CHAPTER **34**

EPIPHYSEAL STAPLING FOR JUVENILE HALLUX VALGUS

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INTRODUCTION

Hallux abducto valgus is a subluxation of the first metatarsophalangeal joint with lateral deviation of the great toe and medial deviation of the first metatarsal. It is occasionally accompanied by rotation or pronation of the great toe in severe cases. In 1871, Heuter described the bunion deformity and an operative procedure for its correction. Since that time more than 130 operative procedures have been described. The literature on bunions is voluminous and there has controversy regarding etiology and even greater controversy over treatment. This controversy gets even more heated when adolescent patients present with a bunion deformity.

Treatment of juvenile hallux abducto valgus has always been a challenging problem for physicians. Some physicians advocate postponing surgery until skeletal maturity and closure of the growth plate of the first metatarsal. Modified McBride bunionectomies alone have been reported to have poor long term outcomes. Other surgeons advocate distal osteotomies such as Mitchell, Chevron, Hohman, and Wilson, etc. McDonald and Stevens advocated the modified Mitchell bunionectomy with good results. Helal advocates the Wilson procedure, a metatarsal neck osteotomy. To achieve a true reduction of the intermetatarsal angle in larger deformities, more proximal osteotomies may be indicated. These surgeries require lengthy recovery and a non weight bearing status during initial post operative course. Epiphyseal stapling uses the body's growth potential to aid in the reduction of the intermetatarsal angle. There is less surgery and immediate post operative weight bearing can be accomplished. Our goal is to gauge subjective, objective, and radiographic long and short term results of the epiphyseal stapling procedure for the correction of juvenile hallux valgus.

HISTORY OF EPIPHYSEAL STAPLING

In 1933, Phemister was the first to report a case of epiphysiodesis to inhibit bone growth. Phemister's technique included taking a bone graft from the physeal plate reversing it to create an epiphysiodesis. This was done at distal femur and proximal tibia to correct for a limb length discrepancy during adolescents. This irreversible technique had less complications than the traditional alternatives.

Haas, in 1945, used wire loops to provide tension across the physis and inhibit growth. He tried epiphysiodesis first on laboratory animals and then later in children. He proved that growth at an epiphysis could be held back mechanically with a wire loop. But even more importantly, he proved that growth resumed when the wire was removed. He became the first to report on a reversible technique of epiphysiodesis. Haas continued his experimental work on dogs, using staples rather than wire loops.

In 1949 and 1952, Blount, Clark, and Zeier used 3/32 inch rods fashioned into staples across the distal femur or proximal tibial physis to correct angular and length deformities in these long bones. They surmised that the operation was less extensive and provided low risk of complication to the patient.

The first surgeon to use the principles of epiphydesis for the correction of metatarsus primus varus was Ellis in 1951. Two or three staples were used to cross the lateral physis of the first metatarsal base. Ellis depressed the second metatarsal base to allow the staples to enter more laterally than dorsal on the first metatarsal. Ellis main concern was metatarsus primus elevatus, which is why he made more of a lateral approach. Ellis performed this procedure on 20 feet with good results. However, the longest followup period was only 14 months.

A more recent article of epiphysiodesis was reported by Fox and Smith in 1983. They described an epiphysiodesis technique of the lateral first metatarsal using a trephine plug autograft that was harvested from the calcaneus. Fox and Smith used this procedure on 6 feet in 4 children, with a 10 year followup. They found this to be a simple operations without many complications. However, this procedure produced irreversible physeal arrest. The key for successful outcome was surgical timing.

Later Marcinko et al in 1985 reported a case of an 11-year-old girl with an intermetatarsal angle of 21 degrees. They performed a McBride bunionectomy along with an oblique closing wedge osteotomy. Also they performed a lateral first metatarsal epiphysiodesis as described by Fox and Smith with a trephine bone graft. Marcinko et al felt that with a patient that had such a large intermetatarsal angle both procedures were necessary to correct the intermetatarsal angle to optimize her results.

Finally, Seiberg et al in 1994 reported on 12 epiphyseal stapling procedures. Seiberg et al reported that epiphyseal stapling for treatment of juvenile hallux abducto valgus is a low risk and well tolerated operation. We will discuss this procedure and look at long term results later in this paper.

TIMING

There are conflicting opinions about the timing of surgery when it concerns the adolescent population and the correction of hallux abducto valgus. Some authors feel that it is advisable to postpone surgery until completion of bone maturation, as earlier operative intervention has been associated with a high rate of reoccurrence. While other authors feel that it is wise to avoid the growth plates until they have closed. Others believe that juvenile bunions can be corrected with conservative options such as splints. Surgeons that perform the epiphysiodesis advocate using remaining growth potential to aid in correction.

Epiphyseal stapling can be used to treat juvenile hallux abducto valgus with bunion deformity. Adequate ossification is required to allow for the staple to purchase both epiphysis and metaphysis. Therefore, most patients are older than 9 years of age. There needs to be adequate physeal growth remaining to allow for correction of the deformity. So the golden period is 9-14 years of age, which is prior to the patients adolescent growth spurt. The most important consideration in epiphyseal stapling is proper timing of the procedure.

It is far more important to assess a patient's skeletal age rather than the chronological age. An atlas by Hoerr et al can guide you to determine their skeletal age. Patients' radiographs are compared with standard aged dorsoplantar and lateral radiographs in the atlas. It should be noted that girls mature faster than boys and a typical radiograph may be labeled 9.2 years for female and 12 years for male (Figure 1). The bones of the rearfoot, midfoot and forefoot are used to establish patterns of ossification centers, joint spaces and accessory bones. Based on these selected maturity indicators, skeletal age can be estimated.

Once their skeletal age is determined then it is important to find out how much potential for continued growth there is in the first metatarsal. Green and Anderson were the first to devise a growth prediction chart. But, their chart was designed for the femur and the tibia, and did not include the feet or metatarsals. Later Mosely modified this chart claiming to make it simpler.

Blais and et al in 1956 developed a growth prediction chart for the foot. This chart correlated skeletal age with total foot length. This was measured from the posterior aspect of the heel to the most distal aspect of the hallux. Correlation was then made by surgeons relating total foot length to the first metatarsal length. Blais' chart did not evaluate the first metatarsal specifically.

Nelson in 1981, published a study of the first metatarsal length growth patterns in 148 children to determine a more accurate chart for feet. Nelson found that the adolescent growth spurt occurred earlier for females 9-14 years as opposed to males 12-15 years of age. Nelson determined that females had an average of 10 millimeters of growth during their adolescent growth spurt. This was 15% of the entire first metatarsal growth. Boys on the other hand average 12 millimeters of growth during their adolescent growth spurt. This equated to 17% of the entire length of the first metatarsal. This information provided a valuable reference for timing of the epiphyseal stapling procedure (Figure 2).

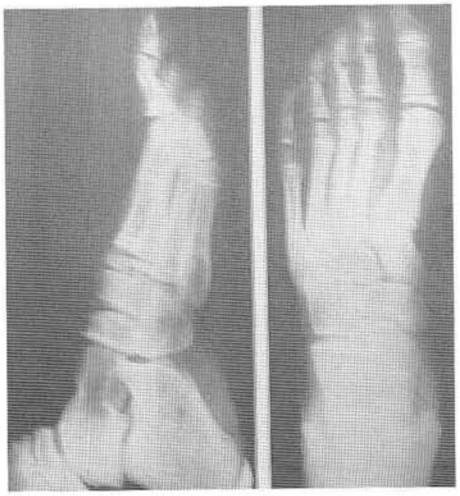

Figure 1. Females mature earlier, in this picture the female is at skeletal age 9.2 years and the male 12 years of age.

Age (Yrs)	Skeletal Age (mm)		Metatarsal Length (mm)		% of Length Attained (mm)
	Mean	SD	Mean	SD	
Boys (57)					
1	1.51	0.26	23.5	2.50	33.6
2	1.29	0.25	23.0	0.25	32.9
3	3.70	0.32	37.5	0.50	53.7
4	4.40	0.69	39.0	2.10	55.8
5	5.00	0.00	45.0	0.81	64.4
6	6.00	0.00	44.5	0.00	63.7
7	7.40	0.10	54.0	0.50	77.3
8	7.70	0.30	56.5	1.50	80.9
9	8.80	0.25	56.9	4.74	81.5
10	10.00	0.00	56.3	2.25	80.6
11	11.40	0.40	57.3	3.25	82.0
12	12.40	0.37	62.2	3.82	89.1
13	13.30	0.29	62.5	0.90	89.5
14	14.30	0.31	64.3	2.48	92.1
15	15.60	0.55	69.1	4.30	99.4
16	16.30	0.16	70.3	2.94	100.0
Girls (91)					
1					
2	2.9	1.40	38.3	1.25	58.7
3					
4	4.1	0.30	38.8	2.75	59.5
5	5.1	0.31	39.2	4.26	60.1
6	6.5	0.00	43.5	0.00	66.7
7	7.0	0.00	47.6	1.75	73.0
8					
9	9.0	0.00	54.5	3.28	83.5
10	10.8	0.80	58.5	0.50	89.7
11	11.7	0.59	59.8	3.50	91.7
12	12.6	1.07	61.7	3.19	94.6
13	13.7	0.42	62.5	4.70	95.8
14	14.4	0.20	64.3	3.24	98.6
15	15.0	0.00	65.1	3.52	99.8
16	16.0	0.00	65.8	4.30	100.0

Figure 2. Chart taken from Nelson J. P. "Mechanical Arrest of Bone Growth for the Correction of Pedal Deformities". The Journal of Foot Surgery. 20:14-16, 1981.

PREOPERATIVE ASSESSMENT

When a child presents with hallux abducto valgus deformity. One needs to consider the following:

1. Skeletal age- by using Hoerr atlas
2. How much correction is needed to reduce the inter-metatarsal angle. This technique can be determined by using cutout templates as described by Gerbert.* The metatarsal is outlined on paper. The metatarsal distal to the physeal plate is then cut leaving the lateral hinge of the physis. The first metatarsal is abducted to the desired position closing down the intermetatarsal angle. The medial opening gap is measured revealing the number of millimeters needed to correct the intermetatarsal angle (Figure 3).
3. An estimate of the growth potential remaining in the first metatarsal can be determined using Nelson's growth potential chart. By determining the skeletal age (step 1), measuring the length of the first metatarsal, and multiplying that by the estimated percentage of growth left, the millimeters of growth left can be calculated. The amount of growth needed for correction (step 2) is compared with amount of future growth estimated. The timing of procedure is established when these figures approximate each other. It is better to err on the side of performing surgery earlier than later.

As in all bunion surgeries, the patient needs to be assessed for deforming forces that may cause a reoccurrence or prevent good surgical outcome. For example, deforming forces such as an ankle equinus or pes planovalgus deformity must be neutralized intra operatively or post operatively. Thus the stapling procedure may need to be done in conjunction with a gastrocnemius recession or a arthroreisis procedure to control the pronation of the subtalar joint. Biomechanical deforming forces should be neutralized with functional orthotic control at least until skeletal maturity.

SURGICAL TECHNIQUE

The authors have prefabricated a special staple for this procedure known as the Johnson staple. The staple is made by bending a 0.062 smooth Kirschner wire so that there are 2 parallel arms approximately 15 millimeters apart. The proximal arm will parallel the metatarsal cunieform joint in the epiphysis. The distal arm should be in the metaphysis of the first metatarsal parallel to the proximal arm across the physis. The staple is angled 15 degrees to allow it to sit flush with the dorsal surface of the first metatarsal. The arms should be excessively long to be cut to length intra operatively (Figure 4).

This procedure is usually done in conjunction with a modified McBride bunionectomy. The incision may be one long incision extending from the first metatarsal base

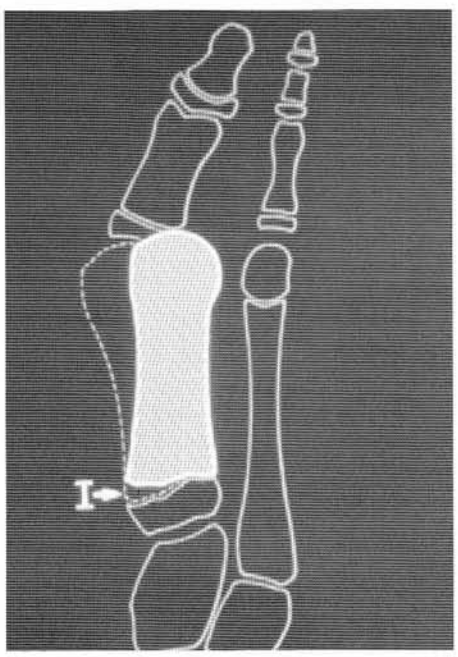

Figure 3. Template showing the desired medial growth of 3 mm to obtain angular correction.

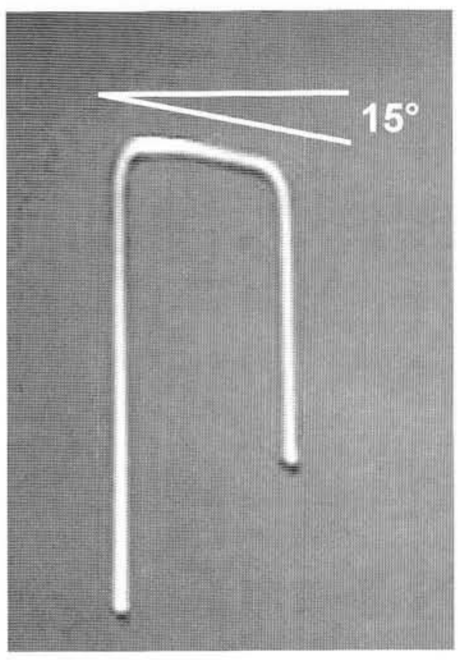

Figure 4. A 0.062 inch k-wire used for epiphysiodesis procedure.

to the proximal phalanx or may be two incisions (Figure 5A). A 3-4 centimeter dorsilinear incision over the lateral base of the first metatarsal between the extensor hallucis longus and extensor hallucis brevis tendons. The periosteum is reflected medially and laterally exposing the first metatarsal cunieform joint, the epiphysis, the physis, and the metaphysis (Figure 5B).

Once the physis is visualized a 0.062 smooth Kirschner wire is inserted into the lateral aspect of the epiphysis from dorsal to plantar parallel to the first metatarsal-cunieform joint (Figure 6). This can be confirmed via fluoroscan. Using a parallel Kirschner wire guide (Figure 7) for the second more distal Kirschner wire is driven in parallel to the first and at the appropriate width that the staple was measured (approximately 15 millimeter). This Kirschner wire is driven dorsal to plantar. Again these are visualized via fluoroscan and measured. The Kirschner wires should penetrate the plantar cortex of the first metatarsal; failure to do so may cause metatarsus primus elevatus. The measured Kirschner wires are compared with preoperative measurements of the lateral x-ray at the base of the first metatarsal. The arms of the staple are then cut to the correct length. The Kirschner wires are then removed and the staple is inserted. The length and position of the Kirschner wire staple should be verified via fluoroscan, confirming that the joint at the first metatarsal-cunieform and the physis are not violated (Figure 8). The periosteum is closed over the staple and the soft tissues are closed anatomically.

Postoperative care includes immediate weight bearing in postoperative shoe. Reduction in activity should last for 4-5 weeks and suture removal in 10-14 days. Orthotic control is highly recommended to neutralize deforming force on the first ray. Hallux splinting with foam spacer interdigitally for 3-4 months postoperatively is recommended. Hallux night splints and regular follow up visits are recommended until skeletal maturity.

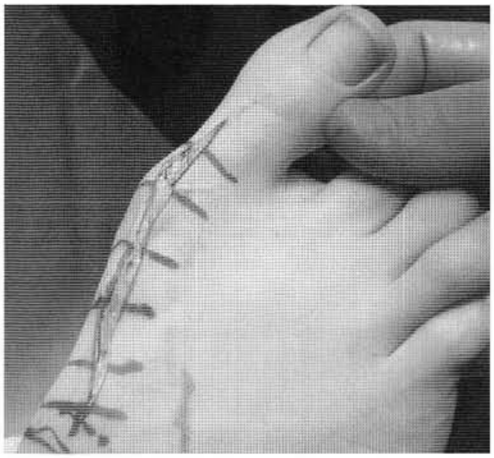

Figure 5A. There may be one long incision as seen or two small incisions.

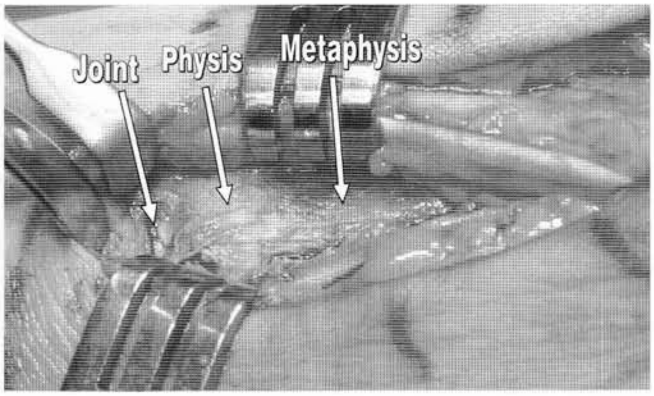

Figure 5B. The joint, the physis, and the metaphysis are identified.

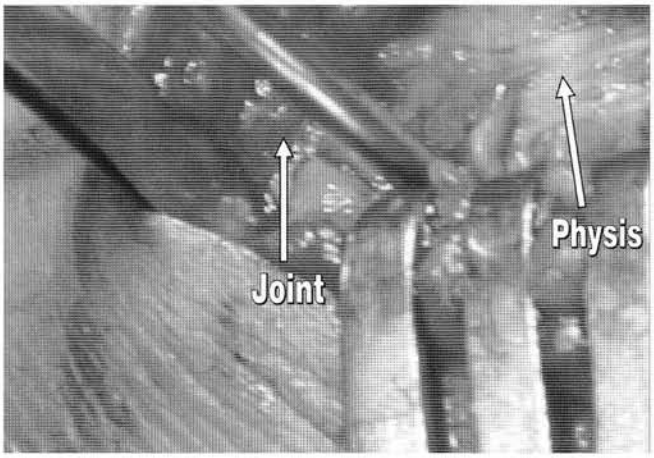

Figure 6A. Placement of the first k-wire is parallel to the first met-cunieform joint in the epiphysis.

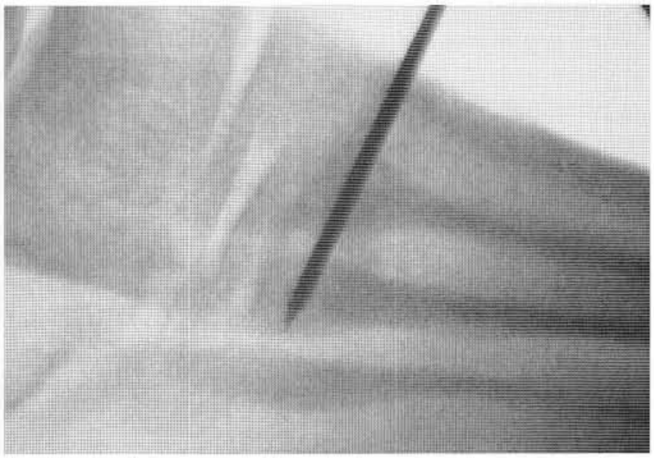

Figure 6B. After placement of k-wire placement is visualized via flouroscopy. Placement is key with the k-wire parallel to the first met cunieform joint and in the epiphysis.

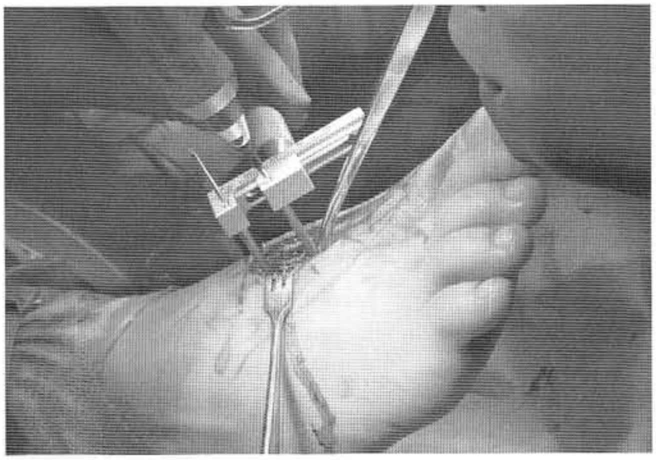

Figure 7. A guide is used for placement of the second k-wire parallel to the first and at the exact distance of the prefabricated staple.

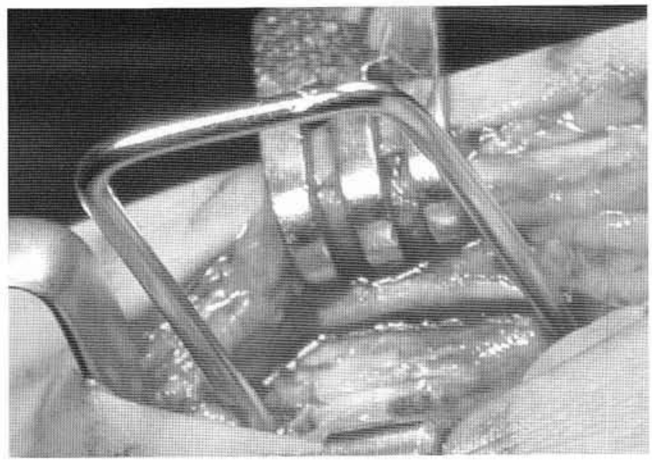

Figure 8A. The prefabricated staple is inserted into the holes previously made by the k-wires and checked via C-arm for length and position.

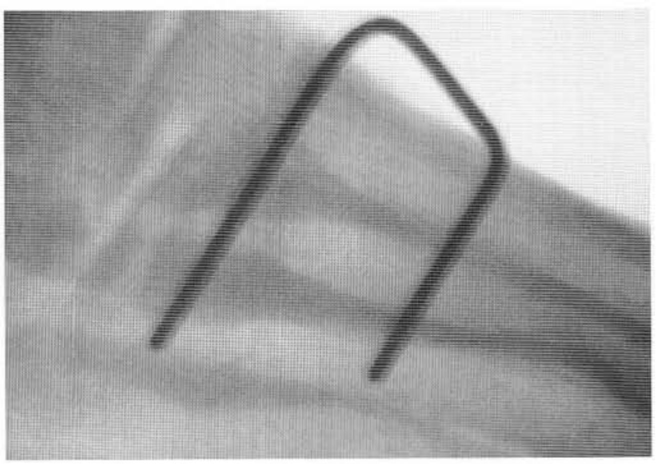

Figure 8B. The prefabricated staple is inserted into the holes previously made by the k-wires and checked via fluroscopy for length and position.

MATERIALS AND METHODS

From 1988 to 2004 21 patients and 38 feet underwent lateral epiphyseal stapling for the correction of hallux abducto valgus. There were 18 females and 3 males involved in the study. Subjective, objective and radiographic exams were done to assess the effectiveness of this procedure. A subjective questionnaire was sent to all 21 patients with 7 replies, 5 patients returned to be examined, and radiographic exams were done all patients. Patients were divided into 2 groups. Group I included patients that had closed their growth plates radiographically; this included 12 patients and 22 feet. Preoperative x-rays could not be located on 1 patient and 2 feet. Group II included patients that still had there growth plates open and included 6 patients and 10 feet.

Three patients and 5 feet were excluded from the study due to the lack of long term x-rays. We were unable to contact them for followup. Nine arthroreisis procedures, 1 gastrocnemius recession, 1 tendo achilles lengthening, were performed along with modified McBride bunionectomies and the epiphyseal stapling. One patient had the McBride bunionectomies and sta-peg arthroreisis done 2 years after the initial stapling procedure.

Subjectively patients were asked about preoperative symptoms, postoperative symptoms, and their feelings about the outcome of this procedure. Charts were reviewed to gather information on follow up and possible complications. Objectively the patients were examined to assess range of motion of the first metatarsophalangeal joint, quality of motion, and clinical appearance of the first metatarsophalangeal joint. Radiographic examination included preoperative and postoperative assessment of length of first metatarsal, intermetatarsal angle, hallux abductus angle, and Seiberg index. Age at surgery ranged from 9.2 to 14.3 years of age with a mean of 11.1 years. The 3 boys included in the study had an average age of 13 while the girl's average age was 10.8. Radiographic followup ranged from 10 months to 183 months with the mean of 35.1 months.

Subjective Data

In the subjective questionnaire patients were asked about preoperative and current symptoms associated with the bunion deformity. Seven of the 21 patients responded to the questionnaire. Patients were asked to rate their preoperative pain on a scale of 1-10 (10 being the worst). The average preoperative pain level was 3.3 and the current postoperative pain level was less than 1. Preoperatively 5/7 patients were limited in sporting activities and 6/7 stated they were unable to wear some shoes due to the pain. The most common reasons for having surgery were fear of progression of the deformity and pain from shoe wear. Postoperatively only 1/7 patients complained of decrease in range of motion and inability to wear high heel shoes. All 7 patients received a night splint postoperatively and wore the splint initially for about a year. Only one patient continued past a year and is still wearing the splint. Currently 5/7 patients are wearing orthotics; all 7 had received them after the surgery. One of 7 patients had complications and that patient would not recommend surgery due to complications although currently she is asymptomatic. Six of 7 patients would recommend surgery and are happy with outcome. There were 4/7 patients that were concerned with the scar over the first metatarsophalangeal joint but were still happy with surgery.

Objective Data

Five of 21 patients returned for clinical exam.; 9 feet were included in this part of the study with the range of follow up ranging from 19 months to 183 months. The average range of motion of the nine feet was 100 degrees, none of the nine feet demonstrated any crepitus on range of motion, and the average range of motion of the first ray was 8.2 millimeters. All feet were clinically assessed for bunion deformity. Eight of 9 feet showed no hallux valgus. There was one foot that showed mild signs of hallux valgus This patient still had growth plates open and had already corrected his intermetatarsal angle by greater than 10 degrees.

Radiographic Exam

The length of the first metatarsal, intermetatarsal angle, hallux abductus angle and Seiberg index were measured and divided into 2 groups. Group I included patients whose growth plate had already closed. Group II included patients that had open growth plates. Preoperatively the average length of thefirst metatarsal in Group I was 59.7 mm; the metatarsal grew 5.8 mm to become 65.5 mm in length. Whereas, Group II started at 58.2 mm and grew 4 mm to become 62.1 mm length so far (Tables 1, 2) .

Preoperatively the average intermetatarsal angle of all 17 patients and 30 feet was 13.2 degrees. Group I average was 13.1 degrees and Group II was 13.5 degrees. The intermetatarsal angle (IM) postoperatively reduced on average 7 degrees to 6.2 degrees in Group I (Table 3). In Group II the IM angle reduced on average 5 degrees to 8.5 so far (Table 4). Overall the IM angle reduced on average 6.3 degrees to 7.1.

The hallux abductus angle preoperatively for all patients was 24.6 degrees. The mean for Group I mean was 25.6 degrees and for Group II was 22.7 degrees. Postoperatively the hallux abductus angle decreased to 11.5 in Group I with nearly a 15 degree reduction in the hallux abductus angle (Table 5). Group II (with open

Table 1

FIRST METATARSAL LENGTH (GROWTH) GROUP I

Patients	Age at Surgery (yrs)	Postoperative F/U months	Preoperative Length (mm)		Postoperative Length (mm)		Growth (mm)	
			R	L	R	L	R	L
1	12.7	26	70	75	5			
2	13.6	28		63		67		4
3	10.7	19	62	62	65	66	3	4
4	9.2	125	55	56	68	67	13	11
5	10.2	24	58	57	60	61	2	4
6	14.3	12	65	63	70	68	5	5
7	10.2	24	50	50	57	57	7	7
8	14.3	23	66	66	72	72	6	6
9	11.8	13	58	57	61	61	3	4
10	12.8	40	57	58	63	64	6	6
11	11.2	183	60	60	68	67	8	7
AVG	**11.9**	**46.9**	**59.7**		**65.5**		**5.8**	

Table 2

GROUP II

Patients	Age at Surgery (yrs)	Postoperative F/U months	Preoperative Length (mm)		Postoperative Length (mm)		Growth (mm)	
			R	L	R	L	R	L
1	11.0	10	54	56	56	58	2	2
2	11.5	12		60		66		4
3	11.8	12	60	60	63	64	3	4
4	11.8	20	59	58	64	64	5	6
5	11.0	22	59	60	64	64	5	5
6	10.2	39	54		58		4	
AVG	**11.2**	**46.9**	**58.2**		**62.1**		**4**	

Table 3

INTERMETATARSAL ANGLE (IM) GROUP I

Patients	Preoperative IM Angle		Postoperative IM Angle		Months Postoperative	Difference IM Angle	
	R	L	R	L		R	L
1	12		5		26	7	
2		12		4	28		8
3	11	12	2	3	19	9	8
4	14	14	1	6	125	13	8
5	15	15	9	8	24	6	7
6	11	12	3	6	12	8	6
7	16	16	8	8	24	8	8
8	12	10	8	7	23	4	3
9	17	15	10	6	13	7	9
10	15	15	11	9	40	4	6
11	10	8	6	1	183	4	7
12			11	11	126		
AVG	**13.1**		**6.5**		**53.6**	**7**	

physis) hallux abductus angle had already decreased 9.2 degrees (Table 6). Overall the hallux abductus angle had reduced 14 degrees to 12.1 degrees.

It was important to evaluate metatarsus primus elevatus to see if the epiphyseal stapling procedure caused elevation of the metatarsal. This was done by using the Seiberg index. The Seiberg index is the measurement of the sagittal plane relationship of the first metatarsal to the second metatarsal. The perpendicular distance from the dorsum of the second metatarsal shaft to the dorsum of the second metatarsal shaft approximately 1.5 cm from its articular base is measured in millimeters. Then the perpendicular distance from the dorsum of the second metatarsal shaft to the dorsum of the first metatarsal shaft at the metatarsal neck level is measured in millimeters. The proximal measurement is subtracted from the distal measurement to obtain the Seiberg index. A positive number indicates an elevate first metatarsal head. In this study the overall Seiberg index was 2.4 mm preoperatively and postoperatively 1.3 mm. In Group I the preoperative Seiberg index was 2.7 mm. This was reduced 1.2 mm postoperatively to 1.4 mm (Table 7). The 1.2 mm demonstrated a decrease in the elevatus of the 1st metatarsal. In Group II the Seiberg index started at 1.7 mm preoperatively. Postoperatively the index went to 1.1 mm, with a reduction of the elevatus of the 1st metatarsal by .7mm (Table 8).

Table 4

INTERMETATARSAL ANGLE (IM) GROUP II

Patients	Preoperative IM Angle		Postoperative IM Angle		Months Postoperative	Difference IM Angle	
	R	L	R	L		R	L
1	14	16	12	10	10	2	6
2		13		10	12		3
3	10		8	8	12	2	6
4	12	12	10	8	20	2	4
5	17	12	6	5	22	11	7
6	15		8		39	7	
AVG	13.5		8.5		19.2	5.0	

Table 5

HALLUX ABDUCTUS (HA) ANGLE GROUP I

Patients	Preoperative HA Angle		Postoperative HA Angle		Months Postoperative	Difference HA Angle	
	R	L	R	L		R	L
1	24		14		26	10	
2		26		-20	28		46
3	16	12	8	8	19	8	4
4	30	31	-15	16	125	45	15
5	20	25	10	15	24	10	10
6	15	20	10	15	12	5	5
7	36	20	20	9	24	16	11
8	16	24	18	10	23	-2	14
9	40	35	25	15	13	15	20
10	27	30	24	4	40	3	26
11	35	30	20	20	183	19	18
12			20	20	126		
AVG	22.7		13.3		19.2	9.2	

Table 6

HALLUX ABDUCTUS (HA) ANGLE GROUP II

Patients	Preoperative HA Angle		Postoperative HA Angle		Months Postoperative	Difference HA Angle	
	R	L	R	L		R	L
1	14	16	12	10	10	2	6
2		26		20	12		6
3	10	19	8	15	12	2	4
4	25	26	14	14	20	9	12
5	30	27	16	12	22	14	15
6	34		12		39	22	
AVG	22.7		13.3		19.2	9.2	

Table 7

SEIBERG INDEX GROUP I

Patients	Preoperative Seiberg		Postoperative Seiberg		Months Postoperative	Difference in Seiberg	
	R	L	R	L		R	L
1	4		3		26	1	
2		2		1	28		1
3	3	2	1	1	19	2	1
4	5	1	-4	-1	125	9	2
5	3	2	2	1	24	1	1
6	3	2	2	1	12	1	1
7	5	5	5	3	24	0	2
8	-1	-1	0	0	23	-1	-1
9	3	3	2	2	13	1	1
10	2	2	0	2	40	2	0
11	4	5	3	2	183	1	3
12			0	1	126		
AVG	**2.7**		**1.4**		**53.6**	**1.2**	

Table 7

SEIBERG INDEX GROUP I

Patients	Preoperative Seiberg		Postoperative Seiberg		Months Postoperative	Difference in Seiberg	
	R	L	R	L		R	L
1	5	8	4	2	10	1	6
2		0		0	12		0
3	2	2	0	0	12	2	2
4	2	1	1	2	20	1	-1
5	-3	-2	0	0	22	-3	-2
6	2		2		39	0	
AVG	**1.7**		**1.1**		**19.2**	**.7**	

COMPLICATIONS

Of the 38 feet included in the study there were two feet with known complications. One patient developed 2 postoperative complications. The first complication was noted on her first postoperative visit. On x-ray one arm of the staple violated the first metatarsal cunieform joint and patient was taken back to the operating room for repositioning of the staple. This was done without incidence. Three months post operatively the patient developed hallux adductus due to over correction of the hallux valgus with the bunion night splint. The patient was taken back to the operating room for soft tissue release and reduction of hallux adductus. At twenty eight months post perative the patient has a negative hallux abductus angle of 20 degrees. However the patient remains asymptomatic. The patient was not disappointed with the outcome but responded to the questionnaire that she would not recommend surgery.

Postoperative infection occurred in the second patient. Interestingly this occurred eight months after initial surgery. The patient developed a Staphylococcus Epidermis infection and had to have the staple removed. She was then placed on intravenous antibiotics and healed without incidence. The opposite foot healed without complications. This patient was lost to followup before the growth plates were closed and did not respond to the questionnaire. At 12 months postoperative the patient had an intermetatarsal angle of 8 degrees (reduced by 4 degrees) and a hallux abductus angle of 15 degrees (reduced by 4 degrees) .

DISCUSSION

When assessing the epiphyseal stapling procedure for correction of juvenile hallux abducto valgus, it is important to look at both the short- term results and the long term results. In Group II the growth plate had not yet closed. Therefore, there was still potential for continued correction. As the patient grows, the correction should improve as the first metatarsal angular correction improves. Group I included patients with a closed growth plate. Group I had an average of 1.8 millimeter more growth in the first metatarsal (5.8mm) than Group II (4mm). Consequently, Group II had an extrapolated potential for an average of 1.8 mm more correction.

In this study, an overall decrease of 6.3 degrees in the average intermetatarsal angle from preoperative to current post operative measurement occurred. The current total intermetatarsal angle was 7.1 degrees at followup. In the closed physeal Group I the IM angle decreased 7 degrees. So far in the open physeal Group II the IM angle decreased only 5 degrees. Perhaps an additional 2 degrees of correction may occur before closure of physis in Group II. Some closure of the IM angle occured initially due to the modified McBride bunionectomy; this reduction continues with bone growth in Group II. On average 4 mm of growth occurs over 19.2 months. Further growth would be expected and more correction of the IM angle in Group II while the physis remains open..

All patients in the study improved with stapling; there was no increase in the intermetatarsal angle and the smallest improvement in Group I was at least 4 degrees. Eight of nine feet that followed up for clinical exam had no signs of a bunion deformity and patients were happy with the results. The one foot that had mild signs of bunion deformity still had the growth plates open. This foot had already reduced the intermetatarsal angle by greater than 10 degrees.

The hallux abductus angle decreased on average of 12.5 degrees (from 24.6 to 12.1 degrees). Group I decreased approximately 15 degrees from 25.6 degrees to 11.5 degrees. Group II decreased from 22.7 degrees to 13.3 degrees for a difference of about 9 degrees. This decrease can be attributed to release of deforming forces at the first metatarsal phalangeal joint with the McBride bunionectomy as well as reduction with growth of the medial epiphysis. Much of the six degrees of difference in reduction of Group I (15 degrees) and Group II (9 degrees) may be attributed to the potential growth remaining of the metatarsal in Group II. The use of postoperative night splints and orthotics should neutralize deforming forces that would potentially increase the deformity even as physeal growth decreased the deformity.

In this study the Seiberg index was used to determine first metatarsal elevatus. Overall the preoperative index was 2.4 mm and reduced to 1.3 mm. Interestingly there were no signs of the stapling procedure causing elevatus. Group I in fact had decreased Seiberg index 1.2 mm while Group II reduced .7 mm implying that the controlling pronatory forces and reduction of the intermetatarsal angle may actually decrease metatarsus primus elevatus.

Nine feet had arthroereisis procedure along with the stapling procedure. The postoperative IM angle averaged 6.2. In 3/9 of these feet that were from Group II where the physis was not yet closed. There was further potential of reducing the IM angle. This emphasizes the importance of controlling the deforming forces to achieve the best results both during surgery and postoperatively.

CONCLUSION

Epiphyseal stapling for the correction of hallux abducto valgus in the adolescent population seems to be a successful alternative procedure with low risk. Inhibiting the growth of the lateral physis with a staple across the growth plate, in conjunction with a modified McBride bunionectomy, can reduce a juvenile bunion as it continues to grow medially. Subjective, objective, and radiographic results have proven to be very successful. Timing is the key with 3 easy steps; 1. Find the skeletal age rather than chronological age. 2. Assess the amount of correction needed with preoperative template. 3. Estimate the growth potential with the aid of a growth chart. Potential overcorrection is always a possibility but with the reversibility of the epiphysiodesis procedure by removal of staple, the chance of overcorrection is significantly decreased.

The intermetatarsal angle and hallux abductus angle decrease significantly by performing a epiphyseal stapling and modified McBride bunionectomy; this correction improved with time and growth. There is no sign of increased elevatus of the first metatarsal. In fact, elevatus may even decrease with surgery and good control of pronatory forces. For the epiphysiodesis to be most effective, assessment and control of pronatory forces preoperatively, intraoperatively, and postoperatively is essential. The procedure greatly reduces the postoperative disability when compared to proximal osteotomies or fusions in that immediate weightbearing can be tolerated.

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