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Results of distal radius fractures treatment depending on the used internal stabilization

Wyniki leczenia złamań końca dalszego kości promieniowej w zależności od zastosowanej stabilizacji wewnętrznej

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Summary

Introduction. The purpose of this study was to evaluate the results of patients' surgical treatment with a fracture of the distal radius depending on type of internal stabilization used - locking and non-locking volar plating.

Material and methods. The retrospective study the group of 46 patients (mean age 54 ± 37 years): 12 men and 34 women treated because of fractures of the distal radius was included. Because of the age and the injury nature, patients were divided into two groups: those under 50 years of age, in which the cause of fractures was high-energy trauma, or those over 50 years of age, who have occurred fracture due to a fall at the same level. Physical examination was performed, during which the range of motion and limb strength has been assessed. Moreover functional assessment using the MAYO (*Mayo Wrist Scoring System*) scale and DASH (*Disabilities of the Arm, Shoulder and Hand*) questionnaire was performed.

Results. In the group of people under 50 years old treated with non-locking volar plates both abduction and adduction as the radially-metacarpal joint achieved a significantly higher mean value ($p < 0.05$) compared with the test results in patients with locking volar plates. Similar results were obtained in patients above 50 years old of age treated with the same operations method. In this age group also demonstrated better results analyzing MAYO scale ($p < 0.05$).

Conclusion. Internal stabilization of distal radius fractures allows to obtain good results in the research and clinical functional limb. The better clinical results obtained after application of non-locking volar plates.

Key words: distal radius fractures, operative treatment outcomes, volar locking plates; volar non-locking plates

Streszczenie

Wstęp. Celem pracy była ocena wyników operacyjnego leczenia pacjentów ze złamaniem końca dalszego kości promieniowej w zależności od zastosowanego typu stabilizacji wewnętrznej - płytek dłoniowych nieblokowanych lub blokowanych.

Material i metody. Retrospektywnym badaniem objęto grupę 46 chorych (średnia wieku 54 ± 37 lat): 12 mężczyzn i 34 kobiety leczonych z powodu złamania dalszego końca kości promieniowej. Ze względu na wiek oraz charakter urazu badanych podzielono na dwie grupy: osoby poniżej 50 roku życia, u których przyczyną złamania był uraz wysokoenergetyczny oraz osoby powyżej 50 roku życia, u których złamanie wystąpiło w wyniku upadku na tym samym poziomie. Wykonane zostało badanie przedmiotowe pacjentów, podczas którego ocenione zostały: zakres ruchomości stawów kończyny górnej, linijne obwody stawów oraz siła chwytu operowanej kończyny. Dokonano ponadto oceny funkcjonalnej przy pomocy skali MAYO (ang. *Mayo Wrist Scoring System*) i kwestionariusza DASH (ang. *Disabilities of the Arm, Shoulder and Hand*).

Wyniki. W grupie osób poniżej 50 roku życia leczonych za pomocą płytek nieblokowanych zarówno odwodzenie jak i przywodzenie w stawie promieniowo-nadgarstkowym osiągnęło istotnie wyższą średnią wartość ($p < 0,05$) w porównaniu z wynikami pomiarów u osób z płytkami blokowanymi. Podobne wyniki otrzymano u pacjentów powyżej 50 roku życia leczonych tą samą metodą operacyjną. W tej grupie wiekowej wykazano ponadto lepsze wyniki analizując skalę MAYO ($p < 0,05$).

Wnioski. Stabilizacja wewnętrzna złamań dalszej nasady kości promieniowej pozwala na uzyskanie dobrych wyników w badaniu funkcjonalnym i klinicznym operowanej kończyny. Lepsze wyniki kliniczne uzyskuje się po zastosowaniu płytek nieblokowanych.

Słowa kluczowe: złamanie końca dalszego kości promieniowej, wyniki leczenia operacyjnego; płytki dłoniowe nieblokowane, płytki dłoniowe blokowane

INTRODUCTION

Radius fractures are one of the most common orthopedic injuries. Taking into consideration the aging of societies in developing countries, the frequency of those injuries will probably be on the rise [1-3].

Most (about 80%) of the distal radius fractures are unstable. This means that even after the fracture is anatomically set and immobilized, there is a high chance of secondary bone fragment dislocation [1-3]. Among many methods of treatment, using volar locking blades is considered to be the best as it guarantees and optimal orientation and a stable connection of the fragments in the most anatomical orientation possible. It also requires minimal post-surgery immobilization [2, 4]. This method has replaced the use of non-locking volar plates. Medical sources show no unambiguous proof of the superiority of this method when compared to the older one.

Distal radius fractures make up for 17-20% of those treated by outpatient medical care and 75% of all forearm fractures. Taking age into consideration they are related to two main groups of patients: boys between 5 and 14 years old and women between 60 and 69 years of age [5]. Intra-articular fractures which are the result of a high energy injury (sports injuries, transportation injuries, falling from heights) occur in the case of younger people. Extra-articular fractures can be observed in the case of bones with osteoporotic changes, in older patients, and they are caused by low force injuries [6-9].

According to the AO Foundation (originally: *Arbeitsgemeinschaft für Osteosynthesefrage*), a German study group researching bone healing), locking plates and screw systems are superior to traditional screw systems. The disadvantage of the conventional plates/screw systems lies in the fact that they need a precise adjustment of the plate to the surface of the bone. A lack of ideal contact between those two may lead to the dislocation of the bone fragments when the screws are tightened. Locked systems are superior as they do not require a precise adjustment

of the plate to the bone on the whole of the surface. When the screws are tightened they are locked in the plate, at the same time stabilizing the bone fragments without the need for compressing the bone to the plate. Another potential advantage is the fact that they do not interfere with the perfusion of the cortical layer of the bone. An advantage of the locked plates/screws is the low chance of the loosening of the screws in the plates what reduces the risk of inflammation. Locked plates/screws were introduced to guarantee a more stable fastening than the conventional non-locking systems [10].

The purpose of this study was to evaluate the results of the surgical treatment of patients with a fracture of the distal radius depending on type of internal stabilization used - locking and non-locking volar plating.

MATERIAL AND METHODS

The retrospective study group consisted of 46 patients (mean age: 54±37 years): 12 men and 34 women treated between 2007 and 2011 in the Clinic of Orthopaedics and Traumatology of the Ludwik Rydygier Memorial Specialized Hospital in Krakow because of fractures of the distal radius. The inclusion criteria were: a presence of an unstable fracture of the base of the distal radius which was treated surgically with internal stabilization and finishing the treatment minimally a year after the surgery took place. Patients volunteered for the control examination and were informed about the purpose and methods of the study.

The patients were divided into two groups. The first was made up of patients treated between 2007 and 2009 in which the connection was made using a non-locking T type Synthes plate. The second group consisted of patients operated upon between 2009 and 2011 in which the connection was made using and APTUS locking volar plate.

The table below shows the detailed division into sex and stabilization type.

Tab. 1. A division of the patients according to sex and stabilization type

Sex	Plate type				Total	
	Non-locking (Group 1)		Locking (Group 2)			
	number	%	number	%	number	%
Men	7	30.4	5	21.7	12	26
Women	16	6.6	18	78.3	34	74
Total	23	100	23	100	46	100

Tab. 2. Division of patients according to age and internal stabilization used

Age group [years of age]	Plate type			
	Non-locking (Group 1)		Locking (Group 2)	
	number	%	number	%
< 35	3	13	3	13
36 – 50	7	30	7	30
51 – 65	8	35	7	30
> 66	5	22	6	27
Total	23	100	23	100

Due to the age and the type of injury the patients were divided into two groups – patients under the age of 50, whose fracture was caused by a high trauma injury, and patients above the age of 50, whose fracture was caused by a same level fall (slip, trip). A detailed division of patients according to age and internal stabilization is shown in Table 2.

The clinical study consisted of a physical examination, filling out a questionnaire (Table 3), Mayo Wrist Scoring System by Conney [11, 12] and the Disabilities of the Arm, Shoulder and Hand (DASH) scale [12].

The physical examination consisted of the evaluation of: the mobility of the joints of the upper limb, linear measurement of the articular circumference and grip power. The mobility of joints was tested using a medical goniometer and the notation was performed according to the International Standard Orthopedic Measurements (ISOM) – SFTR (Sagittal, Frontal, Transverse, Rotation) [13].

The linear measurement of the articular circumference was performed for both limbs for comparative purposes. A global grip power assessment was performed by means of a hydraulic hand dynamometer. During this test the upper limb was aligned as follows: the shoulder in

an intermediate position adducted to the chest, the elbow bent at 90 degrees, forearm in an intermediate position, wrist dorsiflexed at about 25 degrees and about 15 degree elbow abduction. Grip power was tested twice with a 2-minute break, the better result was noted.

The functional measurement of the wrist joint was performed using the Mayo Wrist Scoring System [11] and it encompassed the evaluation of: pain, the ability to work, mobility range and grip power. In each of the categories it was possible to score 25 points. Depending on the number of points – the higher the grade, the better the state of the wrist. The final result was qualified as very good, good, adequate or bad.

The last part of the examination was the DASH (Disabilities of the Arm, Shoulder and Hand) form [11] related to the disabilities of the upper limbs. The score was counted separately for two parts of the questionnaire: questions regarding the limits and symptoms and the additional “Work” or “Sport/Playing an instrument” module. The questionnaire is made up of 30 questions, the first 20 are related to the functionality of the upper limb in everyday activities and the remaining 10 take into consideration the impact of its disability on everyday ailments and disruptions. Each question is scored by the

Tab. 3. Questionnaire for patients with distal radius fractures (jointly created by the Orthopedics and Traumatology of the Movement Organ Clinic of the Ludwik Rydygier Memorial Specialized Hospital in Krakow, the University School of Physical Education in Cracow and the Institute of Physiotherapy of the Jagiellonian University, Collegium Medicum)

QUESTIONNAIRE	
Patient name:	FESEL number:
Date of exam:	Sex: <input type="checkbox"/> female <input type="checkbox"/> male Age: ... years Weight: kg Height: ... cm
Limb injury: <input type="checkbox"/> right <input type="checkbox"/> left Education: <input type="checkbox"/> primary <input type="checkbox"/> vocational <input type="checkbox"/> high school <input type="checkbox"/> higher vocational <input type="checkbox"/> higher Work status: <input type="checkbox"/> working job <input type="checkbox"/> retired <input type="checkbox"/> unemployed	
1. What was the reason of your fracture?	12. Do you use the substance below?
a) same level fall (slip, trip)	a) coffee, how much?
b) fall from height	b) cigarettes, how much?
c) hit	13. What diagnostic procedures did you undergo after your wrist fracture?
d) sports injury	a) xtg
e) transportation injury	b) CT
f) other	c) blood analysis
2. How much time has elapsed since the injury?	d) densitometry
a) 24 hours	e) other
b) 2-7 days	14. Was the upper limb immobilized in a cast?
c) 7-14 days	a) yes, for how long?
d) over two weeks	b) no
e) conservative treatment	15. Did any of the symptoms/ailments appear after the injury?
3. Does the other upper limb also have a plate inserted? a) yes b) no	a) limitation of mobility, when? for how long?
4. Did you have other fractures of the examined upper limb in the past?	b) feeling disorders, when? for how long?
a) yes, localization of the fracture:	c) numbness of fingers, when? for how long?
b) no	d) change of skin color, when? for how long?
5. Did you have any other fractures in the past?	e) no significant changes
a) yes, localization of the fracture:	16. Did you undergo rehabilitation? a) yes b) no
b) no	Questions 17-20 are for patients who answered “yes” to question 16.
6. Did the fractured damage any of the structures:	17. After how long since the fracture did the rehabilitation take?
a) muscles, which?	a) when the dressing was still on
b) nerves, which?	b) shortly after the dressing was taken off
c) blood vessels, which?	c) a long time after the dressing was taken off
d) other which?	18. What physiotherapeutic procedures did you undergo?
7. Did you have a procedure of removing joining material from your wrist?	a) kinesiotherapy e) cryotherapy
a) yes, when?	b) special methods f) thermotherapy
b) no	c) electro-therapy g) laser therapy
8. What was the reason for this procedure?	d) magnetotherapy h) other
a) irritation of the soft tissues by part of the implant	19. How long did the rehabilitation last?
b) loosening of plate or screws	a) 2-3 weeks
c) pain	b) 3-5 weeks
d) limited mobility of the wrist	c) 5-8 weeks
e) esthetic reasons	d) 8-12 weeks
f) other	20. How do you assess the functions of your hand after the rehabilitation process?
9. Are you	a) the same as before
a) right-handed	b) slightly improved
b) left-handed	c) significantly improved
10. Have you been diagnosed with osteoporosis? a) yes b) no	d) worsened
11. Do you take medication which weakens bone structures?	21. Does the current functional state limit you in everyday activities?
a) yes	a) no
b) no	b) yes, which?
c) not to my knowledge	22. Does the current functional state of your hand allow you to continue your professional work? a) yes b) no
	23. Did you take part in physical activities (sport discipline) which had to be ceased after the fracture?
	a) no
	b) yes, which?

patient on a scale from 1 to 5 where 1 means no ailments and no difficulty in performing everyday activities while 5 means constant ailments and an impossibility to perform activities. For it to be possible to calculate the DASH limitations and symptoms factor the patient had to answer at least 27 out of the 30 questions. The circled numbers and added to each other and the result is divided by the number of answered questions. The resulting average is transformed into a 100-point scale by subtracting 1 and dividing by 25. The higher the factor, the higher the difficulty in performing activities. The two additional modules, “Work” and “Sport/Playing an instrument”, consist of 4 question each. Their goal is to identify specific difficulties which may influence everyday activities and thus may not be detected by the standard part of the questionnaire. The DASH form is aimed at assessing the performance of the whole upper limb [12].

All the data was statistically analyzed with the use of the Mann–Whitney U test. Differences on the level of $p < 0.05$ were accepted as statistically significant.

RESULTS

The results of treatment after distal radius fracture in patients below 50 years of age

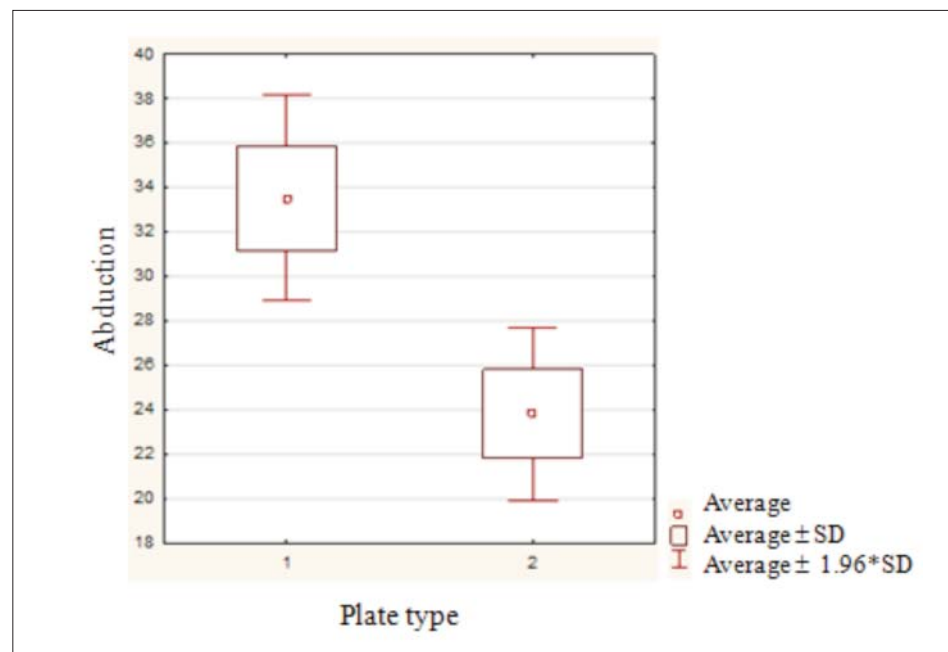
In the case of patients below 50 years of age after a distal radius fracture who were treated surgically a lower range of bending in the radiocarpal joint was found in the case of non-blocking plates (67 degrees) than in the case of locking ones (61,3 degrees). The average range of straightening in the radiocarpal joint was higher in the case of locking plates (49.5 degrees for non-locking, 54.5 for locking) ($p > 0.05$).

The results for the range of abduction in the radiocarpal joint were different – the average range for non-locking plate was higher than in the case of locking plates (Table 4, Fig. 1.) ($p < 0.05$).

The results for the mobility range of adduction in the radiocarpal joint are similar (Table 5) ($p < 0.05$).

The assessment of grip power showed a statistically insignificantly higher average value in the case of non-locking plates (0.49 Nm/kg) than in the case of locking plates (0.38 Nm/kg).

Fig. 1. Mobility range of abduction of the radiocarpal joint depending on the internal stabilization used in patients < 50 years of age ($p < 0.05$) (1-nb, 2-bl)



Tab. 4. Mobility range of abduction of the radiocarpal joint depending on the internal stabilization used in patients < 50 years of age ($p < 0.05$) (1-nb, 2-bl)

Plate type	N of sign	Average	Median	Minimum	Maximum	SD
1	10	27.00	27.50	20.00	35.00	5.87
2	10	20.10	20.00	7.00	32.00	6.06

Tab. 5. Mobility range of adduction of the radiocarpal joint depending on the internal stabilization used in patients < 50 years of age ($p < 0.05$) (1-nb, 2-bl)

Plate type	N of sign	Average	Median	Minimum	Maximum	SD
1	10	33.50	32.50	25.00	50.00	7.47
2	10	23.80	23.50	14.00	31.00	6.30

A global assessment according to the MAYO scale gave a score of 82.5 (good) for non-locking plates and 80 (adequate) for locking plates ($p > 0.05$).

The results of the DASH questionnaire look better for the non-locking plates – the median was 0.83 points, while for locking plates it was 1.67 points ($p > 0.05$).

The results of treatment after distal radius fracture in patients below 50 years of age

In the case of patients above 50 years of age after a fracture of the base of the distal radius who were treated surgically with the use of locking plates as internal stabilization, a higher range of mobility of bending in the wrist joint was achieved when compared to the use of non-locking plates. The average range of bending was 48.8 degrees in the case of non-locking plates and 53.8 in the case of locking plates. A descriptive statistic has been shown. The difference between the mobility ranges did not however allow for a disproval of the study hy-

pothesis as $p > 0.05$. In the case of straightening in the wrist joint the results were different – the average range was 46.1 degrees for non-locking plates and 37.1 for locking plates ($p > 0.05$).

The results for the average abduction in the radiocarpal joint were higher for non-locking plates than for locking plates (Table 6) ($p < 0.05$).

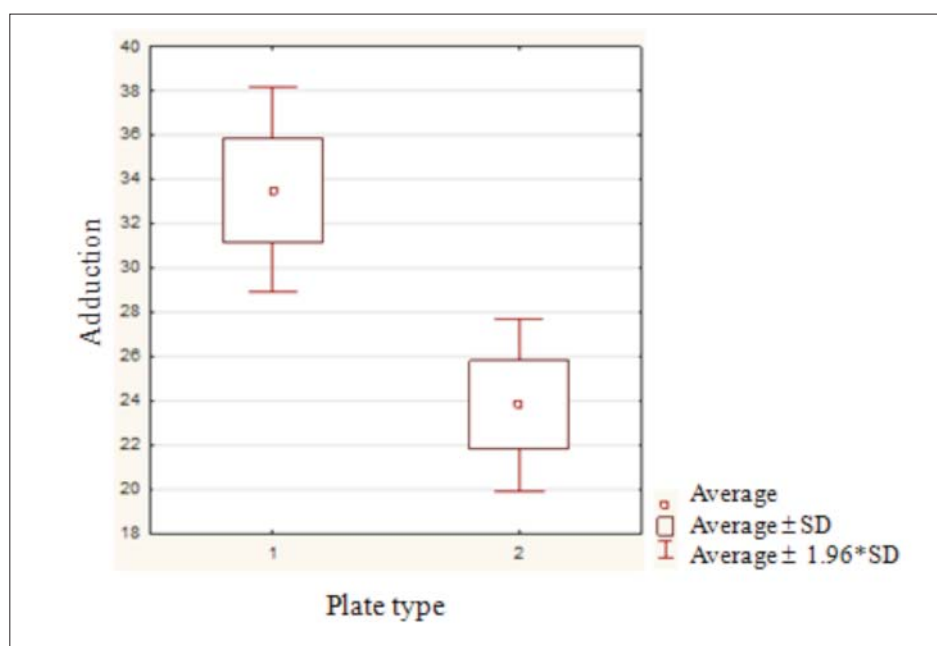
The average mobility range of adduction was higher for non-locking plates than for locking plates. (Table 7, Fig. 2; $p > 0.05$).

Similarly, the average value of grip power was statistically insignificantly higher in the case of non-locking plates ($p < 0.05$).

For the MAYO scale the median result was 85 (good) for non-locking plates and 60 (bad) for locking plates (Table 8) ($p < 0.05$).

More beneficial results in the DASH questionnaire were achieved for non-locking plates: the median was 11.67 points while for locking plates it was 25 points ($p < 0.05$).

Fig. 2. Mobility range of adduction of the radiocarpal joint depending on the internal stabilization used in patients < 50 years of age ($p < 0.05$) (1-nb, 2-bl)



Tab. 6. Mobility range of abduction of the radiocarpal joint depending on the internal stabilization used in patients > 50 years of age ($p < 0.05$) (1-nb, 2-bl)

Plate type	N of sign	Average	Median	Minimum	Maximum	SD
1	13	23.46	25.00	10.00	35.00	9.87
2	13	14.69	15.00	8.00	20.00	4.71

Tab. 7. Mobility range of adduction of the radiocarpal joint depending on the internal stabilization used in patients > 50 years of age ($p < 0.05$) (1-nb, 2-bl)

Plate type	N of sign	Average	Median	Minimum	Maximum	SD
1	13	34.23	35.00	15.00	45.00	9.4
2	13	23.00	25.00	11.00	35.00	8.52

Tab. 8. MAYO scale results depending on the internal stabilization used, patients > 50 years of age ($p < 0.05$) (1-nb, 2-bl)

Plate type	N of sign	Average	Median	Minimum	Maximum	SD
1	13	83.08	85.00	65.00	100.00	11.09
2	13	65.00	6.00	35.00	100.00	21.02

DISCUSSION

Depending on the type of fracture of the base for the distal radius, different methods of treatment are used. In the case of non-dislocated fractures immobilizing the limb in a cast is advised. Dislocated fractures require setting. Percutaneous fixing by means of Kirschner wires, internal stabilization or plates are used for open surgery treatment in order to stabilize the fragments. The choice of the method is dependent on many factors, not only on the type of fracture but also on the accompanying damage to other structures, the degree of osteoporosis, age of the patient, his/her general condition and the preference of the doctor and the medical institution he/she works at [2, 5, 9, 14].

Many studies which show the benefits of treating unstable fractures of the distal radius with locking plates were performed [7, 15, 16]. Thanks to proven, more beneficial biomechanical assumptions, especially in the case of fractures close to the base of the bone and osteoporotic bones, locking plates have replaced the non-locking plates which have been used earlier [17].

Currently fractures of the distal radius are treated mainly by means of volar plates. They replaced the dorsal plates as studies have shown that volar plates have the same stability while they are not linked with complications of the extensor ligaments which often followed the use of dorsal plates [18].

There are also many studies which compare internal stabilization with other methods of treating distal radius fractures. Wickle et al confronted the results of treatment after using non-locking plates with the external stabilization method and they concluded that using internal stabilization means a faster return to physical fitness. However, after one year the differences are not significant [19]. Other studies comparing fracture treatment using internal stabilization with non-surgical setting of fractures and external stabilization also have shown more beneficial yearly results in the case of the surgical method. What is more, less complications connected with incorrect bone adhesion appear [20]. From a mechanical point of view studies have shown that volar plates are the better alternative when compared to Kirschner wires. However, when it comes to economic factors, Kirschner wires have the upper hand [18].

Unfortunately there still is a lack of studies which compare treatment results after using locking and non-locking plates. The results presented in this study differ from the ones that have been performed [17, 21, 22, 23, 24]. Schmelzer-Schmied, Wieloch, Martini and Daecker have compared the results of treating distal radius base fractures using external stabilization and volar locking and non-locking plates in the case of the older patients. The patients underwent surgical treatment of distal radius fractures type C1/C2 according to AO. They were divided into three 15-patient groups. The type of stabilization

used was the division criterion. Observation time was at least 12 months. A functional (range of mobility and grip power were evaluated) and radiological analysis was performed. Further treatment results were evaluated according to the Gartland, Werley and Martini scale as well as the DASH questionnaire. Locking volar plates scored much higher than non-locking ones [23]. Similar results were achieved by Denglu and Yancheng [24]. Non-locking T-plates were compared to locking plates when it comes to dislocated fractures (two or three fragments of the shoulder bone). That was a retrospective study which encompassed 91 patients, 47 of which had T-plates while the remaining 44 had locking plates. This test showed many significant differences between locking and non-locking plates when it comes to two-fragment fractures. However, locking plates had much better results ($p < 0.05$) in the case of three-fragment fractures [24].

Medical sources have no proof of locking plates being more beneficial in treating fractures than non-locking plates. An analysis of the results for both age groups did not show better functional/clinical results in any of the tested elements in the case of locking plates. What is more, the results of the functional test have shown the superiority of non-locking plates. In the group of patients under 50, when the fracture was caused by a high-trauma injury, both the range of abduction as well as adduction of the radiocarpal joint had a higher value ($p < 0.05$) when it comes to non-locking plates. Similarly in the group above 50 years of age in which the fracture was caused by a low-energy injury, better results for the abduction and adduction of the radiocarpal joint ($p < 0.05$) as well as in the MAYO scale ($p < 0.05$) were achieved for non-locking plates when compared to locking plates.

One of the possible reasons for such results may lie in the time differences between the fracture incident (surgery) and the date of the examination of the patients treated using locking/non-locking plates. Theoretically the fracture treatment process should end after a year and the arm should return to full functionality. Studies performed on groups with the same amount of time elapsed since surgery would be more reliable. This criterion is hard to meet during examination as the stabilization of fractures using locking plates is a relatively new method and it has replaced non-locking plates. That is why in the retrospective study it would be extremely hard to find two representative groups with the same amount of time elapsed from when the injury happened.

CONCLUSION

1. Internal stabilization of distal radius fractures allows to obtain good results in the research and clinical functional limb.
2. The better clinical results obtained after application of non-locking volar plates.

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