The Journal of Foot & Ankle Surgery 58 (2019) 609–616

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Original Research

Modified Valenti Arthroplasty in Running and Jumping Athletes With Hallux Limitus/Rigidus: Analysis of One Hundred Procedures

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ARTICLE INFO

Level of Clinical Evidence: 3

Keywords:
athlete
dancer
football
osteotomy
runner
soccer
sport

ABSTRACT

Despite hallux limitus/rigidus being a common condition, results of surgical procedures specifically pertaining to athletes are scarce. The results of 100 modified Valenti procedures, prospectively studied from January 2000 to June 2016 with an average 49.17 months of follow-up, are presented evaluating demographics, sport, time and ability to return to activity (RTA), decreased desired activity level, and need for additional surgery. Inclusion criteria included athletes who have exhausted conservative care without relief of daily pain, dorsiflexion <20°, and grade ≥2. Seventeen had grade 2, 79 had grade 3, and 4 had grade 4 disease. RTA for the 89 procedures where exact time could be determined was 9.25 weeks; however, 100% were confirmed to RTA to some degree. The RTA of dancers and runners (the largest portion of the cohort at 76) was around 8 weeks, whereas soccer players were the slowest at >16 weeks, which was significant. There was no other significant difference in RTA between sport, sex, or grade of hallux limitus/rigidus except for between runners and soccer players. Six patients (6%) stated a decreased desire to activity, although this was not a significant finding. The modified Valenti procedure is a safe and highly effective treatment for running and jumping athletes limited by hallux limitus/rigidus because 94% of patients were able to return to their desired level of activity.

Hallux limitus/rigidus is a common pathology characterized by decreased hallux dorsiflexion, which can hinder athletes' performance and activity. Conservative treatment alone by means of reducing dorsiflexion stress via foot orthoses, taping, and injections are often not an acceptable remedy for athletes, thus making surgical treatment a consideration. However, there is limited literature discussing surgical procedures for hallux limitus/rigidus with regard to athletes. The return to activity (RTA) demand and expectations differ from nonathletic and sedentary individuals (1–5).

Normal range of motion (ROM) for hallux dorsiflexion is between 45° and 65°; when <20° is present (with respect to the first metatarsal), patients are diagnosed as having hallux limitus (1). Hallux limitus and rigidus are often used synonymously, although they are differentiated clinically by having less ROM in the rigidus condition and more bony changes seen on x-ray films. Hallux rigidus (HR) is essentially a more progressive state of hallux limitus. When classifying hallux limitus/rigidus, 4 grades are used. Grade 1 is a "functional" hallux limitus without articular damage, but dorsiflexion is limited with weightbearing. Grade 2 includes bony hypertrophy on the dorsal metatarsal and decreased dorsiflexion but non-weightbearing. Grade 3 is where articular damage is noted to the cartilage and <10° of motion remains. Ankylosis is indicative of grade 4 HR with negligible motion available and severe arthrosis noted on x-ray films (2,3). Tregouet (4) reported that, on average, the ROM of the first metatarsophalangeal joint (MPJ) in athletes is 21.25° less than in inactive individuals. Thus, factors that contribute to hallux limitus/rigidus in athletes extend further than basic etiologic conditions such as gout, rheumatoid arthritis, long first metatarsal, long proximal phalanx, square metatarsal head, and pes planus (1,2,5). These extenuating causes include injuries and trauma that commonly occur during athletic activities (4). For example, direct injuries, such as turf toe or osteochondral fracture, are believed to cause progressive degenerative arthritis (3,6,7). Although they are indirect injuries, such as a weakened peroneus longus caused by inversion ankle sprains, they generate a biomechanical abnormality in which the first ray is no longer functionally "locked" into an everted position (4). Continued repetitive forces placed on the first MPJ during athletic activity also contribute to the pathology in athletes. It should also be noted that runners have a significant decrease in first MPJ dorsiflexion,

Financial Disclosure: None reported.
Conflict of Interest: None reported.
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https://doi.org/10.1053/j.jfas.2018.07.009

19.48°, in comparison to walkers with 25.49° (8). During a normal gait cycle, the joint bears approximately 40% to 60% of the body weight; however, during jogging and running, it will bear 2 to 3 times and up to 8 times the body weight, respectively (7). The decreased dorsiflexion and increased stress in this region are indicative of the differences noted in athletes.

Foot and ankle surgery in athletes, particularly for hallux limitus/rigidus, is not frequently described. Surgical procedures that should be used in athletes are those that will increase motion at the joint, decrease pain, improve performance, and allow for reduced recovery times. Common HR procedures that meet the stated criteria include cheilectomy, the Valenti procedure, and decompressive osteotomies. Implant procedures have not been studied in athletes (9). A study published by Saxena (9) in 2000 defined athletes as those who actively participate in professional, college, and high school sports and includes active patients who run ≥25 miles per week or participate in aerobics or competitive sports ≥6 hours per week (10,11). A quantified outcome for athletes include RTA after surgery and is defined as the ability to participate in a portion of practice or running for 15 to 20 minutes (9). Saxena (9) found that RTA in athletes who had undergone a Valenti procedure, cheilectomy, or first metatarsal osteotomy was 6.5, 5.5, and 8.9 weeks, respectively. Mulier et al (12) concomitantly reviewed and recommended the cheilectomy procedure for athletes with HR, allowing RTA at 6 weeks. Although RTA was similar for both the Valenti and cheilectomy procedures, attention should be drawn to the difference in postoperative dorsiflexion obtained by each procedure. The Valenti procedure was able to obtain a 27° increase, whereas the cheilectomy improved dorsiflexion by 13° (9,12).

The Valenti procedure has been shown to allow athletes increased ROM, immediate weightbearing, decreased rehabilitation times, and quicker return to their sport (13). In 1987, Valente Valenti presented a surgical technique to increase ROM of the first MPJ; this was achieved through an angular arthroplasty, described as a sagittal “V” osteotomy, on the metatarsal head and base of proximal phalanx (14). This procedure was further modified to improve joint stability through joint preservation (14). In Valenti’s original procedure, the dorsal one half to one third of the metatarsal head and proximal phalanx base is removed, protecting the plantar joint, specifically flexor hallucis brevis. This procedure has since been modified, with less resection of bone, yet it still adequately decompresses the joint, even on stress views (15,16) (Fig. 1) This modification also allows for future arthrodesis or implant arthroplasty should further treatment become necessary (14,15).

Patients and Methods

For clarity purposes, in this article hallux limitus/rigidus will be referred to as *hallux rigidus* (HR). The criteria for patients who underwent the index procedure had to have dorsiflexion <20° with respect to the first metatarsal, with stages 2, 3, and 4 HR, as well as failure of nonsurgical treatments such as insoles, orthoses, shoe modifications, and injections, along with pain with daily and recreational activities. No specific time period was required for nonsurgical treatment, but in general most patients had symptoms for more than a year. Institutional review board approval was obtained. Patients were prospectively followed up and retrospectively reviewed. Patients returned annually for a postoperative visit for ≥1 year after the index procedure. Athletically active patients whose primary sporting activity involved running and jumping sports and who underwent surgery for HR with the modified Valenti as an isolated procedure on the first MPJ were prospectively followed up from January 2000 through June 2016. The current study is specific to runners; basketball, soccer (football), and tennis players; dancers; and more. A database of 270 procedures using Current Procedural Terminology code 28289 with International Classification of Diseases, Ninth Revision, code 735.2 was obtained. From this, we were able to review 176 patients who were athletically active. Of these, 100 procedures met our inclusion criteria. These patients were generally seen approximately 3 days after surgery for a dressing change; at 2 weeks for suture removal; and at 2, 4, and 6 months and 1 year. Inclusion criteria consisted of involvement in running and jumping sports as noted earlier as the primary activity, which met the definition of “athlete,” as well as the pertinent demographics, sport/activity, time, and ability to RTA for data analysis (9). The need for additional surgery, decreased desired activity (DDA) level, was noted because these are important patient-reported outcome measures (9). In addition to DDA, the following complications were noted: infection, dehiscence, arthrofibrosis, cock-up toe deformity, lateral compensatory pain, sesamoiditis, and the need for additional surgery. Postoperative dorsiflexion <20° at 1 year after surgery was also noted. Because of the variability of preoperative and postoperative measurements being performed by different evaluators, specific values were not tabulated. Exclusion criteria were those patients not primarily involved in running sports, such as occasional joggers, weightlifters, cyclists, hikers, walkers, swimmers, and golfers, and the inability to verify RTA, to note DDA, and the need for additional surgery as recorded in the patients’ record. The documentation of these data was done by a Fellow not involved with the surgical procedures with minimum follow-up of 1 year. These data were analyzed with STATA Version 14.2 (Statacorp LLC, College Station TX) using Student’s *t* test, 1-way analysis of variance with Scheffé tests for post hoc comparisons, and chi-square tests, with alpha set at ≤.05.

Modified Valenti Procedure

A 4- to 6-cm dorsal linear incision is made over the first MPJ, just medial to the extensor hallucis longus tendon. Dissection is carried down to the joint capsule with care to avoid branches of the medial dorsal cutaneous nerve (or first proper dorsal digital nerve). Minor vessels are cauterized as needed. A linear dorsal capsulotomy is performed, exposing the head of the metatarsal and base of the proximal phalanx. Hypertrophic synovium and bursal tissue is sharply excised. The integrity of the articular cartilage is evaluated, locating any osteochondral defects or cystic lesions. The metatarsal exostectomy is performed, starting below the degenerated articular cartilage (Fig. 2). With a sagittal saw, the dorsal one fourth to one third of osteochondral surface of the metatarsal head is excised from distal plantar to proximal dorsal. The proximal phalanx exostectomy is performed from dorsal distal to proximal plantar, removing only the portion with exposed subchondral bone, ensuring preservation of the entire flexor hallucis brevis tendon insertion. It is critical to avoid entering the medullary canals of the metatarsal and proximal phalanx when performing both exostectomies. Remaining hyperostosis on metatarsal head and base of proximal phalanx is removed with bone rongeur and edges rounded with a burr, confirming that there is no bony abutment and allowing for full ROM in the sagittal plane. The lateral hyperostosis of the proximal phalanx base (aka Valenti spur) is removed with a rongeur, as well as the hyperostosis of the metatarsal head, which may require a saw. The amount of dorsiflexion is measured to confirm that it is ≥45° to 65°, which may be necessary for normal functional gait but primarily for the anticipated eventual loss of some of the motion gained as a result of normal postoperative healing (14) (Fig. 3). The plantar adhesions of the sesamoids may need to be released using a Freer elevator. The capsule is closed using the extensor halluces brevis as an interpositional arthroplasty and “draped” over the exposed metatarsal head surface but not placed plantarly. Subcutaneous and skin closure is performed in standard fashion.

Postoperative Care

Patients are advised to stay non-weightbearing for 2 to 5 days, until the need for pain medication ceases. Icing and elevation are paramount, and patients are advised to begin active ROM exercises. At 12 to 14 days after the procedure, sutures are removed. Patients are advised to continue icing and begin passive ROM exercises. They initiate formal physical therapy approximately 3 to 4 weeks after the procedure. They are instructed on resuming normal gait and receive modalities for pain and edema control. They continue active mobilization of their first MPJ via the physical therapist, as well as on their own. They are allowed to initiate sport activity when they have ≥20° of passive dorsiflexion. Patients are advised to continue first MPJ ROM exercises and ice until they are back to their full activity level.

Results

One hundred modified Valenti procedures were able to be evaluated, with the average age of patients 49.2 ± 10.1 years (range 13 to 71

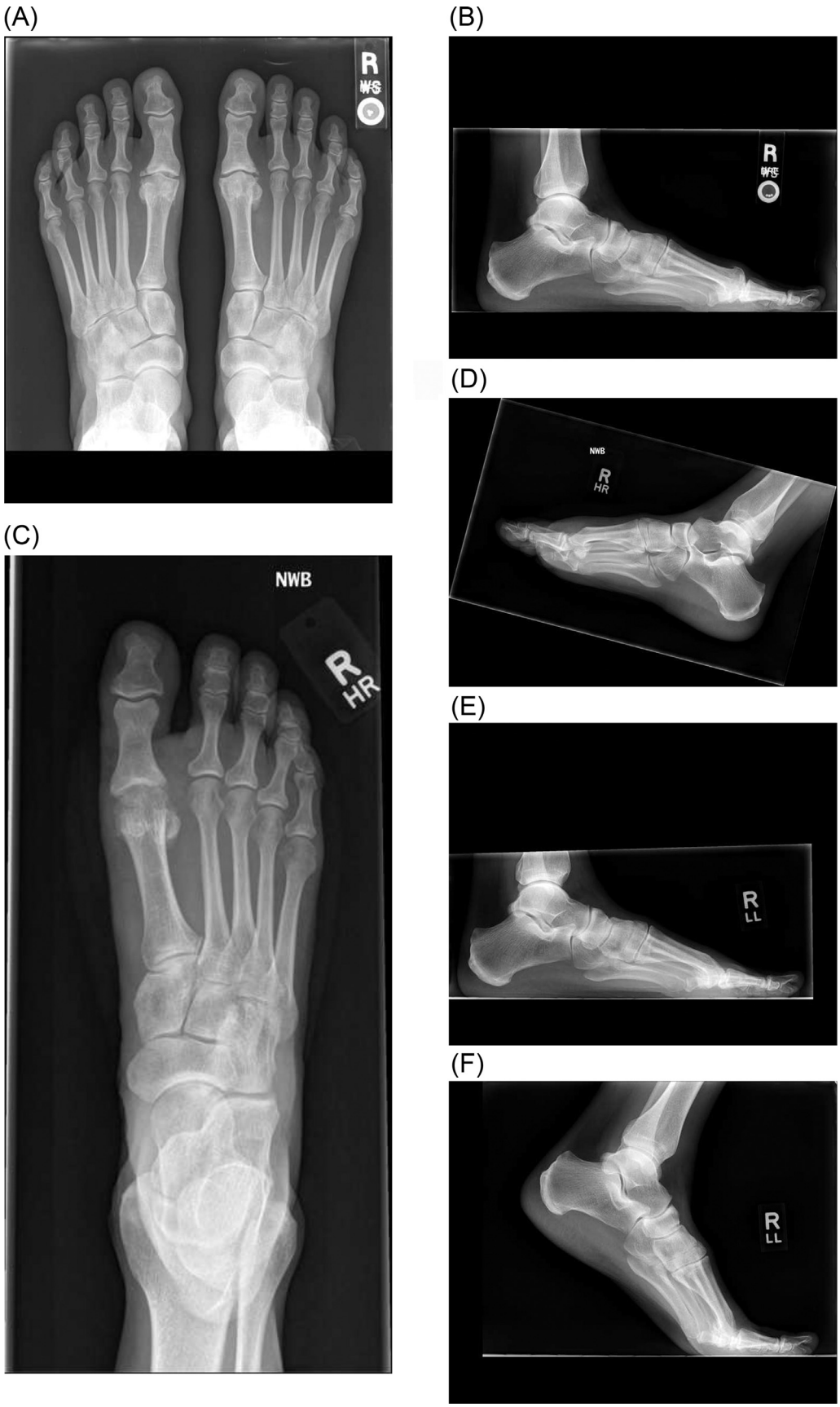

Fig. 1. (*A*) Preoperative anteroposterior x-ray film. (*B*) Preoperative lateral x-ray film. (*C*) Postoperative anteroposterior x-ray film. (*D*) Postoperative lateral x-ray film. (*E*) Postoperative weightbearing lateral x-ray film at 6+ months; note how "elevatus" reduces. (*F*) Postoperative weightbearing stress lateral x-ray film at 6+ months. (Patient clinically has 35° of passive dorsiflexion.)

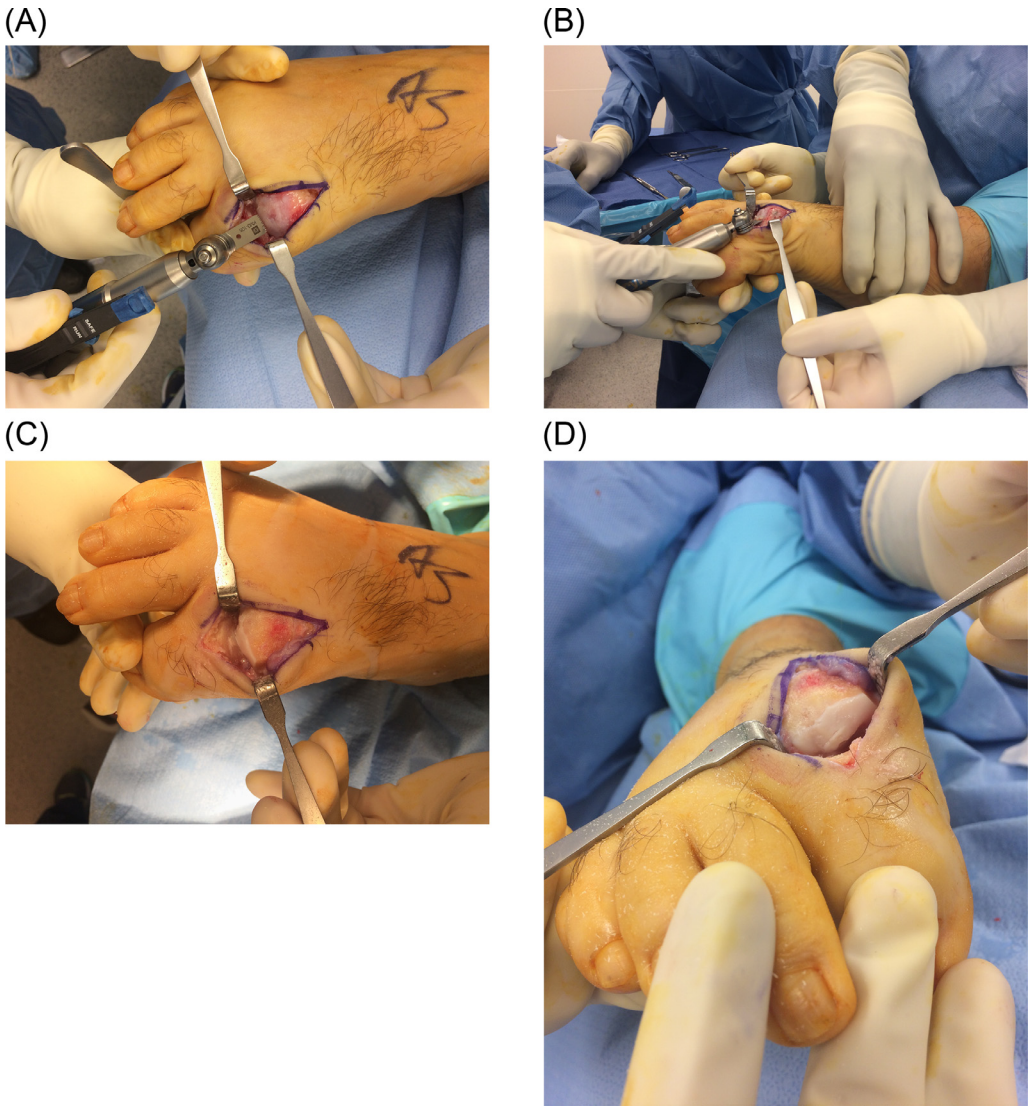

Fig. 2. (*A*) Starting point for first metatarsal osteotomy/resection. (*B*) Lateral view of resection. (*C*) Postresection view from dorsal. (*D*) Postresection view from anterior.

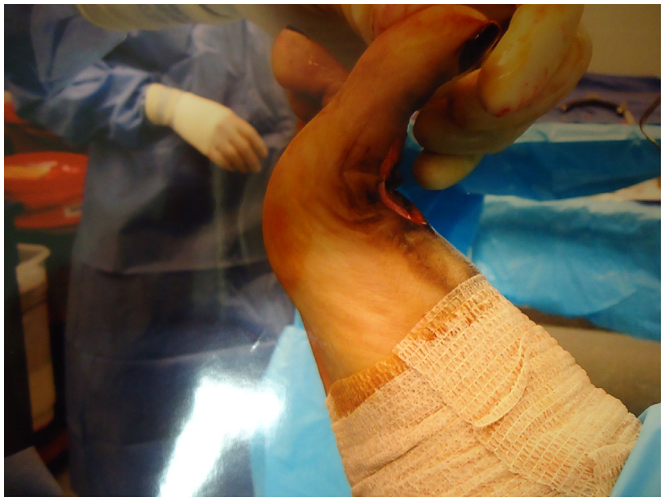

Fig. 3. Intraoperative view of dorsiflexion after modified Valenti and hardware removal in an elite Olympic sprinter with prior surgery.

years) at the time of the index procedure. There were 56 procedures on male feet and 44 on female feet. Average follow-up time from the index procedure was 80.5 ± 45.4 months (range 11.5 to 209.6 months). Seven patients had the contralateral foot operated on for a similar procedure in a separate setting; 1 had bilateral procedures performed. One patient was deceased at the time of the review, 3 years after the index procedure. There were no complications such as cock-up toe deformity, infection, or lateral forefoot complaints. Six (6%) patients required corticosteroid injections for sesamoiditis symptoms at ≥6 months after the procedure.

In the cohort, there were 76 procedures for which running was the primary sport, 9 tennis players, and 5 each dancers and soccer players. For 89 procedures, the exact RTA was determined as 9.2 ± 4.3 weeks. For the other 11 procedures, it was unclear from the records when the exact RTA was; however, the patients confirmed their ability to return to sport at some point during the follow-up process. There was no significant difference in RTA for males versus females, 9.1 ± 2.3 and 9.4 ± 4.4, respectively ($p = .71$). A 1-way analysis of variance test suggested significant differences based on sport ($p = .0098$). The Scheffé post hoc tests indicated that the only significant difference was between runners and soccer players ($p = .014$). Runners were the

Table 1
Return to activity (in weeks) of specific athletes by sport with n >1

Dancers (n = 5)	8.5 ± 2.5
Runners (n = 76)	8.7 ± 4.0
Tennis (n = 9)	9.7 ± 2.7
Soccer (n = 5)	16.5 ± 7.7

Table 2
Return to activity based on grade of hallux rigidus

Grade 2 (n = 17)	11.1 ± 4.6 wk
Grade 3 (n = 79)	9.0 ± 4.3 wk
Grade 4 (n = 4)	7.2 ± 1.9 wk

largest cohort, with an RTA of 8.8 ± 4.0 weeks. Dancers had an RTA of 8.5 ± 2.5 weeks. Soccer players had an RTA as a group of 16.5 ± 7.7 weeks (Table 1).

There were 17 patients with grade 2 HR, 79 had grade 3, and 4 had grade 4. There was no significant difference in RTA for the grade of HR ($p = .15$). Grade 2 had the longest RTA, and grade 4 had the shortest (Table 2). For 5 of the patients undergoing the procedures, the modified Valenti was not their initial surgical intervention. Four had prior cheilectomies, and 1 had a cheilectomy and then a double osteotomy before a Valenti procedure. Six patients (6%) stated that they had DDA after the procedure, with 5 having prior surgery; this was not significant ($p = .27$). Four patients had postoperative dorsiflexion <20°; this did not significantly affect the RTA ($p = .73$). One patient who sustained trauma to her operative foot with a fracture on the dorsal aspect of the proximal phalanx 3 years after surgery underwent an additional exostectomy procedure. Her remaining articular cartilage on the first metatarsal head appeared quite healthy (Fig. 4). The entire group's pertinent data are shown in Table 3.

Discussion

The current study showed a high rate of RTA with the modified Valenti procedure in running and jumping athletes, with only 6 procedures resulting in DDA, which is an important patient-reported outcome measure for athletes (9–11). The RTA range of 8 to 16 weeks for the entire cohort is important to note as well. It is interesting to note that RTA for grade 2 HR was slower than for grades 3 and 4. We are unable to explain why dancers and runners had RTA almost half that of soccer and basketball players. The starting and stopping of soccer and basketball may be more stressful on the first MPJ as well, although this did not appear to be as much of an issue with tennis players. We have not found any other study that documents whether these suppositions are true. Other procedures that are proposed for HR on athletes can be compared with our study's DDA (6%) and RTA at an average of 9 weeks.

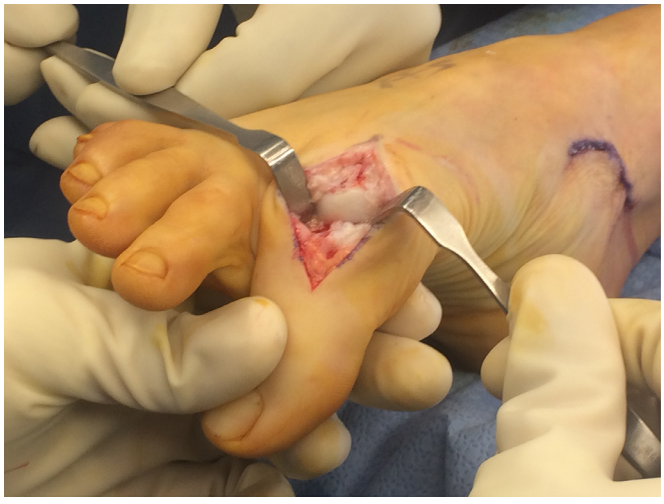

Fig. 4. Intraoperative view of remaining first metatarsal head cartilage 3 years after arthroplasty in a patient who necessitated dorsal proximal phalanx exostectomy after trauma.

Surgical treatment of HR in athletic individuals has been documented by only a few authors. In 1999, Mulier et al (12) reported on 22 cheilectomies in high-level athletes with a mean follow-up of >5 years. They achieved 14 "excellent" and 7 "good" results using the Regnauld classification in grade 1 and 2 cases. They also noted degenerative changes in patients ≥4 years after the index procedure when radiographs were obtained. Their cohort's exact RTA was not specified but was allowed after 6 weeks (12). Cetinkaya et al (17) also showed favorable results with cheilectomy in grade 3 HR patients but did not report on athletes. In 2000, Saxena (9) and Saxena and Krisdakumtom (10) reported on procedures on athletes. RTA for those undergoing the Valenti procedure was 6.5 weeks and first metatarsal osteotomy was 8.9 weeks, respectively. Athletes have been found to have faster RTA than "active patients." Other studies show improvement of hallux dorsiflexion on average of ≥27° after Valenti-type procedures; however, 20° as noted by other authors appears sufficient for athletes (3,4,15,16).

Other authors have reports on first MPJ arthroplasty procedures, which are also modifications of the Valenti procedure. Nicolosi et al (18) reported on a large series. However, they did not report on patients' activity level. They termed their procedure an *aggressive cheilectomy*—in other words, removal of 20% to 30% of the metatarsal head and proximal phalanx. Overall, 51 of their 58 patients were satisfied, with 2 requiring subsequent arthrodesis. Aynardi et al (19) also reported on interpositional arthroplasty with partial joint resection in another recent publication in 169 patients. Similar to the article by Nicolosi et al (18), they did not report on activity level. The article by Aynardi et al (19) focused on survivorship, which was determined by follow-up phone calls. They performed an interpositional arthroplasty, in some cases with local tissue as we did, using extensor hallucis brevis, but in others with an acellular matrix. This would add to the procedure's cost. Their patient-reported outcome was excellent or good in 89.5% of the cases and fair or poor in 10.5%. Overall, 17.3% of patients complained of second or third MPJ pain after the procedure. In our series, we did not have any patients with this complaint but 6% with sesamoiditis.

The elevated position of the first ray has been implicated as a factor in the outcome of HR procedures. This "elevatus" has been studied by Grady and Sanchez (20) and found that the elevatus reduces after the Valenti procedure. They concluded that after hallux dorsiflexion improves, the compensatory lateralization decreases, which in turn decreases the elevatus. Therefore, plantar flexor osteotomy and reduction of elevatus by other procedures, such as the Lapidus, is not warranted (20). There are still advocates of "realignment" of the first metatarsal osteotomies for grades 2 and 3 (21); however, a critical review of the literature by Roukis (22) in 2010 does not support this. Other than Saxena (9) reporting on first metatarsal osteotomies in some athletes, which were primarily for hallux valgus, no others have reported on activity level. Furthermore, shortening and plantarflexion of the first metatarsal may induce sesamoiditis, lessor MPJ overload, or both. This can be particularly problematic in the running and jumping athlete (10).

The concern of revision surgery after a Valenti-type procedure has been noted; however, both Olms et al (23) and Roukis (24) reported that this does not appear to be an issue. Olms et al (23) reported that of

Table 3
Patients undergoing Valenti arthroplasty

Patient	Age (y)	Sex	R/L	DOS	F/U (mo)	Activity	RTA (wk)	Grade	Primary	DDA	DF <20	Inj PO?
1	54	F	L	14-Mar	38.7	Basketball	16	2				
2	33	F	L	9-Jul	94.9	Dancer	8	2				
3	52	F	L	9-Dec	89.8	Dancer	8	3				
4	66	F	R	10-Jun	83.8	Dancer	6	4				
5	50	F	R	15-Feb	27.5	Dancer	*	3				
6	49	F	L	15-Nov	18.6	Dancer	12	3				
7	46	M	R	9-Nov	90.8	Lacrosse	4	3				
8	49	M	R	14-Dec	29.6	Rugby	12	3	No	Yes	Yes	Yes
9	52	M	L	Jan-00	209.2	Runner	12	3				
10	57	M	L	1-Apr	170.2	Runner	6	3				
11	45	F	R	1-Oct	164.2	Runner	8	3				
12	48	M	L	3-May	145.1	Runner	7	3				
13	43	M	R	4-Apr	146.1	Runner	5	3				
14	52	F	R	4-May	145.1	Runner	12	3				
15	53	F	R	4-Aug	142.1	Runner	7	3				
16	43	M	R	4-Sep	141.1	Runner	5	3				
17	52	M	R	4-Dec	138.1	Runner	6	4				
18	49	M	R	5-Oct	140.0	Runner	16	3		Yes		
19	49	M	L	5-Oct	140.0	Runner	16	3		Yes		
20	52	M	L	5-Dec	138.0	Runner	5	3				
21	61	M	L	5-Dec	138.0	Runner	16	3				
22	48	F	R	5-Dec	126.0	Runner	6	3				
23	39	M	R	6-Jan	137.0	Runner	6	3				
24	43	M	R	6-Mar	135.0	Runner	5	3				
25	55	M	L	6-Jul	131.0	Runner	4	3				
26	59	F	L	6-Oct	128.0	Runner	4	3				
27	51	F	R	6-Dec	126.0	Runner	6	3	No		Yes	
28	45	M	L	7-Feb	123.9	Runner	7	4	No			
29	35	M	R	7-Mar	123.0	Runner	8	3				
30	38	F	L	7-Apr	122.0	Runner	8	3				
31	43	F	R	7-May	121.0	Runner	3	3				
32	62	M	R	7-Jun	120.0	Runner	10	3		Yes		
33	57	M	R	17-Jul	118.7	Runner	3	3				
34	49	M	R	7-Sep	116.9	Runner	6	3				
35	47	F	L	8-Jan	112.9	Runner	6	3			Yes	
36	54	M	R	8-Jul	106.9	Runner	10	3				
37	54	M	L	8-Oct	103.9	Runner	14	3				
38	45	M	R	8-Dec	101.9	Runner	10	4	No			
39	49	M	R	9-Jan	100.8	Runner	*	3				
40	56	F	L	9-Feb	99.8	Runner	8	3				
41	56	M	R	9-Jun	95.9	Runner	8	3				
42	57	F	R	9-Jul	94.9	Runner	28	3				
43	44	M	R	9-Jul	94.9	Runner	16	3				
44	52	M	L	9-Oct	91.8	Runner	*	3				Yes
45	46	M	L	9-Oct	91.8	Runner	8	3				
46	54	F	R	10-Jan	88.8	Runner	*	3				
47	53	M	R	10-Jan	88.8	Runner	12	3				
48	61	M	R	10-Feb	87.8	Runner	6	3		Yes		
49	56	F	R	10-Feb	87.8	Runner	8	3				
50	54	M	R	10-Mar	86.8	Runner	12	3				
51	50	F	R	10-Apr	85.8	Runner	8	3				Yes
52	35	M	R	11-Jun	71.8	Runner	5	3				
53	59	M	R	11-Jul	70.8	Runner	6	3				
54	36	M	L	11-Aug	69.8	Runner	*	2				
55	46	F	R	11-Sep	68.8	Runner	10	3				
56	57	F	L	12-Mar	62.7	Runner	6	3				Yes
57	55	F	R	12-May	60.7	Runner	8	3				
58	56	M	R	12-May	60.7	Runner	8	3				
59	42	F	R	12-Oct	55.7	Runner	12	2				
60	46	M	R	13-Feb	51.6	Runner	8	2				
61	67	M	R	13-May	48.7	Runner	10	3				
62	62	M	L	13-Oct	43.7	Runner	10	3				
63	38	M	L	13-Nov	42.6	Runner	16	3				
64	46	F	R	13-Nov	42.6	Runner	12	3				
65	54	F	L	13-Dec	41.6	Runner	4	3				
66	50	M	R	14-Jan	40.6	Runner	10	2				
67	29	F	R	14-Apr	37.6	Runner	6	2				
68	48	M	R	14-Apr	37.6	Runner	12	3				
69	55	M	L	14-Jul	34.6	Runner	6	3				
70	36	M	R	14-Sep	32.6	Runner	8	3				
71	44	F	R	14-Nov	30.6	Runner	*	3				

(*continued*)

Table 3. (*Continued*)

Patient	Age (y)	Sex	R/L	DOS	F/U (mo)	Activity	RTA (wk)	Grade	Primary	DDA	DF <20	Inj PO?
72	55	M	R	14-Nov	30.6	Runner	6	3				
73	51	F	R	14-Nov	30.6	Runner	6	3				
74	28	M	R	14-Nov	30.6	Runner	*	3				
75	40	M	R	14-Dec	29.6	Runner	8	2				
76	45	F	R	15-Mar	26.6	Runner	8	3	No			
77	44	F	R	15-May	24.6	Runner	10	2				
78	71	F	R	15-Jul	22.6	Runner	12	3				
79	50	F	R	15-Jul	22.6	Runner	*	3				
80	54	F	R	15-Sep	20.6	Runner	12	3				
81	56	M	R	15-Oct	19.6	Runner	10	2				
82	30	F	R	15-Nov	18.6	Runner	8	3				
83	81	M	L	16-Mar	14.5	Runner	8	3				
84	36	F	L	16-Mar	14.5	Runner	8	2				
85	49	M	R	9-Jul	94.9	Runner/Hockey	10	2			Yes	
86	53	F	R	6-Jan	137.0	Soccer	6	3				
87	30	M	R	12-Apr	61.7	Soccer	16	2		Yes		Yes
88	40	M	R	13-Jan	52.6	Soccer	20	3				
89	29	M	R	13-Mar	50.7	Soccer	24	2				Yes
90	31	F	R	15-Dec	17.6	Soccer	*	2				
91	13	F	L	16-Jun	11.5	Softball	12	2				
92	49	F	R	7-Aug	118.0	Tennis	*	3				
93	61	M	R	7-Aug	118.0	Tennis	9	3				
94	58	F	L	7-Nov	114.9	Tennis	14	3				
95	56	F	R	10-Aug	81.8	Tennis	8	3				
96	58	M	L	11-Jun	71.8	Tennis	6	3				
97	56	F	L	13-Sep	44.6	Tennis	12	3				
98	55	M	L	14-Sep	32.6	Tennis	*	3				
99	54	M	R	14-Dec	29.6	Tennis	8	3				
100	56	F	R	15-Jul	22.6	Tennis	8	2				
49.17	56			80.52		9.25		5	6	4	6	
10.06	44			45.36		4.34						

DDA, decreased desired activity; DF <20, hallux dorsiflexion <20° with respect to the first metatarsal; DOS, date of service; F, female; F/U; follow-up; Inj PO, injection post-operation; L, left; M, male; R, right; RTA, return to activity.
Grade indicates the grade of hallux rigidus (1 to 4). The asterisks indicate exact RTA unknown.

162 procedures, 2 necessitated an uncomplicated fusion. Interestingly, Olms et al (23) had 80% postoperative sesamoiditis compared with our current study of 6%. This may be owing to a slight difference in surgical technique; we do not dissect out the sesamoids that they do. Roukis (24) reviewed the literature on isolated Valenti procedures and concluded that the low incidence for the need for subsequent arthrodesis supported the continued use of the procedure.

Osteotomies of the proximal phalanx to increase dorsiflexion (Moberg) have also been described for HR, particularly with a hallux valgus deformity. Authors have found a 90% patient satisfaction rate; however, as noted with most studies, activity level is not documented (25). Biomechanical studies have not shown any differences in peak pressure or contact area in the first MPJ; there was a shift of plantar pressure (26).

Implant procedures have been used for HR. A recent multicenter, randomized prospective, industry-funded study was performed using a hydrogel synthetic implant in the first metatarsal head. Although one of the assessment instruments was the "Foot and Ankle Ability Measure—Sports," no documentation of sports and RTA was made. Over the course of the study, 9.2% of the implants were converted to an arthrodesis, termed *the gold standard* (27). This is interesting, because sports activity level after arthrodesis has not been documented, at least through our literature search using the terms "hallux rigidus + arthrodesis + athlete + sport." We plan to make this the subject of a future article.

Another recent study on first metatarsal head resurfacing indicated in its postoperative protocol that return to running was allowed after 6 weeks but again did not indicate any of the study patients' activity level. One of 45 of the study's patients was converted to an arthrodesis during the 10-year study (28). The costs of these implants can be a factor. Clearly, more study is needed to determine whether implants are appropriate in the athletic population.

Ruff and Grady (29) recently reported on a modified Valenti procedure—nonimplant arthroplasty (NIA) for grade IV hallux rigidus—as an alternative to arthrodesis. Their procedures were for patients with grade 4 HR with good outcomes. Unfortunately, they did not track their patients' activity level and return to sports. Future studies should evaluate the outcomes for grade 4 conditions.

Our study, as with other large clinical cohorts, does have weaknesses. We were unable to assess our patients, in general, any longer than 2 years after the index procedure unless they came in for another condition. Another weakness was that the groups of athletes were too small to reveal significant differences. Because of the variability of different assessors' ROM measurements, the actual change in motion is difficult to assess and a limitation of this study. This is a common weakness in case series over a large time frame with different assessors (typically Fellows). Because of the lack of standardization of ROM measurements, we did not use other scoring instruments such as those from the American Orthopaedic Foot and Ankle Society and the American College of Foot and Ankle Surgeons. We were also unable to assess radiographic changes over time. RTA time frames may be biased by scheduling habits and availability. To our knowledge, 1 patient needed additional surgery for an exostectomy; we are unable to verify whether any other patients needed additional treatment elsewhere. Funding may help future studies, but the reality of musculoskeletal research is that most receive funding from implant, device, or pharmaceutical companies. The Valenti procedure does not use any of these.

In conclusion, our modified Valenti procedure is a safe and effective treatment in running and jumping athletes; 94% of our patients were able to RTA to their desired activity level, and none to our knowledge

required a fusion. A predominant number of the procedures were performed in patients with grade 3 HR (79 of 100) who were runners (76 of 100). Further study is needed for athletes with grade 4 HR so that other procedures can be assessed similarly.

Acknowledgment

The authors would like to thank Dominick L. Frosch, PhD, for his statistical assistance.

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