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Original Research Article

Cast Index As A Predictor of Loss of Reduction in Colles Fracture in Adults

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Abstract:

Background: Distal radius fractures are common orthopedic injuries, particularly affecting young males and older women. In elderly patients, conservative management with closed reduction and casting is often preferred due to surgical contraindications. The cast index, a ratio of sagittal-to-coronal width at the fracture site, has been suggested as a predictor of treatment success, though its role in elderly patients remains underexplored.

Aim: This study evaluates the predictive value of the cast index in determining clinical and radiographic outcomes in elderly patients with distal radius fractures managed conservatively.

Methodology: A prospective observational study was conducted at K.S. Hegde Medical Academy, Mangalore, from September 2022 to April 2024. Sixty patients with dorsally displaced, metaphyseal, extra-articular distal radius fractures undergoing closed reduction were included. The cast index was assessed using X-rays on Days 1, 8, and 42. Statistical analysis was performed using SPSS 24.0, with significance set at $p < 0.05$.

Results: Radial height increased significantly from 7.88 ± 2.75 mm (Day 1) to 8.90 ± 3.06 mm (Day 42) (p=0.001). Post-hoc analysis confirmed significant changes between Days 1 and 8 (p=0.008) and Days 1 and 42 (p=0.001). Ulnar variance also showed a significant increase from Day 8 to Day 42 (p=0.001). Volar tilt exhibited a minor but significant increase (p=0.031).

Conclusion: These findings emphasize the importance of radiographic monitoring in elderly distal radius fractures. Age and sex influence fracture displacement, with older patients at higher risk. Further research is needed to refine predictive models for optimizing conservative treatment.

Keywords: Cast Index, Colles Fractur, Loss Of Reduction, Fracture Stability, Orthopedic Trauma.

Introduction

Distal radius fractures are one of the most frequently encountered orthopedic injuries in the upper extremity [1,2], especially in young adult males and older women [3]. These fractures often cause significant disruptions to daily activities and overall quality of life, affecting mobility, independence, and long-term functional capacity. They represent approximately 18% of all fractures in individuals aged 65 and older [4], making them a critical concern in geriatric orthopedic care. These injuries are particularly common in individuals with reduced bone density, such as those with osteoporosis [5], who are more prone to low-energy falls leading to fractures.

The treatment of distal radius fractures varies depending on factors such as patient age, bone quality, fracture pattern, and associated injuries. While surgical interventions, including open reduction and internal fixation (ORIF), are often preferred in younger, more active patients, non-operative approaches such as closed reduction and casting remain a common and viable option for elderly patients, particularly those with comorbidities that may contraindicate surgery. Despite these options, determining the most effective treatment strategy and identifying reliable indicators of treatment success remain critical challenges in patient care [6].

One such indicator, the cast index, measures the ratio of the sagittal to coronal width of the cast at the fracture site [7]. This simple yet valuable metric has been proposed as a useful tool for evaluating the quality of fracture reduction and alignment, particularly in cases managed non-operatively [8]. Prior research has demonstrated its utility in pediatric forearm fractures, where a lower cast index has been associated with improved outcomes, including reduced fracture displacement, better fracture healing, and improved range of motion [9]. However, its potential role in elderly patients with distal radius fractures has not been extensively studied, leaving critical gaps in knowledge regarding its broader clinical relevance and utility in geriatric orthopedic practice.

Given the high prevalence of distal radius fractures among older adults and the ongoing need for optimized conservative treatment strategies, this study aims to assess whether the cast index can reliably predict clinical outcomes in elderly patients with distal radius fractures who have undergone closed reduction and casting [10]. We hypothesize that patients with a cast index of ≤0.8 will achieve superior results in terms of radiographic alignment, reduced fracture displacement, improved wrist range of motion, and higher functional and clinical scores compared to those with a higher cast index. By clarifying this relationship, the study aims to provide evidence for incorporating the cast index into routine treatment protocols for elderly patients. Enhancing the effectiveness of distal radius fracture management with closed reduction and casting could lead to improved patient outcomes, reduced complications, and better overall quality of life for older adults suffering from these injuries. Additionally, a better understanding of the cast index's predictive value may help guide future treatment algorithms, ensuring that non-operative management remains a viable and effective approach for appropriately selected patients.

Methodology

Study design: This Prospective, observational study was conducted over a period of two year in the Department of Orthopaedics of K.S. Hegde Medical Academy, Deralakatte, Mangaluru, India

Study Area: The present study was conducted at Justice K.S. Hegde Hospital, which is affiliated with K.S. Hegde Medical Academy (KSHEMA), NITTE (Deemed to be University'), Mangalore, India.

Study population: The study population consisted of patients diagnosed with dorsally displaced, metaphyseal, extra-articular distal radius fractures that necessitated closed manipulation for realignment.

Study duration: The study was carried out over a span of two years, commencing on September 1, 2022, and concluding on April 30, 2024.

Study tool: Statistical analysis of the data was done using SPSS 24.0 at a 95% confidence level. Categorical variables were presented as frequency and percentage continuous variables were presented as mean+/- standard deviation. Comparison of cast index between groups was done using Unpaired t-test/ Mann Whitney u test. Categorical variables were analysed using the chi-square test. A p-value of less than 0.05 was considered statistically significant.

Sample size: A total of 60 patients were included in the study.

Sampling Method: Based on the study conducted by Debnath UK et al. [11], assuming 95% confidence interval, an 80% power average cast index in "A" group is 0.78 +/- 0.08 and average cast index in "B" group is 0.83 +/- 0.07 the estimated effect size is 0.7 the estimated sample size is 60 by taking a minimum of 20 in each group sample size is estimated by using the software G power 3.1.9.4.

Sample selection: Purposive sampling technique was employed for the selection of samples in this study.

Inclusion and Exclusion criteria

Inclusion criteria

- All dorsally displaced, metaphyseal, extra-articular distal radius fractures that required a closed manipulation.
- Age more than 18 years.

Exclusion criteria

- Unsatisfactory initial reduction.
- Pathological or open fractures.
- Old malunited radius or ulna fracture or carpal instability.
- Very weak pop cast.

Data collection method: All participants with dorsally displaced, metaphyseal, extra-articular distal radius fractures who were willing to be part of the study and were treated at K S Hegde Hospital between September 1, 2022, and April 30, 2024, were included after satisfying the inclusion and exclusion criteria. Check X-rays (PA and lateral views) taken as part of treatment on Day 1, Day 8, and Day 42 were used to assess cast index, palmar tilt, radial height, and ulnar variance. The observed values were analyzed to determine whether the cast index serves as a useful predictor for loss of reduction in Colles fractures.

Statistical Analysis: The statistical analysis was performed using SPSS (Statistical Package for Social Sciences) version 21 (IBM SPSS Statistics, IBM Corporation, NY, USA). Data were entered into an Excel spreadsheet, and descriptive statistics were calculated, including the mean and standard deviation for quantitative variables and frequency and proportions for qualitative variables. Inferential statistical tests were applied, including the Chi-square test to assess associations among qualitative variables, and the ROC curve to determine cut-off values, sensitivity, and specificity of the Cast Index in predicting surgery. Repeated measures ANOVA was used to compare Radial Height, Ulnar Variance, and Volar Tilt at different time intervals, with the post hoc Bonferroni test for pairwise comparisons. A p-value of less than 0.05 was considered statistically' significant.

Result

Table 1 presents 'the demographic distribution of 60 subjects based on age and gender. The age of the subject's ranges from 18 to 71 years, with a mean age of approximately 49.97 years and a standard deviation of 13.4. In terms of gender, 33 subjects (55%) are females, while 27 subjects (45%) are males, resulting in a total of 60 subjects (100%).

Table 1: Demographic Distribution of Subjects Based on Age and Gender

Characteristics	N	Minimum	Maximum	Mean	S.D	Frequency	Percent
Age	60	18	71	49.97	13.4	-	-
Gender	-	-	-	-	-	**Females**	33 (55%)
	-	-	-	-	-	**Males**	27 (45%)
Total	60	-	-	-	-	**Total**	60 (100%')

Figure 2 presents a comparison of the mean radial height changes over 42 days, using repeated measures ANOVA. The analysis includes measurements taken on Day 1, Day 8 and Day 42 for a sample size of 60 subjects. On Day 1, the radial height ranged from 4.0 to 13.7, with a mean of 7.88 and a standard deviation (S.D.) of 2.75. By Day 8, the radial height had increased slightly, with a range of 3.8 to 17.8, a mean of 8.39, and an S.D. of 3.21. On Day 42, the radial height continued to rise, reaching a range of 4.9 to 19.2, a mean of 8.90, and an S.D. of 3.06. The p-value for the change in radial height from Day 1 to Day 42 is 0.001, indicating a statistically significant increase in radial height over the 42 days.

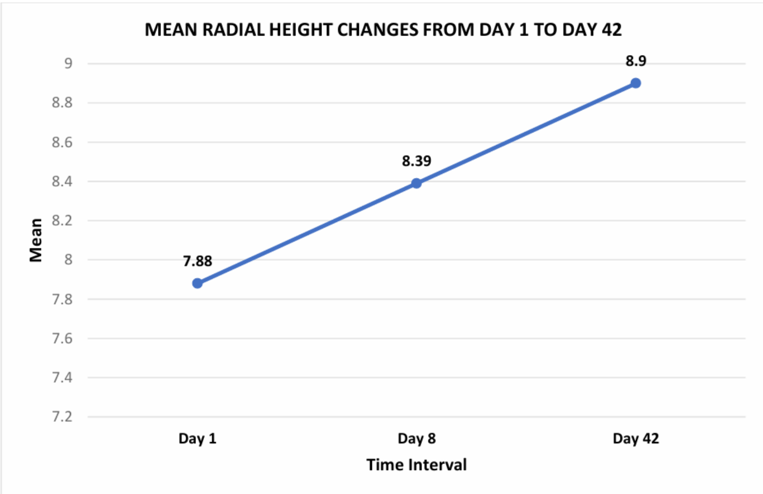

Figure 2: Medial radial height changes from day 1 to day 42

Table 2A provides a post-hoc analysis of the changes in mean radial height between different time intervals using the Bonferroni method. The comparison between Day 1 and Day 8 shows a mean difference of -0.51, with a p-value of 0.008, indicating a statistically significant increase in radial height over this period. Similarly, the comparison between Day 1 and Day 42 reveals a mean difference of -1.018, with a highly significant p-value of 0.001. This suggests an increase in radial height from Day 1 to Day 42. Lastly, 'the comparison between Day 8 and Day 42 yields a mean difference of -0.508, also with a significant p value of 0.001.

Table 2a: Comparison of the changes in mean radial height between the time intervals using post-hoc Bonferroni

	Mean diff	p-value
Day 1 Vs Day 8	-0.51	0.008
Day 1 Vs Day 42	-1.018	0.001
Day 8 Vs Day 42	-0.508	0.001

Figure 3 presents the comparison of mean ulnar variance changes from Day 1 to Day 42, analysed using repeated measures ANOVA. The study involved 60 subjects, with measurements taken at three different time points. On Day 1, ulnar variance ranged from 0.0 to 5.9, with a mean of 1.79 and a standard deviation (S.D.) of 1.21. On Day 8, the ulnar variance showed a slight decrease, with values ranging from 0.0 to 4.9, a mean of 1.74, and an S.D. of 1.15. However, by Day 42, the ulnar variance increased, ranging from 0.0 to 4.5, with a mean of 2.03 and an S.D. of 1.08. The p-value for the change in ulnar variance over the 42 days is 0.005, indicating a statistically significant change in ulnar variance over time.

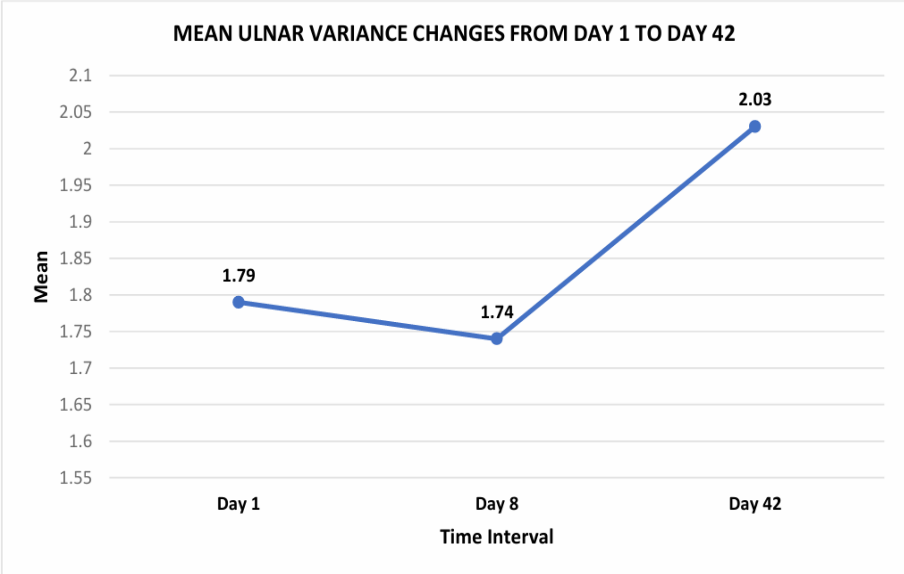

Figure 3: Mean ulnar variance changes from day 1 to day 42

Table 3A provides a post-hoc analysis of the changes in mean ulnar variance between different time intervals using the Bonferroni method. The comparison between Day 1 and Day 8 shows a mean difference of 0.053, with a p-value of 1.00, indicating that there is no statistically significant change in ulnar variance during this period. The comparison between Day 1 and Day 42 yields a mean difference of -0.238, with a p-value of 0.09, which suggests a slight but not statistically significant increase in ulnar variance. In contrast, the comparison between Day 8 and Day 42 shows a mean difference of -0.292, with a significant p-value of 0.001. This indicates a statistically significant increase in ulnar variance from Day 8 to Day 42.

Table 3a: Comparison of the changes in mean ulnar variance between the time intervals using post-hoc Bonferroni

	Mean diff	**p-value**
Day 1 Vs Day 8	0.053	1
Day 1 Vs Day 42	-0.238	0.09
Day 8 Vs Day 42	-0.292	0.001

Table 4 presents the comparison of mean volar tilt changes over 42 days, analysed using repeated measures ANOVA. The study involved 60 subjects, with measurements taken at three time points: Day 1, Day 8, and Day 42. On Day 1, the volar tilt ranged from 2 to 21, with a mean of 12.03 and a standard deviation (S.D.) of 4.81. By Day 8, the volar tilt increased slightly, with a range of 4 to 20.74, a mean of 12.74, and an S.D. of 4.32. On Day 42, the volar tilt measurements showed a similar range of 0.8 to 19.43, with a mean of 12.79 and an S.D. of 4.64. The p-value for the change in volar tilt from Day 1 to Day 42 is 0.031, indicating a statistically significant change in volar tilt over the 42 days.

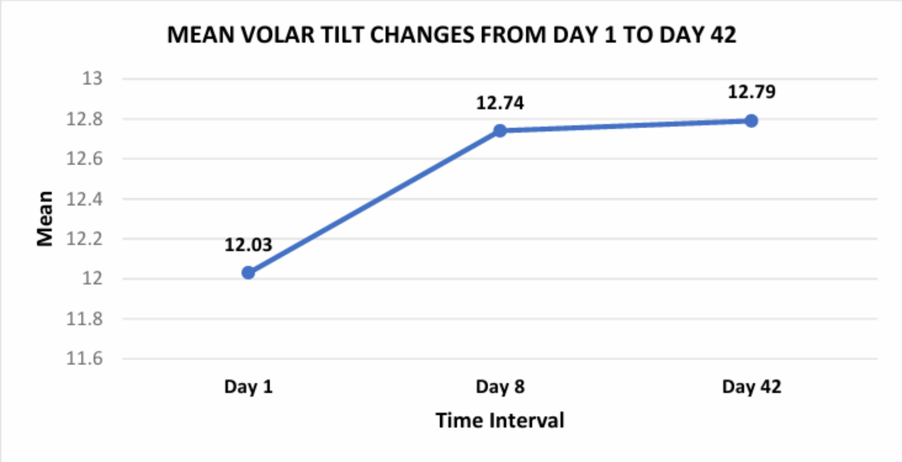

Figure 4: Mean volar tilt changes from day 1 to day 42

Table 4A provides a post hoc Bonferroni analysis of the changes in mean volar tilt between different time intervals. The comparison between Day 1 and Day 8 shows a mean difference of -0.712, with a p-value of 0.012, indicating a statistically significant increase in volar tilt during this period. Similarly, the comparison between Day 1 and Day 42 yields a mean difference of -0.762, also with a significant p-value of 0.012, suggesting a significant increase in volar tilt from Day 1 to Day 42. However, the comparison between Day 8 and Day 42 shows a mean difference of -0.049, with a p-value of 1.00, indicating no significant change in volar tilt during this later period.

Table 4a: Comparison of the changes in mean volar tilt between the time intervals using post-hoc Bonferroni

	Mean diff	p-value
Day 1 Vs Day 8	-0.712	.012
Day 1 Vs Day 42	-0.762	0.012
Day 8 Vs Day 42	-0.049	1

The mean CI was 0.847 ± .087.

Table 5: Mean Cast Index Of The Subjects

	N	Minimum	Maximum	Mean	S.D
CI	60	0.6	1	0.847	0.0871

The majority of the patients 53 (88.3%) did not undergo surgery, whereas, 7 patients (11.7%) underwent surgery.

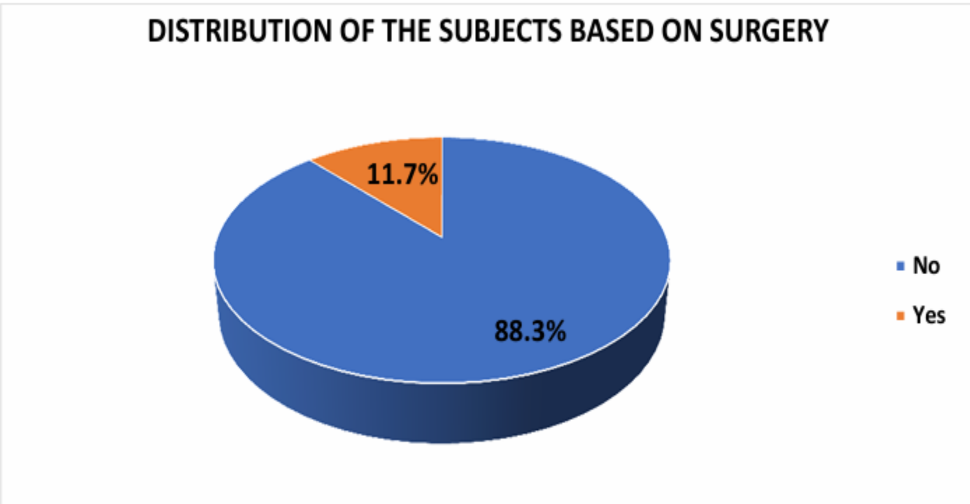

Figure 5: Distribution of subjects based on surgery

The area under the curve for Cast Index is 0.662 and is not statistically significant (p=0.167). The best cut-off to predict surgery would be 0.81 with 71.4% sensitivity and 71.7% specificity.

Table 7: Roc Curve To Predict The Surgery Based On Cast Index

Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error**	**p-value**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
Cast Index	0.662	0.16	0.167	0.348	0.975

The area under the curve for Radial height at Day 42 is 0.611 and is not statistically significant (p=0.345). The best cut-off to predict surgery would be 7.85 with 85.7% sensitivity and 45.3% specificity.

Table 8: Roc Curve To Predict The Surgery Based On Radial Height At 42 Days

Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error**	**p-value**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
Radial Height at 42 Days	0.611	0.089	0.345	0.435	0.786

The area under the curve for Ulnar Variance at Day 42 is 0.710 and is not statistically significant (p=0.072). The best cut-off to predict surgery would be 2.25 with 71.4% sensitivity and 54.7% specificity.

Table 9: Roc Curve To Predict The Surgery Based On Ulnar Variance At 42 Days

Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error**	**p-value**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
Ulnar Variance at 42 Days	0.71	0.123	0.072	0.47	0.951

The area under the curve for Volar Tilt at Day 42 is 0.456 and is not statistically significant (p=0.704). The best cut-off to predict surgery would be 13.5 with 71.4% sensitivity and 52.8% specificity.

Table 10: Roc Curve To Predict The Surgery Based On Volar Tilt At 42 Days

Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error**	**p-value**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
Volar Tilt at 42 Days	0.456	0.098	0.704	0.264	0.647

Discussion

One of the most frequent injuries that orthopaedic surgeons treat is distal radius fractures. Knowing the anatomy well enough to recognize how it presents in imaging investigations is essential to choosing the right plan of action for a particular fracture. Determining fractures that deviate from an acceptable alignment and those that are beyond acceptable parameters is still a challenging but essential assignment [12]. Anatomical deformities in the wrist joint may have harmful effects. Osteoarthritis, loss of strength and range of motion (ROM), carpal–ulnar deviation, triangular fibrocartilage overload, radiocarpal and distal radioulnar joint instability, and radiocarpal and radioulnar discomfort may all result from malunited displaced distal radius fractures [13]. Surgeons generally agree on the significance of regaining preoperative radiographic characteristics. The distal radius profile on conventional anteroposterior and lateral radiographs may be readily assessed using five measurements: volar tilt, radial inclination, ulnar variance, and radial height.

- **Age**

The average age of patients in the current research was 49.97 ± 13.40 years. In the same way, Cummings SR et al observed that the age distribution of these fractures was bimodal, with young individuals and the elderly being most affected [14]. The findings were consistent with the current research, indicating that the majority of patients (35%) were between the ages of 51 and 60. Among the elderly, low-energy falls cause them more often than high-energy trauma. An analysis of 645 Colles fractures treated conservatively revealed that age was a significant predictor of displacement in a prospective study [15]. Additionally, in a trial of 112 fractures treated conservatively, age greater than 60 was a predictor of failure [16]. Similarly, age was the sole statistically significant risk factor in predicting subsequent displacement and instability in a prospective trial of 50 patients receiving closure reduction and cast immobilization [17].

- **Sex**

In the present study, 33 patients (55%) were females and 27 patients (45%) were males. Research has shown that 51% of women with distal radius fractures have osteoporosis and 85% have poor bone mineral density [17]. Measures of fracture displacement were compared with bone mineral density in 125 women over 50 who had distal radius fractures following low-energy trauma.50 These findings were consistent with Raittio L.'s research that revealed 88% of participants were female [18]. An estimated 17% rise in post-menopausal osteoporotic fractures was reported by Stirling et al.[19] A physical and medical history are crucial components in the assessment of distal radial fractures. The most common imaging modality used to diagnose distal radius fractures is X-rays. Radial height, radial inclination, radial shift, volar tilt, and ulnar variation should all be evaluated during the X-ray examination. Anatomic variation is taken into consideration, and radiographic characteristics that are deemed to be within normal limits include a volar tilt of 12° (range 1 21°), a radial height of 12 mm (range 8–18 mm), and a radial inclination of 23° (range 13–30°) [20].

- **Radial height**

The distance between two lines drawn perpendicular to the long axis of the radius on the AP projection from the level of the ulnar aspect of the articular surface and the apex of the radial styloid is known as radial height or radial length. The mean radial height in research by Jaremko et al.[21] was shown to be 6.2 ± 5.54 These results were consistent with the findings of our investigation. In the present study, on day 1, the radial height ranged from 4.0 to 13.7, with a mean of 7.88 and a standard deviation (S.D.) of 2.75. By day 8, the radial height had increased slightly, with a range of 3.8 to 17.8, a mean of 8.39, and a S.D. of 3.21. On day 42, the radial height continued to rise, reaching a range of 4.9 to 19.2, a mean of 8.90, and a S.D. of 3.06. The p-value for the change in radial height from Day 1 to Day 42 is 0.001, indicating a statistically significant increase in radial height over the 42 days. The best cut-off to predict surgery was 7.85 with 85.7% sensitivity and 45.3% specificity.

- **Ulnar variance**

The relative lengths of the distal articular surfaces of the radius and ulna are referred to as ulnar variance, also known as Hulten variance. This measurement is mostly made using plain radiography. When the ulnar variance is positive, the ulna is longer than the radius, and when it is negative, the ulna is shorter. The mean ulnar variance in research by Jaremko et al. [21] was 2.8 ± 3.0.54 In the current research, the p-value for the alteration in ulnar variance over 42 days was determined to be 0.005, suggesting a statistically significant modification in ulnar variance over time. On day 1, ulnar variance ranged from 0.0 to 5.9, with a mean of 1.79 and a standard deviation (S.D.) of 1.21. On day 8, the ulnar variance showed a slight decrease, with values ranging from 0.0 to 4.9, a mean of 1.74, and an S.D. of 1.15. However, by Day 42, the ulnar variance increased, ranging from 0.0 to 4.5, with a mean of 2.03 and an S.D. of 1.08. The p-value for the change in ulnar variance over the 42 days is 0.005, indicating a statistically significant change in ulnar variance over time. Day 8 Vs Day 42 showed a statistically significant increase in ulnar variance. The best cut-off to predict surgery was 2.25 with 71.4% sensitivity and 54.7% specificity. Hoag describes three individuals who had post-traumatic radius shortening in his case report. To lessen compression on the ulnar carpus, he outlined the preferred course of therapy for these individuals as distal ulna resection [23].

- **Volar tilt**

The lateral radiograph of the wrist is used to evaluate the volar tilt, which is defined as the angle created by a line drawn across the points of the dorsal also volar rims (i.e., along the radius articular surface) and perpendicular to the radial shaft's axis. The volar tilt is measured by the angle that forms. The volar tilt in research by Jaremko et al. was -3.4 ± 13.6.

On the contrary, in the present study, on day 1, the volar tilt ranged from 2 to 21, with a mean of 12.03 and a standard deviation (S.D.) of 4.81. By day 8, the volar tilt increased slightly, with a range of 4 to 20.74, a mean of 12.74, and an S.D. of 4.32. On day 42, the volar tilt measurements showed a similar range of 0.8 to 19.43, with a mean of 12.79 and an S.D. of 4.64. The p-value for the change in volar tilt from Day 1 to Day 42 is 0.031, indicating a statistically significant change in volar tilt over the 42 days. The best cut-off to predict surgery was 13.5 with 71.4% sensitivity and 52.8% specificity.

- **Cast Index**

The most significant indicator of malunion is the displacement of the fracture's location inside the plaster cast [24]. The greatest chance of open reduction or further manipulation is present in fully displaced fractures; a translation of the radius that is more than half the bone's width was linked to a 60% failure rate [25]. Redisplacement is a possibility for angulated fractures with comparatively little displacement. Inadequate cast molding may result in insufficient three-point fixation during anatomical reduction, which is one cause of re-angulation in these fractures. The three most important components of a well-applied plaster are sufficient three-point attachment, thin, homogeneous cushioning, and excellent molding. According to Chess et al., focusing on cast fit as determined by CI decreased the likelihood of re-manipulation [26]. Because the index mirrored the forearm cast's molding, it was predictive of the maintenance of fracture reduction. The mean CI in this research was 0.847 ±.087. The findings of this investigation were consistent with a previous study conducted by Debnath et al, which demonstrated that the average cast index(CI) in their study was 0.79±0.07. This study focused on individuals who had a loss of reduction and needed re-manipulation. Conversely, Gonzalez et al. observed an acceptable (r = 0.96) correlation between the cast index and the anatomic measures of the forearm [8].

Treatment Closed reduction and casting will often promote good healing in adults with dorsally angulated solitary radial fractures and closed extra-articular Colles' fractures. These fractures must have no more than 5 mm of shortening, 5 degrees of radial inclination change, 2 mm of articular step-off, and 5 degrees of angulation to be suitable for closed reduction as primary therapy. Splinting in a sugar tong splint is an option for successfully closed reductions until official short or long-arm casting can be carried out [27]. Surgery will most likely be necessary for a fracture that cannot be corrected with a closed reduction to the aforementioned limitations. In the current research, seven individuals (11.7%) had surgery, whereas the majority of the 53 patients (88.3%) were handled conservatively and did not have surgery. The Cast Index's area under the curve is 0.662, and its p-value of 0.167 indicates that it was not statistically significant. With 71.4% sensitivity and 71.7% specificity, 0.81 was the optimum cut-off point to predict surgery.

Limitations

- Limited sample size.
- There is a possibility of inter observer variation. It would have been better if measurements were done by more than 1 person and then an average was taken.

Conclusion

This was a prospective, observational study conducted at Justice K.S Hegde Hospital, K.S Hegde Medical Academy, NITTE (Deemed to be University), Mangalore, India from 01-09-2022 to 30-04-2024 to evaluate the role of cast index as a predictor of loss of reduction in Colles fractures in adults managed with plaster cast. Total number of 60 participants with dorsally displaced, metaphyseal, extra-articular distal radius fracture were included in the study after satisfying inclusion and exclusion criteria. The check x-rays (PA and lateral views) which were usually taken as part of treatment on Day 1, Day 8 and Day 42 were used to study the following parameters, namely cast index, palmar tilt, radial height, and ulnar variance. The observed values were studied to check if the cast index is a useful predictor for loss of reduction in colles fracture. The mean CI was 0.847 ± .087. The best cut-off of CI to predict loss of reduction would be 0.81 with 71.4% sensitivity and 71.7% specificity. A statistically significant increase in the palmar tilt, radial height and ulnar variance over the 42 days period post reduction was observed.

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