ORIGINAL ARTICLE

Can the screw number in volar locking plate fixation for distal radius fractures predict the Patient-Rated Wrist Evaluation outcome?

¿Puede el número de tornillos en la fijación con placa de bloqueo volar para fracturas de radio distal predecir el resultado de la Evaluación de la Muñeca Calificada por el Paciente?

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Abstract

Objective: *The optimum number of screws in a volar locking plate (VLP) for distal radial fractures (DRF) fixation has not been established. We conducted a retrospective observational study aimed to evaluate the relationship between the number of used screws and the post-operative results provided by the patient-rated wrist evaluation (PRWE) questionnaire.* **Method:** *A total number of 62 surgically treated participants for DRF were included in the study between July 2019 and September 2022. Information was gathered regarding the number and arrangement of screws by examining X-ray images and using health records. We were looking at five variables: the total number of screws, the number of proximal fragment screws, the number of distal fragment screws, the number of locking screws, and finally number of cortical screws.* **Results:** *Our data suggests that the number of screws in VLP for DRF fixation is a weak predictor of post-operative results and is therefore unlikely to influence the PRWE score.* **Conclusions:** *The ability to predict outcome by knowing the number of screws turned out to be an unreliable prognostic sign.*

Keywords: *Distal radius fracture. Patient-rated wrist evaluation. Screw number. Volar locking plate.*

Resumen

Objetivo: *El número óptimo de tornillos en la placa volar de bloqueo para la fijación de fracturas distales del radio no ha sido establecido. Realizamos un estudio observacional retrospectivo con el objetivo de evaluar la relación entre el número de tornillos utilizados y los resultados posoperatorios proporcionados por el cuestionario de Evaluación de la Muñeca Calificada por el Paciente (PRWE, Patient-Rated Wrist Evaluation).* **Método:** *Se incluyeron en el estudio 62 participantes tratados quirúrgicamente por fractura distal del radio entre julio de 2019 y septiembre de 2022. Se recopiló información sobre el número y la disposición de los tornillos mediante la revisión de imágenes de rayos X y el uso de registros médicos. Se analizaron cinco variables: número total de tornillos, número de tornillos en el fragmento proximal, número de tornillos en el fragmento distal, número de tornillos de bloqueo y número de tornillos corticales.* **Resultados:** *Nuestros datos sugieren que el número de tornillos en la placa volar de bloqueo para la fijación de fracturas distales del radio es un predictor débil de los resultados postoperatorios, y por lo tanto es poco probable que influya en la puntuación de la PRWE.* **Conclusiones:** *La capacidad de predecir el resultado mediante el conocimiento del número de tornillos resultó ser un signo pronóstico poco fiable.*

Palabras clave: *Fractura del radio distal. Evaluación de la Muñeca Calificada por el Paciente. Número de tornillos. Placa volar con bloqueo.*

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Introduction

Open reduction and internal fixation of distal radial fractures (DRF) with a volar locking plate (VLP) has become a standard surgical method[1]. This procedure enables early post-operative wrist movement and has shown good functional outcomes[2]. Unstable and multifragmentary DRF require anatomical reconstruction and stable fixation to allow for optimal functional outcome[3]. These multifragmentary fractures require a greater number of screws when using VLP to accomplish a stable fixation. Although additional screws can be used to ensure firm fixation, the use of extra screws can be associated with an increased risk of complications such as joint and tendon irritation[4]. Therefore, it is well known that unstable and multifragmentary fractures have a significantly worse post-operative result[5].

Many studies concerning the distal radius VLP have been published. Typically, they compare different VLP designs or positions of screws[6-8]. We identified also numerous studies investigating the success of the VLP surgical procedure using the patient-rated wrist evaluation (PRWE) questionnaire[9-13], but no studies concerning the number of used screws. Therefore, there is an objective need to evaluate this relationship between the number of used screws and the post-operative results provided by the PRWE questionnaire. We are guided by the opinion that more screws are needed in unstable and multifragmentary fractures and will therefore show worse PRWE results.

Methods

Study design

We included participants who were surgically treated during the period between July 2019 and September 2022 (i.e., 38-month period) in the University Hospital in Novi Sad, Serbia.

The applied inclusion criteria were: (i) ≥ 18 years of age; (ii) surgical treatment of DRF using a VLP; and (iii) follow-up at least 6 months after the procedure. Patients were excluded if they had a (i) pre-existing neurologic hand injury; (ii) compartment syndrome; (iii) dementia; (iv) psychiatric disorders, and/or (v) multiple upper limb injuries (except distal ulna fractures).

Surgical procedure

The surgical procedure was performed by three different surgeons using a VLP (Aptus, Medartis, Switzerland) through a *flexor carpi radialis* approach and under image intensification (BV Endura, Philips, The Netherlands). During the procedure, a tourniquet was used. Postoperatively, the wrist was bandaged for 2 weeks, and active finger flexion and extension exercises were encouraged. Two-week post-operative dressings and sutures were removed. No strengthening work, heavy pushing, pulling, or lifting was allowed for 8 weeks post-operative. Physiotherapy was commenced, with an aim to achieve full range of movement at the wrist and hand.

Parameters of interest

Extracted data from the patient health record include sex, age, and date of the injury. All four researchers were gathering information regarding the number and arrangement of screws by examining X-ray images and using health records. Five variables of interest were as follows: (i) the total number of screws; (ii) number of proximal fragment screws; (iii) number of distal fragment screws; (iv) number of locking screws and finally; and (v) number of cortical screws. As the number of samples, using the structural modeling observation should be at least 10-15 times the number of variables, the sample size should be 50-75 people. Finally, the sample size of our follow-up survey was determined to be 62 patients (n = 62).

In addition, wrist function was assessed using the validated PRWE questionnaire[14]. The PRWE questionnaire is a 15-item patient-reported measure of pain and function, specific to the wrist. It scores between 0 and 100, with higher scores indicating poorer outcomes. All four researchers independently conducted the interview. Given the broad catchment area of our institution, patients were contacted by telephone. For this sake, the informed consent was waived.

Data analysis

The first stage of data analysis implied examination of the average number for each screw type or position (variables of interest) used during the VLP procedure and comparison with the PRWE scores. For the screw type or position where a statistically significant difference in the PRWE score was found, new groups were

formed to examine a possible link between number of specific screws used and the PRWE scores. More precisely, screw-specific groups were stratified according to the amount of screws used (i.e., [i] less than average; [ii] average, and [iii] above the average) and finally compared for variations in the PRWE scores. Finally, the link between the total number of screws used and the PRWE score was accessed in the same fashion.

The statistical analysis was performed using R-project software (Bell Laboratories, United States, version 4.2.2.). We used the Kruskal–Wallis test for the comparison of all variables (number of screws) and the Dunn *post hoc* test where we got significance. A $p < 0.05$ was considered statistically significant.

Results

Demographic characteristics of enrolled patients

One hundred nine patients (n = 109) were included in the study over a 38-month period. After the initial number was identified, 47 patients were excluded due to death, or dementia or were lost to follow-up due to a change of residence. This left a total number of 62 patients for evaluation (62/109; 56.88%), including 24 males and 38 females. The mean age of all enrolled patients was 50.58 years (95% CI 46.79-54.36). More specifically, women were on average 9 years older than men (54 years; 95% CI 49.40-58.96 vs. 45 years; 95% CI 38.97-50.77). The average duration of follow-up in all enrolled patients (calculated from the day of injury) was 22 months (95% CI 19.14-24.59).

As far as continuing employment, the majority of patients (55/62; 88.7%) continued their previous occupation, while others were either not able to continue their previous occupation (3/62; 4.8%) or they got retired but were capable of recreational activity (4/62; 6.4%).

Frequency of specific screw-type usage during VLP and link with the PRWE score

The average number of screws used during the VLP procedure was 6.67 (95% CI 6.38-6.97). Among them, locking and distal fragment screws were used the most (on average 3.83 and 3.75/VLP procedure, respectively), while proximal and cortical screws were used in slightly less number (2.93 and 2.83/VLP procedure, respectively).

Table 1. Kruskal Wallis tests show a significant difference between the number of distal screws

Variable	χ^2	df	p-value
Number of distal fragment screws	7.474	2	0.024(*)
Number of proximal fragment screws	1.590	2	0.451(ns)
Number of cortical screws	3.799	2	0.150(ns)
Number of locking screws	4.576	2	0.101(ns)

*statistically significant (i.e., $p < 0.05$); ns: not significant.

Table 2. Dunn test for number of distal fragment screws shows significant difference in the PRWE score

Number of screws used comparison	Difference	p-value
Less than average (< 4) versus average (4)	2.667	0.003(*)
Less than average (< 4) versus more than average (> 4)	1.481	0.069(ns)
Average (4) versus more than average (> 4)	–0.621	0.267(ns)

*statistically significant (i.e., $p < 0.05$); ns: not significant.

The mean total score for the PRWE was 18.42, (95% CI 13.67-23.17). Only four patients (4/62; 6.4%) had a PRWE score over 50, while majority (30/62; 48.3%) had PRWE scores < 15. As the PRWE score is not normally distributed (Kolmogorov-Smirnov, D = 0.691, $p < 0.001$) non-parametric tests were used for further comparisons (i.e., Kruskal-Wallis tests with the PRWE score being the dependent variable). We found a significant difference in the PRWE score between patients with the distal number of screws compared to other used screws (Table 1). Dunn *post hoc* test was conducted for both variables to see between which groups the difference exists. In addition, we found a significant difference in the PRWE score between the patients who had an average number of screws inserted (i.e., four screws) compared to the group where less than average number of screws was used (Table 2). The group with less than 4four screws has statistically significantly higher scores than the group with four screws.

Finally, when we examined patients according to the total number of screws received we found a significant difference in the PRWE score between patients who had average screws (7) compared to those less than average (< 7) and more than average (> 7 screws) (Table 3). In both cases, the group with seven screws has a statistically significantly lower PRWE score compared to the two other groups.

Table 3. Dunn test for total number of screws shows significant difference in the PRWE score

Number of screws used comparison	Difference	p-value
Less than average (< 7) and Average (7)	3.225	< 0.001(**)
Less than average (< 7) and more than average (> 7)	1.025	0.152(ns)
Average (7) and more than average (> 7)	−1.671	0.047(**)

**statistically highly significant (i.e., p < 0.001); ns: not significant.

Linear regression was used to predict the PRWE score. The model was created with all the before-stated variables as predictors. The following results were obtained: $R^2 = 0.168$, $F(7, 544) = 1.554$, $p = 0.169$. The overall model is not significant so no further interpretation is needed. Variables used in this study (i.e., screw type and screw number used) cannot successfully predict the PRWE score.

Discussion

Our data suggests that the number of screws in the VLP surgical procedure for the treatment of DRF is a weak predictor of post-operative results and is therefore unlikely to influence the PRWE score. While we were able to demonstrate significance between two distal fragment screw groups as well as significance among the three groups in the total number of screws, the meaning of that significance is lost in the entire context of the work.

The total number of screws used during the procedure ranged 4-12 screws. Using fewer screws is generally considered sufficient, with no need to fill all the plate holes, there is no consensus about how many screws and which screws should be chosen[8].

VLP fixation of DRF is mostly performed using between four and nine distal locking screws[7], thus there is no general position or optimal screw number that should be used. Our number of 3.75 screws was below this range. Synek et al. stated that configurations with just three distal screws can outperform (higher stiffness or lower peri-implant strains) those with five screws depending on the screw selection[8]. On the contrary, Mehling et al. stated that three screws in the distal part created an unstable condition and there should be at least four screws, two of these screws should be in a different direction[6]. Additional screws can be used to ensure firm fixation, using extra screws we can anticipate higher costs and increased risk of tendon irritation complications[4].

Similarly, three bicortical screws are commonly used for the proximal fragment, but the question of how many screws are necessary has also not been answered sufficiently[7,15]. Our number of 2.93 screws is slightly below this range. Schindelar et al.[15] used a number of 3.2 proximal fragment screws in both of their groups and they had no statistical differences in fixation failure. One reason for using a lower number of screws, in our study, could be the fact that we tend to put an external fixator in extremely multifragmentary distal radius fractures, other than reconstruct with a VLP and a high number of screws. Second, the "paid per screw" compensation for the surgeon is not custom in our health-care system.

The PRWE questionnaire is commonly used and extensively validated in literature[16]. Moreover, evidence supports the use of the PRWE questionnaire after a 6-month period of the distal radius fixation[17] as it is the case in our study (22 months).

Our mean PRWE score of 18.42 is lower than the score of Duprat et al. whose results were 22.97 and 20.56 in their splinting and non-splinting groups, consecutively. Although, they conducted the PRWE questionnaire early at 3 and 6 months postoperatively[10]. In a randomized controlled trial with a 3-year follow-up by Südow et al., the mean PRWE result of 7 is significantly better[18]. Similarly, Dennison et al. documented a PRWE score of 5.4 and 5.1 in their two groups of early and late rehabilitation protocol[19]. Worth mentioning is the existence of bias in their case, where they excluded patients with diabetes, metabolic diseases, and if they had a concomitant ulnar side fracture. Therefore, the lower PRWE score in our study can be explained by our mild exclusion criteria and the fact of short experience in using VLP for distal radius fractures by < 4 years.

As the VLP procedure enables early mobilization and good fracture healing outcomes[2], likewise is the return to work. Patel et al. documented that 28 patients (93.3% out of 30) returned to their pre-injury employment[20]. Watson et al. conducted a study with 133 participants and noted a 90% return to work at the 26th week[21]. In accordance with our higher PRWE score, our return to work incidence was lower (88.7%).

There are several limitations of this study. Foremost is our ability to contact only 56.8% of the patients, which results mostly from the large geographic area served by our institution. One important limitation was that the study was retrospective, which may limit data quality. Worth mentioning is also the short monitoring period of 6 months in some cases, although our mean follow-up was 21.87 months.

Although our sample size was adequate to allow comparison between groups on the independent variables in regards to the PRWE score, the medians of the groups are distributed closely together, so it is likely that we would not find any significance with a larger sample. Finally, our study did not take into account the location of the distal fracture screw relative to the proximal or distal row nor the type of screw, i.e., cortical or locking.

Conclusion

As medicine and lifestyle improve, we can expect a greater number of VLP procedures for DRF. Patient demand for surgical treatment that will provide adequate wrist function will increase. The ability to predict outcome by knowing the number of screws turned out to be an unreliable prognostic sign. Counseling patients and selecting appropriate post-operative rehabilitation plans should be rather focused on the anatomical restoration of fragments.

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Conflicts of interest

The authors declare no conflicts of interest.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article. Furthermore, they have acknowledged and followed the recommendations as per the SAGER guidelines depending on the type and nature of the study.

Right to privacy and informed consent. The authors have obtained approval from the Ethics Committee for analysis and publication of routinely acquired clinical data and informed consent was not required for this retrospective observational study.

Use of artificial intelligence for generating text. The authors declare that they have not used any type of generative artificial intelligence for the writing of this manuscript nor for the creation of images, graphics, tables, or their corresponding captions.

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