Nonoperative Treatment of Closed Extra-Articular Distal-Third Diaphyseal Fractures of the Humerus: A Comparison of Functional Bracing and Long Arm Casting

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Background/Purpose: Advocates of functional bracing for nonoperative treatment of distal-third diaphyseal humerus fractures are concerned that long arm casting may cause elbow stiffness, while advocates of long arm casting claim superior alignment. We performed a retrospective comparison of these two nonoperative treatment methods.

Methods: 105 consecutive patients with a closed, extra-articular fracture of the distal third of the humeral diaphysis were identified from two orthopaedic trauma databases between 2003 and 2011. 80 patients were followed until healing and near full motion, to surgery for nonunion, or at least 6 months otherwise. 51 patients managed with functional bracing and 24 patients managed with long arm casting had adequate follow-up. Elbow range of motion and radiographic alignment of the humerus at the last follow-up were compared between the two treatment groups using the Student *t* test.

Results: All of the fractures healed. The average arc of elbow flexion was 130° ± 9.4° in braced patients versus 127° ± 11.9° in casted patients ($P = 0.26$). Four (8%) patients in the bracing group and four (17%) in the casting group had lost >20° of elbow motion. The average varus-valgus angulation was 17° ± 7.8° versus 13° ± 8.4°, respectively ($P = 0.11$) and the average anterior-posterior angulation was 9° ± 6.2° versus 7° ± 7.5° ($P = 0.54$), respectively.

Conclusion: For closed extra-articular distal-third humeral fractures, both functional bracing and long arm casting have a 100% union rate and there are no differences in average elbow motion or radiographic alignment.

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Functional Outcome Scores of Humeral Shaft Fractures in Patients Treated Nonoperatively Compared to Those Treated Surgically

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Purpose: Most studies of humeral shaft fractures report fracture angulation and shoulder range of motion, but not functional outcomes. This study used validated functional outcome measures to assess patients following nonoperative and surgical management of humeral shaft fractures. Our hypothesis is that patients treated surgically will have less disability and better shoulder function.

Methods: 240 patients treated between 2004 and 2011 were retrospectively identified with billing codes. Patients from this cohort were recruited by telephone to obtain the following functional outcome scores: Disabilities of the Arm, Shoulder and Hand (DASH), the Simple Shoulder Test (SST), and general health questionnaire Short Form-12 (SF-12). Patients were asked to rate their pain during the immediate 3-week period following surgery or splinting (scale 1-10), whether or not they would undergo the same treatment again, and if they were pleased with the cosmetic appearance of their arm. Patient chart reviews were conducted to obtain basic demographic data. Data were analyzed using two-tailed Student *T* tests, Mann-Whitney U test, or χ^2, and the data are present as the mean ± the standard error of the mean (SEM).

Results: 66 patients were recruited with complete data sets. Number of months from treatment rendered to interview date (surgical 44.6 ± 4.9 vs nonoperative 45.6 ± 5.7; $P = 0.89$) and average age (surgical 48.9 ± 3.2 vs nonoperative 43.5.8 ± 4.7; $P = 0.32$) did not differ between treatment groups. The DASH scores were higher in patients treated surgically (DASH 26.8 ± 3.7; n = 38) than in patients treated nonoperatively (DASH 12.9 ± 3.2; $P < 0.05$; n = 29). Average functional shoulder scores were lower in patients treated surgically (SST 8.00 ± 0.6) than in patients treated without surgery (SST 9.93 ± 0.5; $P < 0.05$). The SF-12 physical component summary (PCS) was higher in the nonoperative group (49.6 ± 2.3) compared to the surgical group (39.4 ± 1.3; $P < 0.05$). The mental component summary (MCS) did not differ between the groups (surgical MCS 51.8 ± 1.8; nonoperative MCS 53.2 ± 1.6; $P = 0.55$). 79% of surgical patients would undergo surgery again, while 66% of the nonoperative group would repeat the same treatment ($P = 0.19$). Self-reported pain scores in the 3 weeks following treatment were 5.9 ± 0.5 for surgery and 6.4 ± 0.4 for nonoperative treatment ($P = 0.51$). Of the patients surveyed, 73% of the surgical group were happy with the cosmetic appearance of the arm, and 66% were pleased in the nonoperative group ($P = 0.51$).

Conclusion: Patients with humeral shaft fractures that meet surgical criteria and undergo surgical fixation have less shoulder function, worse overall physical health, and more upper extremity disability compared to patients who can be managed nonoperatively. Both patient populations have similar mental health outcomes, posttreatment pain, and cosmetic appeal. The difference in outcomes suggests that humeral shaft fractures meeting surgical criteria are more severe and result in decreased long-term upper extremity function compared to injuries that do not meet these criteria.

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A Prospective Randomized Study of Operative Treatment for Noncomminuted, Humeral Shaft Fractures: Open Plating Versus Minimally Invasive Plate Osteosynthesis (MIPO)

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Purpose: This study was prospectively designed to compare the clinical and radiologic results for open plating and minimally invasive plate osteosynthesis (MIPO) in the treatment of simple-type humeral shaft fractures. The hypothesis was that the clinical result in the MIPO group would be the same or superior to that of the conventional plating group.

Methods: From June 2011 to Dec 2011, 68 patients presented to five Level I trauma centers. These patients were prospectively randomized into an open plating group (32 cases) and MIPO group (36 cases). All patients had average 15-month follow-up with minimum 12 months. Clinical outcome measurements included fracture healing time, operation time, radiation exposure time, intraoperative nerve injury, and elbow and shoulder function. Complications such as infection, nonunion, and malunion were also evaluated. Radiographic measurements included fracture alignment, time to healing, delayed union, and nonunion.

Results: 31 fractures (97%) in the open plating group were healed by 16 weeks versus 36 fractures (100%) in the MIPO group by 15 weeks ($P = 0.588$). Blood loss was 185 mL in open plating group and 102 mL in the MIPO group and it showed significant difference statistically ($P < 0.001$). Time of radiation exposure was 10 seconds in the open plating group and 68 seconds in the MIPO group ($P < 0.001$). There was no difference in operation time (116 minutes vs 105 minutes, $P = 0.106$) or complication rate. Both groups had excellent radiologic result and functional outcomes of the elbow and shoulder and there were no differences.

Conclusion: For patients requiring surgical treatment of a noncomminuted humeral shaft fracture, both open plating and MIPO both provide predictable results for achieving fracture healing with excellent elbow and shoulder function.

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Upright Compared to Supine Radiographs of Clavicle Fractures: Does Patient Positioning Affect Displacement?

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Background/Purpose: Clavicle fracture displacement, as determined from plain radiographs, is an important criterion in treatment planning. Radiographs taken with the patient supine may yield different results compared to those taken with the patient upright. The null hypothesis was clavicle fracture displacement measured on supine radiographs would be similar to displacement measured on upright radiographs.

Methods: 43 patients (average age 47 ± 18 years, 31 male) with clavicle fractures (35 OTA 15B, and 8 OTA 15C) who had AP and 30° caudal clavicle radiographs taken in both supine and upright positions were studied. Using a picture archiving and communication system (PACS), vertical displacement and clavicle length were measured and compared between the supine and upright positions retrospectively. One resident and two fellowship-trained traumatologists classified the fractures and measured displacement and shortening. Data were aggregated and compared to ensure reliability with a two-way mixed interclass correlation coefficient (ICC).

Results: Vertical fracture displacement averaged 13.8 ± 11 mm in upright radiographs and 8.1 ± 8.1 mm in supine radiographs (*t* test, $P < 0.001$), representing a 69% increase in fracture displacement with upright positioning. Injured clavicle length was 15.9 ± 2 cm in upright radiographs and 16.4 ± 1.8 cm in supine radiographs (*t* test, $P < 0.05$), a 3% decrease. 15 of 43 patients (35%) had greater than 100% clavicle diameter displacement seen on upright, but not on supine, radiographs. The ICC was 0.82 (95% confidence interval [CI]: 0.7-0.9) for OTA fracture classification, 0.92 (95% CI: 0.86-0.95) for vertical displacement measurement, and 0.91 (95% CI: 0.81-0.95) for injured clavicle length, demonstrating very high agreement of fracture classification and measurement among evaluators.

Conclusion: Increased fracture displacement and shortening was observed in upright radiographs compared to supine radiographs when evaluating clavicle fractures. The null hypothesis was disproved. This suggests that upright radiographs may better estimate fracture energy and severity, and better predict the position at healing if nonoperative treatment is selected. Both upright and supine radiographs are recommended to accurately determine the extent of fracture motion. The addition of upright radiographs could have significant impact on operative indications for clavicle fixation.

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Can Complications of Locked Plating About the Proximal Humerus Fractures Be Minimized? The Effect of the Learning Curve

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Background/Purpose: We previously reported on early complications of proximal humerus fractures treated with locked plates. In 51 consecutive patients, we found a complication rate of 24%, the most common of which was screw penetration. Other recent studies have reported complication rates as high as 43% for proximal humerus fractures treated with locking plates. The purpose of this study was to reassess the incidence of complications following locking plate treatment of proximal humerus fractures (OTA Types 11) to determine if the effect of the learning curve could diminish these outcomes.

Methods: 163 consecutive patients with proximal humerus fractures were prospectively tracked following operative fracture fixation with a locking plate. All patients were treated between February 2003 and July 2012 at our institution, and received similar treatment of open reduction and internal fixation with a locked plate followed by early range of shoulder motion. The only difference in the surgical technique over time was a greater use of calcium phosphate cement as a bone void filler in more recently treated patients. Patient outcomes were assessed by radiographic examination and physical exam. All complications were recorded. Subgroup analysis for correlation with complication was performed for age, gender, body mass index, fracture type, mechanism of injury, and number of screws in the humeral head.

Results: Overall 30 of 163 patients (18%) had experienced a complication by the time of most recent follow-up (mean 16 months; range, 6-60 months). Of the 112 patients not included in our previous study, 18 patients (16%) developed 26 complications. Average fracture healing time was 3.7 months (range, 1.5-8 months). Only 6 of 112 patients (5%) had screw penetration, yet in our previous study 8 of 51 patients (16%) had screw penetration. The incidence of infection, hardware failure, and osteonecrosis remained low and largely unchanged. There was one intraoperative complication in the latter cohort.

Conclusions: As with most procedures, a learning curve with this procedure does appear to exist. The lower complication rate in our more recent patients suggests that complications reported in early locked plating series are not inherent to the implant or fracture. They can be diminished when surgeons and support teams frequently treat proximal humerus fractures, and/or employ new treatment strategies.

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Minimally Displaced Radial Head/Neck Fractures (Mason Type I, OTA Types 21A2.2 and 21B2.1): Are We "Overtreating" Our Patients?

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Background/Purpose: Nondisplaced or minimally displaced radial head fractures (Mason Type I, OTA Types 21A2.2 and 21B2.1) are encountered frequently by orthopaedic surgeons following falls on outstretched arms. Although it is widely accepted that these fractures have excellent outcomes, there is no defined algorithm for the non-operative treatment radial head fractures. The aim of this study is to identify medical, radiographic, and demographic factors that predict full return to preinjury function for patients with Mason Type I radial head fractures treated nonoperatively.

Methods: We conducted a retrospective review of every patient who presented with a closed radial head/neck fracture seen at our tertiary care specialty institution in the past 2 years. A search of ICD-9 code 813.05, closed fracture of the radial head/neck, in our electronic record system yielded 82 consecutive patients with closed radial head/neck fractures. Initial injury radiographs were analyzed for fracture classification, displacement, size of effusion, and intra-articular fracture. Injury mechanism, additional injuries, and demographic information were recorded. For patients treated nonoperatively, follow-up intervals, physical exam scores, radiologic information, and physical therapy attendance were recorded for each outpatient visit. Statistical analysis of factors leading to full recovery was conducted.

Results: 54 patients (66%) were determined to have 56 nondisplaced or minimally displaced (2 mm or less) Mason Type I radial head fractures without additional injury to the affected limb. All patients in this cohort were treated nonoperatively and no patients in this cohort developed a complication or had any medical or surgical intervention other than physical therapy. Treating surgeons recommended a second outpatient follow-up visit with radiographs for 49 of 54 patients (91%), and of the patients who returned for a second follow-up, 16 of 27 (59%) were recommended to return for a third follow-up with radiographs. The average number of additional radiographs taken of the affected elbow after initial presentation was 4.4 (range, 0-12) for patients who returned for any follow-up. The presence of intra-articular fractures, 1 to 2 mm of displacement, and high-energy injury mechanisms was not significantly associated with recommendation for a second outpatient follow-up, third outpatient follow-up, or with the number of additional radiographs ordered beyond the initial exam. Pain with palpation of the radial head and range of motion deficits (both assessed at the second outpatient visit) were not associated with recommendation for a third outpatient follow-up or with the number of additional radiographs ordered beyond the initial exam.

Conclusion: In this study of patients with isolated, nondisplaced or minimally displaced radial head fractures, no patient developed a complication or needed subsequent surgery. Orthopaedic surgeons are likely overtreating patients with Mason Type I radial head fractures by recommending frequent follow-up without modifying treatment, leading to unnecessary patient visits, radiation exposure, and increased health-care costs.

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PROMIS Physical Function Computer-Adaptive Test Compared to Other Upper Extremity Outcome Measures in the Evaluation of Proximal Humerus Fractures in Patients Over 60 Years of Age

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Background/Purpose: In 2004 the National Institutes of Health funded PROMIS (Patient Reported Outcomes Measurement Information System) with the goal of creating highly reliable, precise measures of patient–reported health status. Key components of this effort were to use item response theory and computer-adaptive testing (CAT) to increase measure accuracy while decreasing patient burden. The effort has been very successful and several outcome measures have been created including ones for physical function. Although these measures have been studied in the general population and in some disease-specific populations, there has been little work evaluating them in orthopaedic trauma populations and they have not been compared to more commonly used, existing measures. The purpose of this study was to compare the PROMIS Physical Function (PF) CAT to commonly used traditional measures for the evaluation of patients with proximal humeral fractures. The traditional measures included the Disabilities of the Arm, Shoulder and Hand (DASH) measure, Short Musculoskeletal Functional Assessment (SMFA), and Constant shoulder score.

Methods: Patients over 60 years of age with displaced proximal humerus fractures treated either operatively or nonoperatively between 2006 and 2009 at two Level I trauma centers were identified and invited to participate in a study evaluating outcomes. 47 patients agreed to participate and returned for additional evaluation. Evaluation included completion of the DASH, SMFA, the PROMIS PF CAT, and the Constant shoulder score. All measures were administered electronically via an iPad accessing www.assessmentcenter.net, an online data management tool. Range of motion and strength measurement for the Constant shoulder score were collected by a research coordinator blinded to the treatment method. Descriptive statistics (eg, percentage, median, minimum, maximum) were obtained, and histograms were produced to review the distributional qualities of all continuous data. Pearson correlation analyses were then used to determine the observed correlations among the administered outcome measures.

Results: Of the 47 patients completing the study, 38.3% were male and 55.3% received surgical fixation. Median age at injury was 68.0 years (range, 60-88 years), while median time from injury to completion of outcome measures was 39.0 months (range, 17-77 months). On average, patients answered 86 outcome-related questions for this study: 4 for the PROMIS PF CAT (range, 4-8 questions), 6 for the Constant shoulder score, 30 for the DASH, and 46 for the SMFA. Time to complete the PROMIS PF CAT (median completion time = 98 seconds) was significantly less than that for the DASH (median completion time = 336 seconds, $P < 0.001$) and the SMFA (median completion time = 482 seconds, $P < 0.001$). Median completion time was not significantly different between the PROMIS PF CAT and the Constant shoulder score measures. PROMIS PF CAT scores correlated significantly with all other outcome measure scores. PROMIS PF CAT scores correlated highly with the DASH

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(r = –0.64, P <0.001), the SMFA Bother Index (r = –0.71, P <0.001), the SMFA Functional Index (r = –0.83, P <0.001) and the Constant-shoulder score (r = 0.50, P <0.001). The SMFA displayed ceiling effects with 35% of patients scoring within 10 points of the maximum on both function and bother indices. Similarly, 23% of patient scored within 10 points of the maximum on the DASH.

Conclusion: The median completion time for the PROMIS PF CAT was less than one-third of that for the DASH and one-fifth of that for the SMFA. At the same time, it strongly correlated with these more commonly used upper extremity outcome measures, suggesting that it is measuring the same concept. This study suggests using the PROMIS PF CAT alone yields an assessment of upper extremity function similar to those provided by more commonly used measures while substantially reducing patient testing time.

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Pain Exposure Physical Therapy Versus Conventional Therapy in Patients With Complex Regional Pain Syndrome Type 1: A Randomized Controlled Trial

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Background/Purpose: More than half the patients with complex regional pain syndrome type 1 (CRPS-1) do not respond well to the current conventional evidence-based treatments and may progress to chronic disease with associated disabilities and restrictions in daily life. Nonrandomized studies have shown that a more comprehensive CRPS-1 treatment, Pain Exposure Physical Therapy (PEPT), is safe and possibly effective. The aim of this study is to determine whether PEPT is more effective than current conventional treatment regarding CRPS-related impairments, activities, and quality of life.

Methods: In a single-blinded randomized controlled trial, adult patients with CRPS-1 according to the "Budapest" criteria were recruited and randomized to receive either PEPT or conventional treatment. Primary outcome was the CRPS-1 Impairment level Sum Score (ISS). Secondary outcome measures were pain intensity, muscle strength, active joint range of motion, pain disability index, activity monitor, Tampa Scale for Kinesiophobia, and quality of life. Baseline measurements were performed before treatment and follow-up measurements were done at 3, 6, and 9 months after inclusion.

Results: Between January 2009 and June 2011, 58 patients were randomly assigned to either PEPT (n = 29) or conventional (CONV) (n = 29) treatment. The Impairment level Sum Score improved significantly more in the PEPT group compared to the CONV group as primary end point. The estimated group difference for ISS-RV for patients that did not switch after randomization was 3.22 (95% confidence interval [CI] –0.29, 6.72; $P = 0.076$). The estimated group difference for patients who switched after randomization was 3.79 (95% CI 0.83, 6.75; $P = 0.013$). The secondary end points visual analog scale (VAS) pain, pain disability index, and active joint range of motion improved significantly more in patients treated with PEPT compared to CONV. The estimated group difference for VAS pain, pain disability index, and active joint range of motion was, respectively, 18.39 (95% CI 4.28, 32.48; $P = 0.012$), 9.59 (95% CI 1.87, 17.31; $P = 0.017$), and 8.22 (95% CI 2.38, 14.06; $P = 0.007$). The secondary end points muscle strength, activity monitor, and quality of life improved more in the PEPT group compared to CONV treatment but did not reach the level of significance. The improvement in kinesiophobia was equal in both groups. None of the patients reported serious side-effects or disease deterioration.

Conclusion: Pain Exposure Physical Therapy is a safe, nonpharmacological, and effective treatment of CRPS-1 and is superior to the current evidence-based conventional treatment.

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When Do Distal Radius Fractures Most Likely Displace and When Do They Stop Moving: Long-Term Follow-up of Closed Reduction and Casting

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Background/Purpose: Distal radius fractures treated with closed reduction and casting lose position over a long time frame. Although most surgeons immobilize these fractures for 4 to 6 weeks, little data exist predicting when these fractures are most likely to lose reduction and when they ultimately stop moving. Our goal was to use a large data set of radiographic measurements, specifically volar tilt and radial height, for regression analysis in order to determine the change in these parameters over long-term follow-up.

Methods: We prospectively screened 546 consecutive distal radius fractures. We excluded patients with <10° of dorsal tilt upon presentation, leaving 275 fractures of which 168 were treated nonoperatively with closed reduction and casting. Patients were managed with short arm casts and seen every other week in the clinic by an attending orthopaedic trauma surgeon until 6 weeks and then at the discretion of the treating surgeon. Patients were re-casted if there was thought to be a shift in the fracture position or if the cast became loose. We excluded patients with less than 150 days of follow-up, measuring the radial height and volar tilt on initial injury film, postreduction, and all subsequent follow-ups in order to perform a regression analysis and place a best-fit curve for 96 measurements for each parameter. Based on this function, we calculated the number of days when 50%, 75%, and 95% of change occurred relative to 1 year, when full healing is presumed.

Results: Using regression analysis, we placed a best fit curve and determined the function for both radial height and volar tilt (Figures 1 and 2). Based on this function, we found a logarithmic curve in which 50% of the radial height is lost in approximately the first 30 days after reduction, 75% is lost in the first 82 days, and 95% is lost by day 278. Similarly, for volar tilt, 50% loss in reduction is seen in the first 18 days, 75% is lost in the first 81 days, and 95% is lost by day 263.

Discussion/Conclusion: Our goal was to use a large data set of radiographic measurements, specifically volar tilt and radial height, for regression analysis in order to determine the change in these parameters over longer-term follow-up. We found that 50% of the primary reduction parameters of radial height and volar tilt are lost in approximately the first 4 weeks after reduction, but loss continues to occur at a slower rate up until approximately 9 months. The majority of radial height and volar tilt are lost in the first 30 days after closed reduction and casting of distal radius fractures; however, the reduction continues to shift up to nearly 1 year. Because both loss of radial height and volar tilt have been implicated in long-term wrist dysfunction, these data are important in predicting both immediate and long-term radiographic outcomes of patients and may be important in early discussions regarding treatment.

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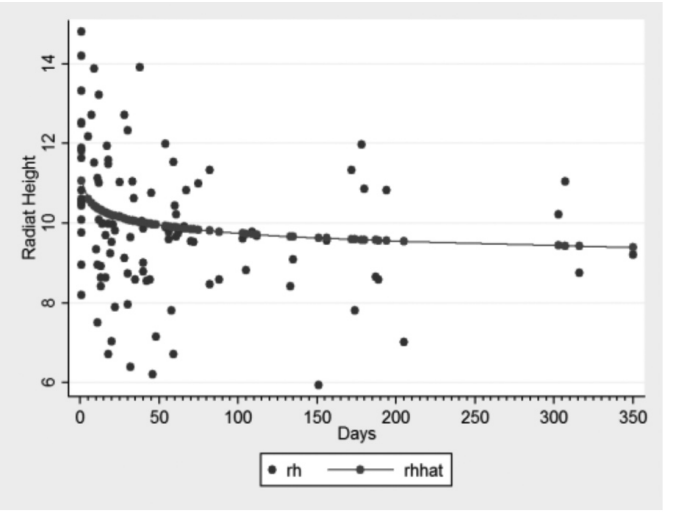
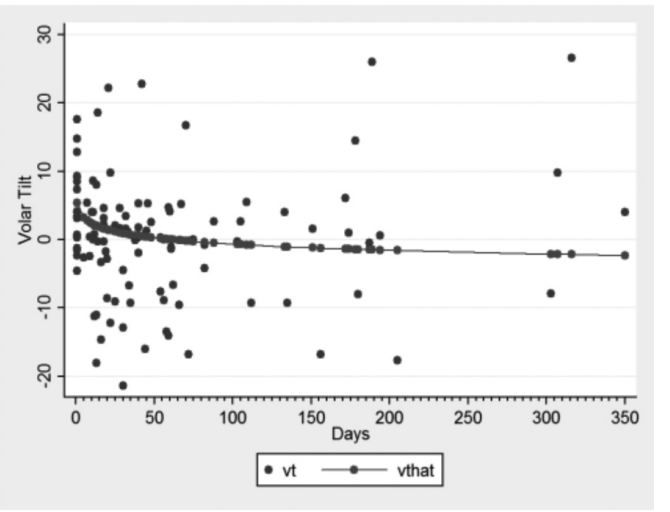


Figures 1 and 2: Best-fit regression curve and function for radial height and volar tilt. rh and vt: individual radial height and volar tilt measurements; rhhat and vthat: radial height and volar tilt function.

RHhat=11.0566–0.2837log(days) (*P* value = 0.0002)

VThat=5.3851–1.3131log(days) (*P* value = 0.0015)



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