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Correlation Between Radial Height, Radial Inclination, Volar Tilt, and Radius Union Score System (RUSS) on Modified Mayo Wrist Score (MMWS) In Patients with Distal Radius Fractures Three Months Post Conservative Therapy

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ABSTRACT

Introduction: Distal radius fractures are one of the most common injuries in orthopedics and conservative management is still the most frequently used treatment. Conservative treatment with closed reduction may still leave deformity that can be evaluated from several radiological parameters. However, of the many existing radiological parameters, there is no parameter that has become a standard for assessing good function. This study aims to determine the relationship between radiological parameters (radial inclination, radial height, and volar tilt) and the Radius Union Score System (RUSS) on the functional outcomes of patients with distal radius fractures at 3 months after conservative therapy.

Methods: Thirty-five patients with distal radius fractures with age range of 18-65 years at Prof. Ngoerah General Hospital Denpasar who were managed conservatively with closed reduction and short/long arm cast immobilization were evaluated 3 months after therapy. Functional outcomes were evaluated using the Modified Mayo Wrist Score (MMWS) and evaluation of radiological parameters including radial height, radial inclination, volar tilt, and RUSS. The data analysis used was the Pearson and Spearman correlation test to assess the relationship between radiological parameters and RUSS with functional outcomes and the linear regression test to assess the parameters that had the strongest relationship with a significance value of $p < 0.05$.

Results: There is moderately significant positive correlation between radial height and volar tilt on MMWS with r values respectively 0.504 and 0.401 ($p = 0.020$, 0.017); a weak positive correlation between radial inclination and MMWS ($r = 0.365$, $p = 0.031$). Moderate positive correlation was also found between RUSS and MMWS ($r = 0.544$, $p = 0.001$). With the linear regression test, it was found that the influence of the three radiological parameters was 37.3% on MMWS ($R2 = 0.373$). The linear regression F test shows that the three radiological parameters have a significant effect with a value of $p = 0.002$ ($p < 0.005$). However, in the t test it was found that radial inclination was not significant to MMWS ($p = 0.350$)

while radial height and volar tilt were significant to MMWS (p = 0.049, 0.015).
Conclusion: Radial height, radial inclination, volar tilt, and RUSS have a positive correlation with the functional outcome of distal radius fracture cases. Radial height and volar tilt are the radiological parameters that have the most influence in patients with distal radius fractures in observation 3 months after conservative therapy.

Keywords: distal radius fracture, conservative therapy, radial height, radial inclination, volar tilt, RUSS, MMWS

INTRODUCTION

Distal radius fractures are one of the most common and frequent injuries in children and adolescents especially those who exercise or from traffic accidents, as well as in the elderly in osteopenia and osteoporosis populations who experience trivial trauma. conservative treatment can still leave deformity if fracture reduction is not achieved. Deformities that occur can be evaluated from several radiological parameters, but of the many radiological parameters that exist, there is no standard parameter to assess good function.

Radiological parameters that are often measured in the case of distal radius fractures include *radial inclination*, *radial height*, and *volar tilt.* These three parameters can be used to see the functional output direction of the distal radius fracture management. If these three parameters are managed properly, the resulting functional output will also be good.[2] However, in some previous studies there are also those who say that this radiological parameter continues to evolve and is not clinically significant. (Gutiérrez-Monclus et al, 2018).

One of the examination modalities to assess the functional output of the wrist joint is the *Modified Mayo Wrist Score* (MMWS), which consists of subjective and objective examinations. Evaluation of pain, joint range of motion, grip strength and ability to return to work or activity are assessed in *MMWS*. Total scores range from 0 to 100 points with higher scores indicating better results (Dacombe et al, 2016).

The initial process of healing distal radius fracture cases radiologically is usually reached at week 6 and in the majority of patients, the function and range of motion of the wrist joint can return within 3 months.[5]

To assess the healing of radius bones radiologically, *the Radius Union Scoring System* (RUSS) can be used, which is a scoring system used to measure the degree of bone union or healing in cases of distal radius fractures (Patel et al, 2022).

This study aims to evaluate the relationship of these radiological parameters to the functional outcomes of patients with conservatively managed distal radius fractures.

METHODS

Study Design

This study is a cross-sectional study which consists of patients with distal radius fractures who underwent conservative treatment over a period of three months. The evaluation, performed at RSUP Prof. Dr. I G N G Ngoerah Denpasar from November 2023 to January 2024, focused on both radiological and clinical parameters of the wrist. Radiological assessments included radial height, radial inclination, and volar tilt, while the Radius Union Scoring System (RUSS) was utilized to gauge the degree of radiological healing and union. Additionally, clinical evaluation incorporated the Modified Mayo Wrist Score (MMWS).

Data Collection

The study population comprised all patients with distal radius fractures who received conservative therapy for three months and visited RSUP Prof. Dr. I G N G Ngoerah Denpasar during 2023. Sampling was conducted using consecutive sampling until the desired sample size was achieved. Based on the calculations and allowing for a 10% dropout possibility, the minimum required sample size was determined to be 35 patients. Eligibility criteria included Indonesian residency, age between 18-65 years, a history of distal radius fracture managed conservatively, and willingness to participate in follow-up examinations after three months.

The research procedure involved data collection from visit registers at the Orthopaedic Outpatient Clinic and Medical Record Installation of RSUP Prof. dr I G N G Ngoerah Denpasar. Subjects were identified based on inclusion and exclusion criteria, followed by contact through phone or chat applications to explain the research procedures and obtain consent for participations.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS 22 software, including descriptive analysis, normality tests (Sapiro-Wilk), Pearson and Spearman correlation tests to determine the relationship between radiological parameters, RUSS, and MMWS. Linear regression was applied to determine radiological parameters that have the strongest relationship with MMWS

RESULTS

A. Research Subject Characteristics

The study included 35 patients with distal radius fractures who visited the Orthopaedic and Traumatology Clinic of RSUP Prof. Dr. Ngoerah between November 2023 and January 2024. Table 1 outlines the demographic characteristics of the patients. The average age of the sample was 45.17 ± 20.12 years, with male patients (51%) predominating.

Table 1. Patients' Characteristics

Variable	Group	Proportion	Mean
Age (years)	18 – 30	12 (34%)	45.17±20.12
	30 – 45	5 (14%)	
	45 – 65	18 (52%)	
Gender	Male	18 (51%)	-
	Female	17 (49%)	
Radial height	10 – 12	16 (46%)	9.73±2.62
	< 10	19 (54%)	
	> 12	0 (0%)	
Radial inclination	21^O – 25^O	14 (40%)	20.4±3.8
	< 21^O	19 (54%)	
	> 25^O	2 (6%)	
Volar tilt	11^O – 12^O	4 (12%)	11.27±4.36
	< 11^O	15 (43%)	
	> 12^O	16 (45%)	
RUSS	< 6	1 (2%)	-
	> 6	34 (98%)	
MMWS	90 – 100	14 (40%)	84.71
	80 – 89	11 (31%)	
	65 – 79	10 (29%)	
	< 65	0 (0%)	

B. Inferential Analysis

For the correlation analysis, normality tests using the Sapiro-Wilk test were conducted. Pearson correlation tests were used for normally distributed data, while Spearman tests were used for non-parametric data, with a significance level set at $p < 0.05$. The Pearson correlation test showed a medium-strength positive correlation ($r = 0.504$, $p = 0.02$) between radial height and MMWS, indicating a positive relationship. Similarly, radial inclination showed a weak positive correlation ($r = 0.365$, $p = 0.031$), as did volar tilt ($r = 0.401$, $p = 0.017$), both of which were significant. The Spearman correlation test for RUSS parameters showed a moderate positive correlation ($r = 0.544$, $p = 0.001$) with MMWS, indicating a significant relationship. In the regression analysis, volar tilt had the strongest impact on MMWS ($B = 0.397$, $p = 0.015$), followed by radial height ($B = 0.298$, $p = 0.049$), highlighting their influence on functional outcomes in distal radius fracture patients undergoing conservative treatment.

Table 2. Normality test using Saphiro-Wilk test

Variable	**n**	**p**	
Radial height	35	0.883	Normal Distribution
Radial Inclination	35	0.104	Normal Distribution
Volar Tilt	35	0.969	Normal Distribution
RUSS	35	0.001	Abnormal Distribution
MMWS	35	0.73	Normal Distribution

Table 3. Correlation Test of Radiological Parameters and RUSS on MMWS

Parameter		MMWS	
	Test	R	p value
Radial Height	Pearson	.504	0.020
Radial Inclination	Pearson	.365	0.031
Volar Tilt	Pearson	.401	0.017
RUSS	Spearman	.544	0.001

Table 4. Simultaneous Test (F Test) Linear Regression of Radiological Parameters with MMWS

Model	**df**	**F**	**p value**
Regression	3	6.157	0.002
Residual	31		

Table 5. Partial Test (t Test) Linear Regression of Radiological Parameters with MMWS

Variabel	**B(Coefficient)**	***Std Error***	**t-value**	**p value**
Radial Height	0.298	0.344	2.028	0.049
Radial Inclination	0.148	0.438	0.948	0.350
Volar Tilt	0.397	1.516	2.579	0.015

DISCUSSION

The study's participants had a median age of 45.17+20.12 years, with the largest age group being 45 – 65 years old. This aligns with prior research by Candela et al., indicating that distal radius fractures are common in adults aged 45 – 65 years, alongside pediatric and postmenopausal female populations. Candela's study in Italy from 2017 to 2021 found an average age of 40.62 years for distal radius fracture patients visiting level 1 trauma hospitals. Other studies emphasize the prevalence of these fractures, accounting for 17.5% of all

fractures, influenced by factors like lifestyle, environment, obesity, osteoporosis, and aging.[7] Regarding gender distribution, this study slightly favored men over women (51% : 49%), consistent with Patel et al.'s findings that distal radius fractures are similar in incidence between genders under 50 years old. Chao et al.'s study in Malaysia noted age-specific incidence rates, with men peaking in the 20-29 age group and women in the 60-69 age group.[6,8]

Analyzing radiological parameters of radial height, a positive correlation (R = 0.504) was found with Modified Mayo Wrist Score (MMWS), indicating improved wrist function with increased radial height. This echoes prior research by Cai et al. and Cheng et al., emphasizing radial height's importance in assessing outcomes and surgical interventions.[9,10] Loss of radial height is associated with a positive ulnar variance which causes the load on the ulnar column to increase and creates a risk for the TFCC tears and DRUJ instability. Loss of radial height is also said to be one of the causes of loss of grip strength.[10,11]

Radial Inclination showed a weak positive correlation (R = 0.365) with MMWS, aligning with studies by Patel et al. and Ali et al. that link good radial inclination with favorable functional outcomes.[6] However, Kong et al. found no significant correlation between radial inclination and functional outcomes.[12] Biomechanically, decrease in radial inclination increases the load on the scaphoid bone resulting in the risk of radioscaphoid arthritis. Apart from that, radial inclination also plays a role in the range of motion of the distal radioulnar joint where a decrease in radial inclination is associated with a decrease in the range of motion of the distal radioulnar joint. A decrease in radial inclination of 10 degrees will cause dorsal translation of the radius when the forearm is in pronation, while a decrease of 20 degrees causes volar translation of the radius in pronation.[11]

Volar Tilt exhibited a moderate positive correlation (R = 0.401) with MMWS, supported by research by Kamal et al. and Dario et al., highlighting volar tilt's impact on functional recovery post-fracture.[13,14] Nevertheless, conflicting results by Plant et al. suggest minimal correlation due to functional movement preservation.[15] Reduced volar tilt will cause increased load on the carpal bones, compensatory instability in the dorsal intercalated segment (DISI), accelerated osteoarthritis, and rotational deformities that can result in impaired pronation and supination function.[11]

The Radius Union Scoring System (RUSS) showed a moderate positive correlation (R = 0.544) with MMWS, indicating bone union's role in functional recovery. This is consistent with the understanding of hand and wrist biomechanics, where bone structure integrity is crucial for optimal function.[16]

Linear regression analysis revealed that volar tilt had the most significant impact on MMWS, followed by radial height, while radial inclination showed no significant effect. Similar findings were reported by Cai et al. and Kamal et al., emphasizing the importance of volar tilt and radial height in predicting functional outcomes.[9,13] However, Monclus et al.'s study on older patients contradicted these findings, suggesting that good radiological alignment may not always correlate with functional outcomes, highlighting the complexity of fracture management and recovery.[3] Limitations of this study include a small sample size, wide age range, short research duration, and limited examination of all distal radius anatomical parameters, suggesting the need

for further comprehensive investigations in this area

CONCLUSION

Our study identified significant associations between key radiological parameters and functional outcomes, as assessed by MMWS, in distal radius fracture patients undergoing conservative therapy within a 3-month observation period. Radial height, radial inclination, volar tilt, and RUSS demonstrated moderate to weak but meaningful correlations with MMWS, indicating their roles in predicting and influencing wrist function post-fracture. Particularly, radial height and volar tilt emerged as the most influential parameters affecting MMWS functional outcomes. These findings emphasize the importance of considering these radiological factors in clinical decision-making and rehabilitation strategies for optimizing outcomes in patients with distal radius fractures.

Declaration by Authors

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