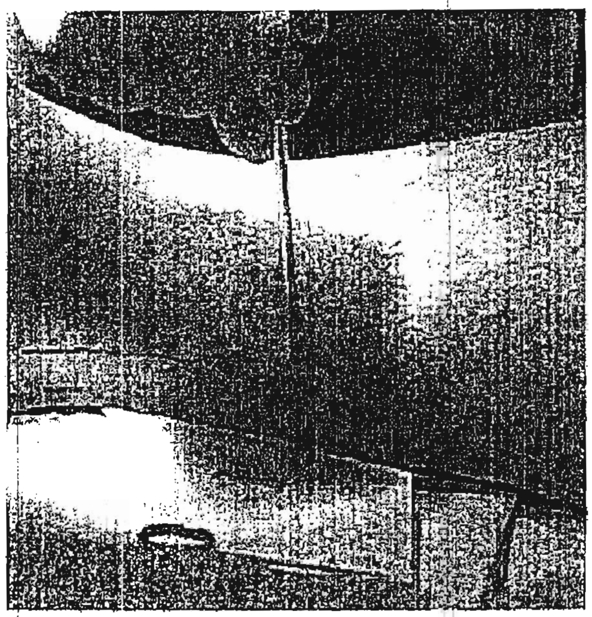

Fig. 2 Insertion of the cannula. A cannula is inserted through subcutaneous fat to the medial aspect of the ventral gastrocnemius aponeurosis. The inserted cannula then allows for the positioning of a 3.5-mm scope to visualize the aponeurosis. (Reproduced with permission of Amol Saxena, DPM.)

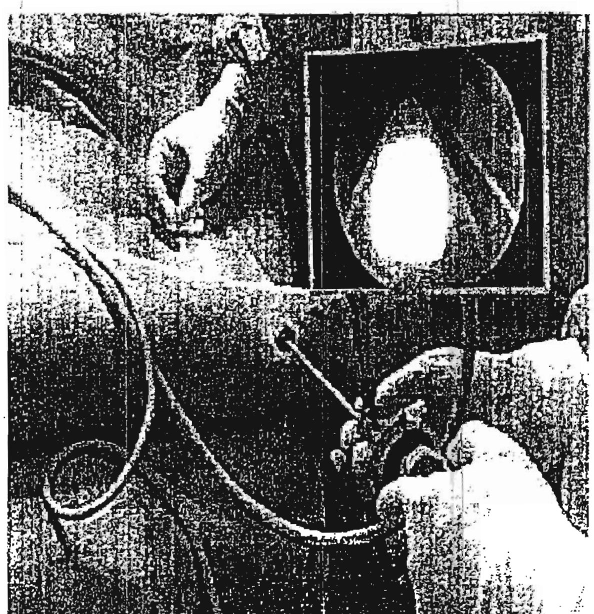

Fig. 3 Visualization of the gastrocnemius aponeurosis. The cannula with inserted 3.5-mm scope allows for a clear view of the aponeurosis. On visualization of the gastrocnemius aponeurosis, the cannula is rotated 180° to identify the sural nerve before any cutting. (Reproduced with permission of Amol Saxena, DPM.)

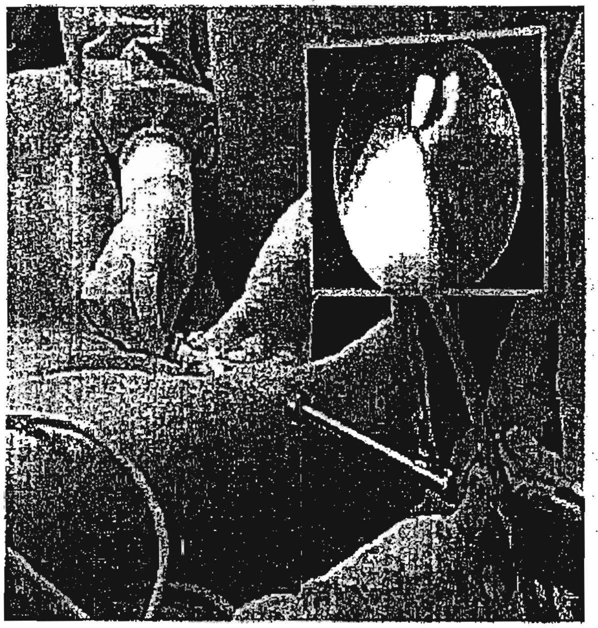

Fig. 4 Cutting the gastrocnemius aponeurosis. A hook blade is inserted into the slotted cannula, which has been rotated. The hook blade is then used to cut from the medial aspect to the lateral aspect of the aponeurosis. As the surgeon makes this cut, the aponeurosis is continually observed through the scope. (Reproduced with permission of Amol Saxena, DPM.)

Fig. 5 Assessment of correction. The aponeurosis is cut until gaining 10° of dorsiflexion with the knee extended. By concurrently sectioning the aponeurosis and dorsiflexing the foot, adequate dorsiflexion can be obtained while avoiding overcorrection (gaining greater than 10° of dorsiflexion.) (Reproduced with permission of Amol Saxena, DPM.)

Postoperatively, two of us (JG, EZ) assessed ankle motion using a tractograph as we did preoperatively. Ankle range of motion was assessed postoperatively at the specific intervals of 2 weeks, 6 months, and 2 years after the procedure. Every patient was evaluated for nerve damage. Each patient's level of nerve sensation was measured using a Semmes-Weinstein 5.07-g monofilament directed to all digits bilaterally as well as along the lateral aspect of the leg. In addition, sharp sensation, dull sensation, and proprioception were evaluated. Babinski's sign and the Achilles reflex were also observed.

Results

Ankle dorsiflexion increased for every patient in the study (mean, 15°; standard deviation, 4°) (Table 1). The postoperative dorsiflexion was maintained for all patients over the followup time (Table 1).

No patients experienced either diminished nerve sensation or nerve damage at any followup visit (Table 3). We observed no postoperative complications such as infection or blot clots.

Discussion

Although various literature cites the advantageous effects of EGR in the adult population [14, 17] and the use of open gastrocnemius recession procedures in children with neuromuscular deformities such as cerebral palsy [5], there is no literature to date corresponding to the use of this specific EGR technique for pediatric patients who lack neurologic abnormalities. Usually the treatment of choice for these patients involves nonoperative care, but what if this treatment option fails? Although EGR has been used in these situations in adults it is reportedly associated with sural nerve damage [14]. The sural nerve, as a result of its relationship to the gastrocnemius muscle, may be more susceptible to damage during surgical recessions [16]. In video-assisted gastrocnemius-soleus lengthening in patients with cerebral palsy, which also uses an endoscopic technique, young patients experiencing both spastic cerebral palsy and equinus foot deformity benefit from this treatment

Table 3. Intact nerve sensation at different times of evaluation

Evaluation time	Presence of sensation to Semmes-Weinstein monofilament (number of patients)
2 weeks	23
6 months	23
2 years	23

in that their ankle range of motion increases [12] although that study reported one patient with sural nerve damage. Additionally, open gastrocnemius recessions with larger incisions [11] may lead to poor cosmesis. We therefore developed a new technique of EGR to be used on otherwise healthy pediatric patients with gastrocnemius equinus. We then asked whether our technique would (1) increase ankle dorsiflexion range of motion and (2) avoid injury to the sural nerve.

We note several limitations. First is the small sample size, which, although similar in size to another study of gastrocnemius recession [14], is especially limited as a result of the lack of previous reports of equinus correction in healthy children and adolescents. A larger study could find a larger number of complications. Second is the possibility of evaluator bias when assessing both postsurgical range of motion and testing for nerve damage. Because the evaluator was also the surgeon who developed the procedure, enthusiasm for the procedure could lead to optimistic findings. Incorporating at least two pre- and postoperative data evaluators would reduce the possibility of evaluator bias. Third, we did not use a standardized device when assessing range of motion both preoperatively and postoperatively [14, 17]. Our methods were similar to those used on adults in a comparable study [17]. Fourth, we did not have a control group; our patients had been specifically referred for surgery because they failed nonoperative treatment. Conversely, patients might be seen as serving as their own control group since they had previously failed nonoperative treatment. Fifth, because there was only one procedure being performed in the study, it could only be compared with other procedure techniques through literature. Finally, there is limited literature on equinus in pediatric patients, specifically those without neurologic pathologies such as cerebral palsy. However, equinus can exist in individuals who are otherwise seemingly healthy, essentially contributing to abnormalities such as flatfoot deformity, lateral foot pain, and eventual arthritis [2]. This new EGR technique, although acquiring some limitations, can essentially aid in correcting a gastrocnemius equinus in youth with few complications.

We found ankle dorsiflexion improved by an average of 15° overall. With these improvements, the ranges of values may better meet the comparable standards of dorsiflexion for child athletes [13]. Increased dorsiflexion serves as a key outcome for many studies of equinus deformity [5, 8, 11, 14].

By ensuring proper visualization of the sural nerve every time before making the cut, nerve dysesthesia was avoided. Several studies report this as a complication [12, 14]. None of our patients experienced this complication, further emphasizing the importance of technique.

Based on these outcome variables, we believe EGR an alternative for treating pediatric patients without neuromuscular limitation who are considered for surgery. A prospective controlled study comparing EGR in healthy pediatric patients to other forms of gastrocnemius equinus correction techniques may be the solution to the issue of some of the limitations of our study. Regardless of the limitations, we believe EGR can be an alternative approach when surgery is a reasonable option for these young patients.

Acknowledgments We thank Emil Zager, DPM for his assistance with data collection.

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Each author certifies that his or her institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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We prospectively followed 23 patients (40 procedures) in which we performed EGRs from 2003 until 2008 (Table 1). The procedure was performed bilaterally on 17 of 23 patients. This procedure was indicated for these patients because they had attempted nonoperative treatment under the care of previous physicians that had proved unsuccessful. Twenty-two of the patients were diagnosed by us as having idiopathic equinus and one having osteoarthritis. All patients initially presented with pain that had lasted at least 1 year. Pain was generally located along the lateral or plantar aspect of the foot. The pain caused the patients to limp and limited their ability to participate in activities. These patients underwent a minimum of 6 months of nonoperative treatment including NSAIDs, stretching [4], orthoses, and physical therapy. Before surgery, the patients were experiencing various preoperative symptoms either contributing to or as a result of their equinus deformity (Table 2). As patients were referred, all nonoperative treatments were performed under the care of a previous physician, and it was ensured all patients had been treated nonsurgically for at least 6 months before surgical intervention. Indications for the procedure were: pediatric patients (younger than age 18 years) with gastrocnemius equinus who had not benefited from nonsurgical treatment, those who walked with a limp or had difficulties walking in general (antalgic gait), and those whose active lives were limited as a result of lack of range of motion and foot pain. Neuromuscular disease was a contraindication for the procedure. As a guideline for the study, we excluded any patients who did not follow up for 1 year. Because all patients met this guideline, none were excluded from our study. Eight of the 23 patients in the study were athletes or very active children whose activities were limited by their conditions. There were seven female and 16 male patients with an age range of 7 to 16 years (one patient was 17 years old at the time of second recession). The minimum followup was 1 year (mean, 2.9 years; range, 2–5.1 years). No patients were lost to followup. We discussed the risks with the patients and parents, and informed parental consent was obtained.

Before surgery, two of us (JG, EZ) assessed ankle range of motion using a tractograph with one arm placed laterally on the fibula, the axis at the ankle, and the other arm parallel to the inferior lateral aspect of the calcaneus (Fig. 1). The ankle was dorsiflexed, keeping the knee in an extended position with the subtalar joint in neutral position. Additionally, this same method was used when flexing the knee. If dorsiflexed limitation was relieved (in other words, if the measured dorsiflexion of the ankle was 10° or greater), we considered the limited motion secondary to gastrocnemius equinus as defined by the Silfverskiöld test [1]. To assess nerve sensation, we used a Semmes-Weinstein 5.07-g monofilament to test all digits bilaterally. These assessments were also followed postoperatively. All patients were screened for neuromuscular disorders because there is a higher recurrence of equinus in patients with neuromuscular abnormalities [3, 8, 17]. Each child or adolescent was assessed preoperatively for a definitive diagnosis (Table 1).

We made a 1-cm length incision at the medial aspect of the ventral gastrocnemius aponeurosis. Deep dissection was carried out bluntly with a hemostat, observing for any nerve along the way. This was carried through subcutaneous fat to the aponeurosis. We used an aponeurosis elevator to dissect across the posterior aspect of the calf anterior to the subcutaneous fat and posterior to the gastrocnemius aponeurosis. An exit wound was made laterally by a stab incision over the periosteal elevator and projecting that through. We then inserted an obturator and a cannula through the same pathway and then, inserting a 3.5-mm scope, we observed for the aponeurosis across the entire length of the slotted cannula (Fig. 2). Noting the aponeurosis, we then rotated the cannula 180° (Fig. 3). Then we identified the sural nerve. It is important to identify the sural nerve before proceeding. If it is not posterior to the cannula, it can be inadvertently cut. Next, we inserted a hook blade laterally into this same slotted cannula with the cannula now rotated anteriorly. The hook blade was used to cut from the medial aspect of the aponeurosis to the lateral aspect of the aponeurosis as we observed with a scope inserted from medial to lateral as the blade leaves our visual field (Fig. 4). We ensured we cut the aponeurosis until we gained 10° of dorsiflexion on the table with the knee extended. We avoided overcorrection (that is, gaining greater than 10° of dorsiflexion with the knee extended

Table 1. Summary of data on 23 patients undergoing EGR

Age (years)	Gender	Diagnosis	Side (R/L)	Preoperative ankle DF (°)	Postoperative ankle DF (°) at 2 weeks, 6 months, and 2 years	Number of years after initial procedure
12	F	DJD	L	0	12	5
10	M	Equinus Def	L	1	11	4
9	M	Equinus Def	R	0	10	4
12	M	Equinus Def	L	−2	9	3
13	M	Equinus Def	R	−2	10	3
12	F	Equinus Def	R	−6	10	3
16	M	Equinus Def	L	−4	10	3
15	M	Equinus Def	R	−4	12	2
14	M	Equinus Def	L	−5	9	3
14	M	Equinus Def	R	−5	10	3
17	F	Equinus Def	L	−11	10	3
16	F	Equinus Def	R	−8	10	2
13	M	Equinus Def	L	−8	10	2
12	M	Equinus Def	R	−8	10	2
13	M	Equinus Def	L	−2	14	3
13	M	Equinus Def	R	−3	15	2
9	M	Equinus Def	L	−6	10	2
13	M	Equinus Def	L	−20	10	2
12	M	Equinus Def	R	−7	10	4
12	M	Equinus Def	L	−6	10	4
7	M	Equinus Def	L	−2	12	2
7	M	Equinus Def	R	−6	11	2
16	F	Equinus Def	L	−8	10	2
15	F	Equinus Def	R	0	10	3
8	F	Equinus Def	L	−7	10	4
9	F	Equinus Def	R	−7	11	4
11	F	Equinus Def	L	0	10	2
12	F	Equinus Def	R	−2	12	2
13	M	Equinus Def	R	−2	10	4
15	M	Equinus Def	L	−1	10	3
14	M	Equinus Def	L	−5	10	4
14	M	Equinus Def	R	−5	15	3
12	M	Equinus Def	L	−4	11	2
12	M	Equinus Def	R	−2	11	3
9	F	Equinus Def	L	2	12	4
9	F	Equinus Def	R	2	12	3
9	M	Equinus Def	L	−6	10	2
9	M	Equinus Def	R	−6	10	3
12	M	Equinus Def	L	−8	10	3
12	M	Equinus Def	R	−6	11	3

EGR = endoscopic gastrocnemius recession; R = right; L = left; DF = dorsiflexion; F = female; M = male; DJD = degenerative joint disease; Equinus Def = equinus deformity.

perioperatively), and we sectioned the aponeurosis millimeter by millimeter as we concurrently dorsiflexed the foot (Fig. 5). The tension in the foot, applied to first anatomic resistance, allowed us to judge when we made a complete release. An additional cutting type of endoscopic unit can be used as well. In 15 patients, we additionally performed a subtalar joint arthrodesis, which is the insertion of an MBA implant into the sinus tarsi to correct subtalar joint

Table 2. Number of patients experiencing various preoperative symptoms

Symptom	Number of patients
Generalized foot pain	23
Ligamentous laxity	18
Flatfoot deformity	10
Achilles tendonitis	3
Arthritis	1
Tibialis posterior tendonitis	1
Sinus tarsi syndrome	1

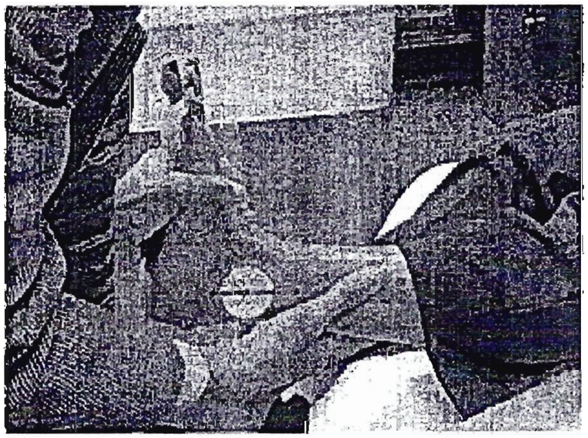

Fig. 1 Measurement of ankle dorsiflexion. The evaluator assesses ankle range of motion with the knee extended. One of the arms of the tractograph is placed on the lateral aspect of the fibula with the axis at the ankle. The other arm is placed parallel to the inferior aspect of the calcaneus. This technique represents part of the Silfverskiöld test.

instability. We then irrigated the area with saline, putting the suction tip on one end of the cannula. We closed the incisions using one simple interrupted suture of 4-0 Monocryl (Ethicon, Somerville, NJ).

Postoperatively, we applied a posterior splint keeping the foot in dorsiflexion at 10° to the leg for 2 weeks, during which time the patients were kept nonweightbearing. Subsequent to that, we had patients bear weight normally with flexibility exercises, depending on which concurrent procedures were performed. We allowed return to normal activity, including aggressive sports, no sooner than 1 month postoperatively. After that time, weakness and nerve sensation were noted for at least another 3 to 4 months. This was assessed through routine muscle strength tests such as strength of dorsiflexion and plantar flexion of the ankle to active resistance of the patient. Additionally, range of motion of the ankle was assessed.

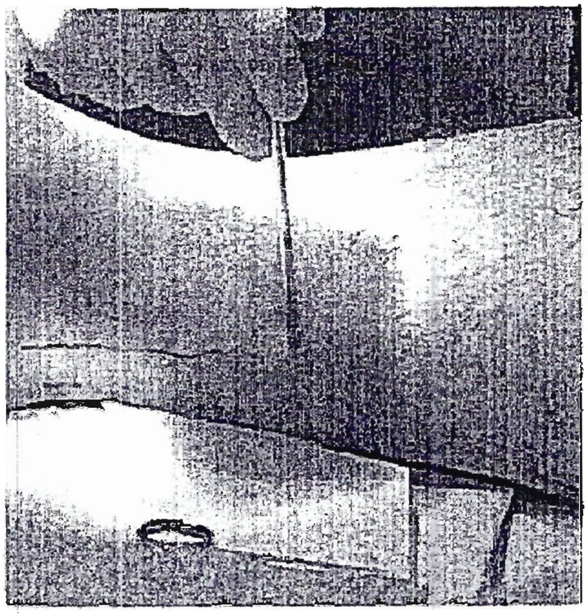

Fig. 2 Insertion of the cannula. A cannula is inserted through subcutaneous fat to the medial aspect of the ventral gastrocnemius aponeurosis. The inserted cannula then allows for the positioning of a 3.5-mm scope to visualize the aponeurosis. (Reproduced with permission of Amol Saxena, DPM.)

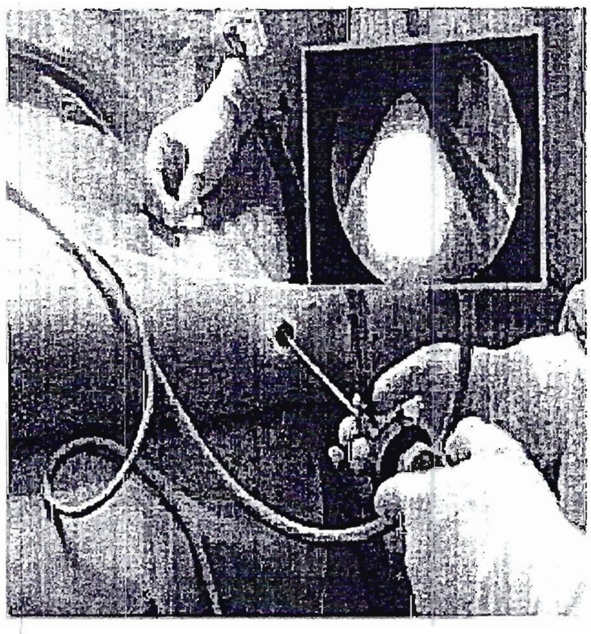

Fig. 3 Visualization of the gastrocnemius aponeurosis. The cannula with inserted 3.5-mm scope allows for a clear view of the aponeurosis. On visualization of the gastrocnemius aponeurosis, the cannula is rotated 180° to identify the sural nerve before any cutting. (Reproduced with permission of Amol Saxena, DPM.)

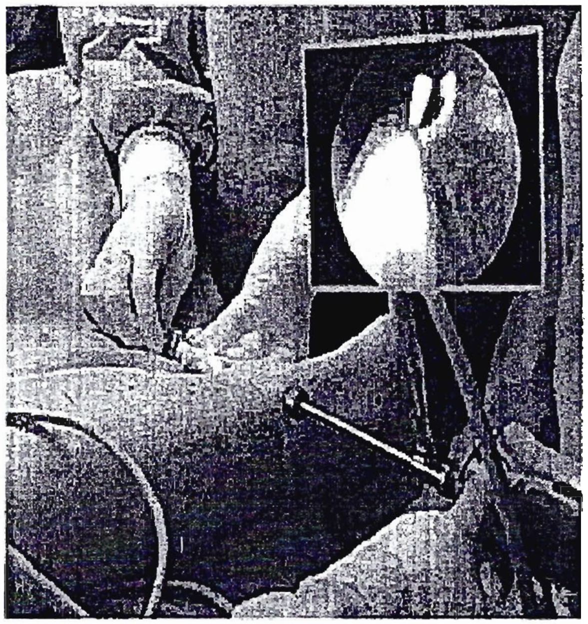

Fig. 4 Cutting the gastrocnemius aponeurosis. A hook blade is inserted into the slotted cannula, which has been rotated. The hook blade is then used to cut from the medial aspect to the lateral aspect of the aponeurosis. As the surgeon makes this cut, the aponeurosis is continually observed through the scope. (Reproduced with permission of Amol Saxena, DPM.)

Fig. 5 Assessment of correction. The aponeurosis is cut until gaining 10° of dorsiflexion with the knee extended. By concurrently sectioning the aponeurosis and dorsiflexing the foot, adequate dorsiflexion can be obtained while avoiding overcorrection (gaining greater than 10° of dorsiflexion.) (Reproduced with permission of Amol Saxena, DPM.)

Postoperatively, two of us (JG, EZ) assessed ankle motion using a tractograph as we did preoperatively. Ankle range of motion was assessed postoperatively at the specific intervals of 2 weeks, 6 months, and 2 years after the procedure. Every patient was evaluated for nerve damage. Each patient's level of nerve sensation was measured using a Semmes-Weinstein 5.07-g monofilament directed to all digits bilaterally as well as along the lateral aspect of the leg. In addition, sharp sensation, dull sensation, and proprioception were evaluated. Babinski's sign and the Achilles reflex were also observed.

Results

Ankle dorsiflexion increased for every patient in the study (mean, 15°; standard deviation, 4°) (Table 1). The postoperative dorsiflexion was maintained for all patients over the followup time (Table 1).

No patients experienced either diminished nerve sensation or nerve damage at any followup visit (Table 3). We observed no postoperative complications such as infection or blot clots.

Discussion

Although various literature cites the advantageous effects of EGR in the adult population [14, 17] and the use of open gastrocnemius recession procedures in children with neuromuscular deformities such as cerebral palsy [5], there is no literature to date corresponding to the use of this specific EGR technique for pediatric patients who lack neurologic abnormalities. Usually the treatment of choice for these patients involves nonoperative care, but what if this treatment option fails? Although EGR has been used in these situations in adults it is reportedly associated with sural nerve damage [14]. The sural nerve, as a result of its relationship to the gastrocnemius muscle, may be more susceptible to damage during surgical recessions [16]. In video-assisted gastrocnemius-soleus lengthening in patients with cerebral palsy, which also uses an endoscopic technique, young patients experiencing both spastic cerebral palsy and equinus foot deformity benefit from this treatment

Table 3. Intact nerve sensation at different times of evaluation

Evaluation time	Presence of sensation to Semmes-Weinstein monofilament (number of patients)
2 weeks	23
6 months	23
2 years	23

in that their ankle range of motion increases [12] although that study reported one patient with sural nerve damage. Additionally, open gastrocnemius recessions with larger incisions [11] may lead to poor cosmesis. We therefore developed a new technique of EGR to be used on otherwise healthy pediatric patients with gastrocnemius equinus. We then asked whether our technique would (1) increase ankle dorsiflexion range of motion and (2) avoid injury to the sural nerve.

We note several limitations. First is the small sample size, which, although similar in size to another study of gastrocnemius recession [14], is especially limited as a result of the lack of previous reports of equinus correction in healthy children and adolescents. A larger study could find a larger number of complications. Second is the possibility of evaluator bias when assessing both postsurgical range of motion and testing for nerve damage. Because the evaluator was also the surgeon who developed the procedure, enthusiasm for the procedure could lead to optimistic findings. Incorporating at least two pre- and postoperative data evaluators would reduce the possibility of evaluator bias. Third, we did not use a standardized device when assessing range of motion both preoperatively and postoperatively [14, 17]. Our methods were similar to those used on adults in a comparable study [17]. Fourth, we did not have a control group; our patients had been specifically referred for surgery because they failed nonoperative treatment. Conversely, patients might be seen as serving as their own control group since they had previously failed nonoperative treatment. Fifth, because there was only one procedure being performed in the study, it could only be compared with other procedure techniques through literature. Finally, there is limited literature on equinus in pediatric patients, specifically those without neurologic pathologies such as cerebral palsy. However, equinus can exist in individuals who are otherwise seemingly healthy, essentially contributing to abnormalities such as flatfoot deformity, lateral foot pain, and eventual arthritis [2]. This new EGR technique, although acquiring some limitations, can essentially aid in correcting a gastrocnemius equinus in youth with few complications.

We found ankle dorsiflexion improved by an average of 15° overall. With these improvements, the ranges of values may better meet the comparable standards of dorsiflexion for child athletes [13]. Increased dorsiflexion serves as a key outcome for many studies of equinus deformity [5, 8, 11, 14].

By ensuring proper visualization of the sural nerve every time before making the cut, nerve dysesthesia was avoided. Several studies report this as a complication [12, 14]. None of our patients experienced this complication, further emphasizing the importance of technique.

Based on these outcome variables, we believe EGR an alternative for treating pediatric patients without neuromuscular limitation who are considered for surgery. A prospective controlled study comparing EGR in healthy pediatric patients to other forms of gastrocnemius equinus correction techniques may be the solution to the issue of some of the limitations of our study. Regardless of the limitations, we believe EGR can be an alternative approach when surgery is a reasonable option for these young patients.

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