

The Lateral Hallux Stress Dorsiflexion View for Evaluation of Hallux Rigidus: Utility in Predicting Cartilage Condition on the Dorsal Metatarsal Head Intra-Operatively

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STATEMENT OF PURPOSE

Diagnosis and staging for hallux limitus/hallux rigidus (HL/HR) is based on clinical and radiographic assessment aimed at predicting the condition of the joint surface. Accurate staging plays a major role in surgical procedure selection as the surgeon contemplates joint preserving versus joint destructive procedures. Final procedure selection occurs intraoperatively which may have implications regarding operating room time, full consent for indicated procedures, availability of hardware, and anticipation of prolonged recovery. It is therefore beneficial to accurately predict the condition of the first MTPJ cartilage which leads to less intraoperative surprises and more definitive procedure selection.

Loss of joint space on x-ray is the primary surrogate marker for thin or absent cartilage in HL/HR. Early cartilage loss commonly occurs at the upper 1/3 of the 1st metatarsal head with progressive loss from dorsal to plantar as the disease progresses to later stages (Figure 1). Clinical exam can also raise concern for cartilage damage based on crepitus or pain on range of motion and bone block on end range of dorsiflexion (DF). Standard weight bearing (WB) radiographic views of the foot are taken with the patient standing with the hallux in neutral position which primarily evaluates joint space through the central aspect of the joint where the cartilage may still be intact in late stage 2 and early stage 3 disease. This scenario leaves the surgeon somewhat unsure of what they will find intraoperatively as symptoms and exam findings may suggest stage 3 disease while neutral position x-rays indicate stage 2 disease.

The lateral stress dorsiflexion (LAT SD) view images the first MTPJ in a functional position of maximum DF allowing for true radiographic assessment of the cartilage condition at the upper 1/3 of the joint. The LAT SD view allows clear demonstration of joint space narrowing in mid-term disease, bone on bone arthritis, and restricted DF ROM due to bone spur impingement (Figure 2). Each of these parameters can be shown to the patient and described in terms that patients can understand. We hypothesize that the LAT SD view will lead to more accurate prediction of cartilage condition on the 1st metatarsal head. In addition, based on clinical experience, we also predict that the LAT SD shows a false negative result in patients with central stellate lesions where the dorsal cartilage remains intact despite a central cartilage defect.

The purpose of this prospective study was to compare the LAT SD view to gold standard WB foot views in regards to accuracy of predicting cartilage condition and staging of HL/HR, when compared to intra-operative findings and procedure. Additionally, we measured the preoperative and postoperative lateral stress dorsiflexion angle (LSDA) to assess for change in functional DF.

LITERATURE REVIEW

The use of the LAT SD view in the evaluation of 1st metatarsal head cartilage in the HL/HR has very few descriptions in the literature and has not been scientifically evaluated.

In 2015 a case series by Boffeli & Collier demonstrated the technique and clinical utility of the LAT SD view. They found the LAT SD view to be simple, reproducible and inexpensive. They concluded that this view allows for the assessment of the upper 1/3 of the joint surface where cartilage damage is commonly seen in early disease [1].

Taranto in 2005 evaluated the reliability of various radiographic measurements including the LAT SD view in adults with HL/HR. He concluded that the LAT SD view had low differences between raters and that the LSDA could be measured reliably [2].

In 2002, Roukis et al. performed a prospective comparison of different clinical, radiographic and intraoperative findings in patients with HL/HR. He found a relationship between a novel radiographic grading system and the amount of cartilage loss found intraoperatively [3].

Coughlin in 2003 evaluated grading & long-term results after operative treatment for HL/HR. He found that 97% (107/110) patients had good to excellent results after cheilectomy. He recommended that cheilectomy was the procedure of choice for grade 1 & 2 patients, but those with late grade 3 or grade 4 should undergo fusion. He also concluded that based on standard lateral radiographs grade 3 & 4 look identical [4].

METHODOLOGY

After obtaining approval by the institutional review board, we prospectively analyzed consecutive patients undergoing surgery for stage 2 and stage 3 HL/HR to evaluate the preoperative and postoperative clinical utility of the LAT SD view. The Drago classification system was utilized for HL/HR staging [5]. Patients over the age of 18 years with stage 2 or stage 3 HL/HR undergoing surgery were included. Patients were excluded if they were under the age of 18, had stage 1 or stage 4 disease, were undergoing revision surgery, had arthritis secondary to rheumatoid arthritis, or had history of trauma to the first MTPJ.

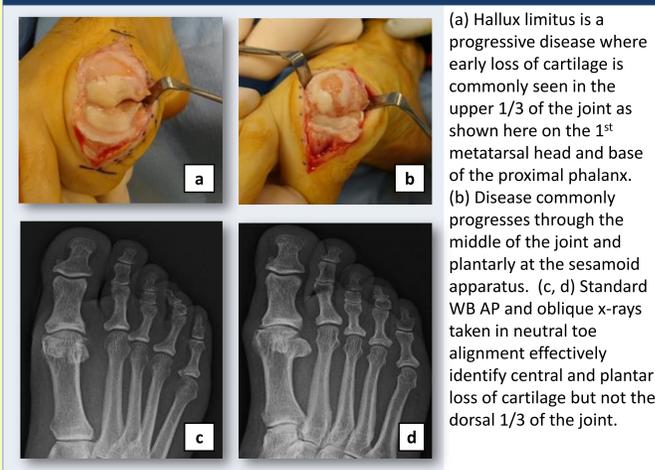
Outcomes of Interest

Patient characteristics including gender, age, BMI, height, weight, side of involvement, cartilage condition, stage of HL/HR, procedure choice, radiographic measurements, follow-up data, postoperative results and complications were collected prospectively and throughout the observational period. The cartilage condition and stage of HL/HR was predicted and recorded separately by staff surgeon and resident prior to viewing the LAT SD view, after viewing the LAT SD view, and finally confirmed intraoperatively. The LAT SD angle was measured preoperatively and at 6 to 10 weeks postoperatively for comparison.

Statistical Analysis

Continuous variables were described in terms of the mean \pm standard deviation (SD), range (minimum - maximum). Categorical variables were described in terms of frequency counts and percentages. Tests of the null hypothesis were used comparing the preoperative to postoperative outcomes of interest, and statistical significance was set at $P \leq 0.5$.

Figure 1. Imaging challenges to assess upper 1/3 of joint



(a) Hallux limitus is a progressive disease where early loss of cartilage is commonly seen in the upper 1/3 of the joint as shown here on the 1st metatarsal head and base of the proximal phalanx. (b) Disease commonly progresses through the middle of the joint and plantarly at the sesamoid apparatus. (c, d) Standard WB AP and oblique x-rays taken in neutral toe alignment effectively identify central and plantar loss of cartilage but not the dorsal 1/3 of the joint.

Figure 2. Standard lateral view vs. LAT SD view in HL/HR

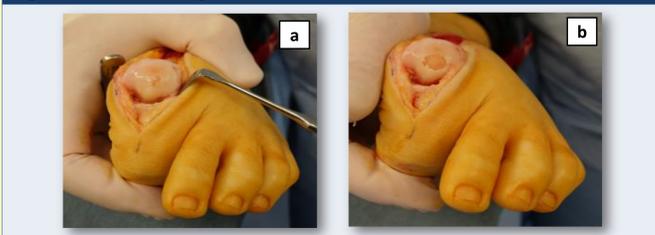


(a) Standard lateral WB view demonstrates dorsal spurs and intact joint space. (b) The same patient imaged with LAT SD view which allows radiographic evaluation of the first MTPJ in a functional position of maximum DF. Note joint space narrowing at the upper 1/3 of the joint which would predict full thickness loss of cartilage in this area. Bone-on-bone impingement on end range of DF is also evident which helps patients better understand why the joint hurts and what role the spurs play in their condition. Maximum DF can also be objectively measured and compared to postoperatively.

Table 1. Patient Characteristics

Variable	Average \pm St. Dev.	Range (min - max)
Age (Years)	48.9 \pm 13.1	20 to 63
Height (cm)	170.7 \pm 8.7	156 to 188
Weight (kg)	82.4 \pm 18.2	62.6 to 112.9
BMI (kg/m ²)	28.4 \pm 6.6	12.8 to 37.9

Figure 3. False negative result with central stellate lesion



(a) Example of a central stellate chondral lesion with thin but intact dorsal cartilage. (b) Post-debridement of stellate lesion. The central stellate lesion creates a false negative result with LAT SD imaging which was found in 5/15 (33%) patients. This finding cannot be detected on standard radiographs or on the LAT SD view. A high index of suspicion is warranted in patients with joint symptoms that do not match radiographic findings.

Table 2. Summary of results

Gender	Total	Percentage
Males	7/15	46.6%
Females	8/15	53.3%
Side of Involvement		
Right	12/15	80%
Left	3/15	20%
Procedure		
Cheilectomy	9/15	60%
1 st MPJ Fusion	3/15	20%
Midfoot fusion & cheilectomy	3/15	20%
Stage of HL/HR (based on Intraoperative Findings)		
Stage 2	6/15	40%
Early Stage 3	5/15	33.3%
Late Stage 3	4/15	26.6%

Table 3. Comparison of Preoperative Estimation of Cartilage Condition & Staging in HL/HR to Intraoperative Findings

Variable	Intra-op Finding Correlate w/ Estimate PRE-LAT SD View	Intra-op Finding Correlate w/ Estimate POST-LAT SD View	p value
Cartilage Condition	3/15 (20%)	10/15 (67.7%)	0.009
Stage of HL/HR	6/15 (40%)	8/15 (53%)	0.48

Table 4. Comparison of Preoperative to Postoperative LSDA

Variable	Average \pm St. Dev.	Range (min - max)
LSDA		
Preoperative	41.6° \pm 10.5°	30° to 50°
Postoperative	47.2° \pm 9.3°	30° to 60°
Difference/Improvement	7.4 \pm 8.3°	-0.9° to 15.7°

Figure 4. Preoperative vs. postoperative LSDA on LAT SD imaging



(a) LSDA is shown here on preoperative LAT SD view which is compared to (b) postoperative LAT SD view. Note improved DF ROM 6 weeks after cheilectomy.

RESULTS

Patient characteristics are depicted in table 1 and table 2. A total of 15 patients/feet were included, 8 (53.3%) females and 7 (46.6%) males. The mean age was 48.9 \pm 13.1 (range 20 to 63) years. The mean body mass index was 28.4 \pm 6.6 (range 12.8 to 37.9) kg/m². Laterality included 12 (80%) right and 3 (20%) left. Procedures performed included: 9/15 (60%) cheilectomy, 3/15 (20%) first MTPJ fusion, and 3/15 (20%) midfoot fusion with cheilectomy. Confirmed intraoperative stage of HL/HR included: 6/15 (40%) with stage 2, 5/15 (33.3%) with early stage 3, and 4/15 (26.6%) with late stage 3.

Correlation of Predicted cartilage condition and staging of HL/HR with confirmed intraoperative findings are depicted in table 3. Prediction of cartilage condition based on standard radiographic views correlated with intraoperative findings in 3/15 (20%) while prediction of cartilage condition after viewing the LAT SD view correlated with intraoperative findings in 10/15 (67%), a difference which was significant ($p = 0.009$). LAT SD imaging lead to a false negative result in the form of a central stellate lesion found intraoperatively in 5/15 (33%) of patients (Figure 3). This finding was not seen on either standard radiographs or the LAT SD view and represents 5/5 (100%) patients where the LAT SD view did not correlate with intraoperative findings.

Staging of HL/HR correlated with confirmed intraoperative stage in 6/15 (40%) with standard preoperative radiographs compared to 8/15 (53%) after viewing the LAT SD view.

A comparison of the preoperative to postoperative LSDA is depicted in table 4. The average preoperative LSDA was 41.6 (30 to 50) degrees compared to 47.2 (30 to 60) degrees postoperatively. The average improvement in the preoperative to postoperative LSDA was 7.4 (-0.9 to 15.7) degrees ($p = 0.19$) at 6-10 weeks post-operative (Figure 4).

There were no complications reported at 6-10 weeks postoperative.

ANALYSIS AND DISCUSSION

This prospective study was performed to determine if obtaining a LAT SD view preoperatively in addition to the standard radiographic views better correlates with intraoperative findings related to cartilage condition and staging, in HL/HR. The data evaluated here depict the early results of the first 15 patients of the study with the goal of reporting 50 patients with a 1 year follow up period to assess long-term results.

Prediction of cartilage condition based on standard radiographic views with the toe in neutral alignment can identify cartilage loss in the mid- and plantar-portion of the joint, however it cannot reliably predict cartilage loss at the dorsal 1/3 of the joint. The results presented here support this with only 3/15 (20%) correlating with intraoperative findings with standard x-rays compared to 10/15 (67%) correlation with the LAT SD view which was statistically significant ($p = 0.009$). A false negative, in the form of a central stellate lesion was noted in 5/15 (33%) of patients with both standard x-rays and the LAT SD view. These 5 patients accounted for 100% of the patients whose LAT SD view didn't correlate with intraoperative findings.

The standard approach to staging and procedure selection in HL/HR is primarily focused on standard weightbearing x-rays with patient symptoms and exam findings taking a secondary roll. This poses a potential issue for clinicians when the time comes for evaluation of patients with stage 2 & early stage 3 HL/HR as these stages are difficult to tell apart based on the standard preoperative radiographs. The results found in this study showed a 6/15 (40%) staging correlation with standard x-rays compared to an 8/15 (53%) correlation with the LAT SD view. While this result was not statistically significant, it did allow for a 13% rate of more accurate staging, and is not surprising given overlap of staging criteria in stage 2 and 3 disease.

The LAT SD view also allows for measurement of LSDA which allows objective preoperative assessment of maximum DF which can be compared to postoperative values. The average improvement in preoperative to postoperative LSDA was 7.4 degrees at 6-10 weeks postoperative (Table 4). Although this finding was not statistically significant ($p = 0.19$), LSDA did improve by 6-10 weeks postoperative when swelling and some level of discomfort are still present. A more accurate measurement will be performed at the 1 year postoperative visit.

Limitations of this study include the relatively small group of 15 patients/feet and short term follow up. Early results demonstrate the utility of this simple, inexpensive, and easily reproducible radiographic view. It also highlights the limitations of imaging modalities for HL/HR. The addition of the LAT SD view to the standard radiographic views allows for evaluation of the first MTPJ in a functional position of maximum DF which allows the clinician to more accurately predict cartilage condition at the upper 1/3 of the joint which is intended to minimize the potential for unexpected intraoperative findings.

REFERENCES

- Boffeli, T. J., & Collier, R. C. (2015). Lateral Stress Dorsiflexion View: A Case Series Demonstrating Clinical Utility in Midterm Hallux Limitus. *Journal of Foot & Ankle Surgery*, 739-746.
- Taranto, M.J., Taranto, J., Bryant, A., Singer, K.P. (2005). Radiographic Investigation of Angular and Linear Measurements Including First Metatarsophalangeal Joint Dorsiflexion and Rearfoot to Forefoot Axis Angle. *Journal of Foot & Ankle Surgery*, 190-199.
- Roukis, T.S., Jacobs, P.M., Dawson, D.M., Erdmann, B.B., Ringstrom, J.B. (2002). A Prospective Comparison of Clinical, Radiographic and Intraoperative Features of Hallux Rigidus. *Journal of Foot & Ankle Surgery*, 76-95.
- Coughlin, M.J., Shurnas, P.S. (2003). Hallux Rigidus: Grading and Long Term Results of Operative Treatment. *Journal of Bone & Joint Surgery*, 2072-2088.
- Drago, J.J., Oloff, L., Jacobs, A.M. (1984). A Comprehensive Review of Hallux Limitus. *Journal of Foot Surgery*, 213-220.