



# Total wrist Arthrodesis Using a Low-Profile, Variable-Angled Locked Dorsal Plate: Consolidation Rate and Complications of 85 Consecutive Cases

## *Artrodesis Total de La Muñeca Con Placa Dorsal Bloqueada de Bajo Perfil y Ángulo Variable: Tasa de Consolidación y Complicaciones de 85 Casos Consecutivos*

Eduardo Farias Vasquez<sup>1,2</sup> Pedro Henrique Martinez Grosse Siestrup<sup>1</sup>  
Giovanni Vilardo Cerqueira Guedes<sup>1,2</sup> Rafael Sousa Lima Barbosa<sup>1</sup> Anderson Vieira Monteiro<sup>1</sup>  
Arnaldo Couto<sup>1,3</sup>

<sup>1</sup> Hand Surgery Department, Instituto Nacional de Traumatologia e Ortopedia Jamil Haddad (INTO), Rio de Janeiro, RJ, Brazil

<sup>2</sup> Orthopedic Department, Hospital São Vicente de Paulo, Rio de Janeiro, RJ, Brazil

<sup>3</sup> Pharmacy Department, Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Brasil

Address for correspondence Giovanni Vilardo Cerqueira Guedes, MD, Hand Surgery Department, Instituto Nacional de Traumatologia e Ortopedia Jamil Haddad (INTO), Avenida Brasil, 500, Caju, Rio de Janeiro, RJ, 20940-070, Brazil (e-mail: vcggiovanni@gmail.com).

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### Abstract

**Introduction** Wrist arthrodesis has evolved over time with the growing use of a more rigid implant, and a resultant increase in healing rates. However, complications such as irritation of the extensor tendons have led to the development and introduction of improved low-profile implants in recent years. This study aimed to examine the factors that influence the healing of total wrist arthrodesis and the frequency of complications using a low-profile plate from the same manufacturer.

**Materials and Methods** This is a retrospective study analyzing the medical records and radiographs of patients who underwent wrist arthrodesis using a long or short Aptus® 2.5 Trilock Wrist Fusion Plate (Medartis AG, Basel, Switzerland) between 2015–2021 in a single hospital. Epidemiological and clinical variables were analyzed. The Chi-square test or Fischer's Exact Test was used to compare proportions and the results, with a p-value  $\leq 0.05$  being considered statistically significant.

**Results** Of the 85 wrist arthrodesis performed, 100% consolidation was observed in an average of 4.6 months after surgery. Most patients were non-smokers (80%) men (69.4%) with a mean age of 50.7 years. The complication rate was 10.5%, all of which were resolved after a further intervention, requiring only one implant removal. The mean time of consolidation in smokers was 5.8 months and in non-smokers 4.2 months ( $p = 0.03$ ).

### Keywords

- wrist arthrodesis
- wrist fusion
- plate
- consolidation rate
- complications

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The mean time of consolidation following the long plate procedures was slightly shorter than with the use of the short plate but was without statistical significance.

**Conclusion** The wrist arthrodesis in the present study had a consolidation rate of 100% with a low rate of complications and without differences in results regarding graft placement, carpometacarpal joint fusion, or the demographic profiles of the patients. Smoking was associated with increased consolidation time but did not lead to nonunion.

**Level of evidence** IV

## Resumen

**Introducción** La artrodesis de muñeca ha evolucionado con el tiempo con el uso creciente de un implante más rígido y un aumento resultante en las tasas de consolidación. Sin embargo, complicaciones como la irritación de los tendones extensores han llevado al desarrollo e introducción de implantes mejorados de bajo perfil en los últimos años. Este estudio tuvo como objetivo examinar los factores que influyen en la curación de la artrodesis total de la muñeca y la frecuencia de complicaciones utilizando una placa de bajo perfil del mismo fabricante.

**Materiales y métodos** Se trata de un estudio retrospectivo que analiza las historias clínicas y radiografías de pacientes sometidos a artrodesis de muñeca utilizando una placa de fusión de muñeca Aptus® 2.5 Trilock larga o corta (Medartis AG, Basilea, Suiza) entre 2015 y 2021 en el mismo hospital. Se analizaron variables epidemiológicas y clínicas. La prueba de Chi-cuadrado o Prueba exacta de Fischer se utilizó para comparar las proporciones y los resultados, con un valor  $p \leq 0,05$  que se considera estadísticamente significativo.

**Resultados** De las 85 artrodesis de muñeca realizadas, se observó una consolidación del 100% en un promedio de 4,6 meses después de la cirugía. La mayoría de los pacientes eran no fumadores (80%) hombres (69,4%) con una edad media de 50,7 años. La tasa de complicaciones fue del 10,5%, todas las cuales se resolvieron después de una intervención adicional, requiriendo solo una extracción del implante. El tiempo medio de consolidación en los fumadores fue de 5,8 meses y en los no fumadores de 4,2 meses ( $p = 0,03$ ). El tiempo medio de consolidación después de los procedimientos de placa larga fue sutilmente más corto que con el uso de placa corta, pero no tuvo significación estadística.

**Conclusión** Las artrodesis de la muñeca en el presente estudio tuvieron una tasa de consolidación del 100% con una baja tasa de complicaciones y sin diferencias en los resultados en cuanto a la colocación del injerto, la fusión de la articulación carpometacarpiana o los perfiles demográficos de los pacientes. Fumar se asoció con un mayor tiempo de consolidación, pero no condujo a la pseudoartrosis.

**Grado de comprobación** IV

## Palabras clave

- artrodesis de muñeca
- fusión de muñeca
- placa
- tasa de consolidación
- complicaciones

## Introduction

Total wrist arthrodesis using a dorsal plate is a safe and practical alternative for patients with several pathological conditions that evolve with wrist arthrosis.<sup>1</sup> However, its indication is not limited to this situation, and it may also be indicated, for example, to increase the flexion force of the fingers in a patient with brachial plexus injury submitted to free functional motor transfer surgery.<sup>2</sup> Total wrist arthrodesis is often considered the last therapeutic option for degenerative or post-traumatic painful arthrosis of the wrist<sup>3</sup> because although it can relieve pain, it eliminates flexion-extension movements and ulnar-radial deviation of the wrist.<sup>4</sup>

Fixation with dorsal plates in total wrist arthrodesis results in high healing rates (96 to 98%) when compared with older techniques such as bone graft without an implant, intramedullary pinning with Steinmann pin, and trans-articular pinning with Kirschner wires, which attain much higher nonunion rates (19%).<sup>5-9</sup> Over time, specific locked intramedullary implants were developed in order to reduce the rate of complications.<sup>10</sup>

Over the years, some studies have shown a high rate of complications associated with the use of dorsal plates such as plate fractures, and a high potential for soft tissue irritation, including symptomatic friction, tenosynovitis, and extensor tendon adherence, despite the high healing rate.<sup>11-13</sup> A more

recent systematic review (2018) found a complication rate of 6.1% for total wrist arthrodesis.<sup>14</sup>

In this context, a low profile and variable angle locked plate (TriLock APTUS 2.5 wrist arthrodesis plate, Medartis AG, Basel, Switzerland) was developed for total wrist arthrodesis. It has rounded edges and an anatomically curved “low profile” minimizing the potential for soft tissue irritation or tendon friction. Due to the lack of availability of implants in our hospital for arthroplasty (which presents promising results and allows the maintenance of a greater range of motion in the wrist),<sup>15,16</sup> arthrodesis with a low profile plate is our main option for treating wrist arthrosis.

Therefore, the present study was carried out with the aim of identifying the factors that influence the healing of total wrist arthrodesis using the Aptus® 2.5 Trilock Wrist Fusion Plate (Medartis AG, Basel, Switzerland) and the frequency of complications.

## Material and Methods

All participants in this research were studied according to the Research Standards Involving Human Beings (Res. CNS 466/12) of the National Health Council after approval of the project by the Ethics and Research Committee of the Institution (CAAE: 98775418.9.0000.5273).

We undertook a review of patients' medical records to collect data in a descriptive, observational, retrospective study. Patients submitted to total wrist arthrodesis procedure in a single hospital from April 2015 to November 2021 using a long or short (with or without fusion of the joint between carpal and third metacarpal) Aptus® 2.5 Trilock Wrist Fusion Plate (Medartis AG, Basel, Switzerland) were included in the study. The surgeons of this hospital normally choose the long plate for narrower bones and rheumatoid arthritis patients. (► **Figures 1 and 2**).



**Fig. 1** Radiographs of wrist arthrodesis with fusion of the joint between carpal and third metacarpal (long plate).



**Fig. 2** Radiographs of wrist arthrodesis without fusion of the joint between carpal and third metacarpal (short plate).

All cases with incomplete medical records, with post-operative follow-up of less than 1 year, use of another type of implant, or the absence of postoperative imaging records were excluded from the study.

To evaluate the healing and complications, *mDicom Viewer software* was used to visualize the radiographs and computed tomography scans of the wrists. Pre- and postoperative radiographs were obtained for follow-up and confirmation of healing with further tomographic studies being undertaken when consolidation was not certain in the radiographs. Arthrodesis that demonstrated bone bridging of three cortices on orthogonal radiographs or the formation of a single bone block on tomographic images were considered healed.

Data on age, gender, smoking, etiology and time of pathology, date of surgery, comorbidities, use of bone graft, time for healing, complications, and need for review were collected using a previously prepared form.

The results were presented using descriptive measures, such as absolute and relative frequencies; and by means of numerical summary measures, such as minimum, maximum, means, and respective standard deviations. For data analysis, a comparison of categorical variables was performed using the chi-square test or Fischer's Exact Test (if applicable) by means of comparisons between proportions.

For all statistical analyses, a p-value of  $\leq 0.05$  was considered statistically significant. All data analyses were performed using the statistical software SPSS 23.0 (*Statistical Package for Science - Chicago, IL, USA 2008*).

## Results

The present study consisted of a sample of 82 research participants with 85 cases of arthrodesis (since 3 individuals were operated on bilaterally). The surgical indications were: 30 cases of arthrosis caused by distal radius malunion, 17 cases of rheumatoid arthritis, 17 cases of scapholunate

**Table 1** General sample characteristics (n = 85)

VARIABLES	n (%)
<b>Sex</b>	
Female	26 (30.6)
Male	59 (69.4)
<b>Smoking</b>	
No	68 (80.0)
Yes	17 (20.0)
<b>Comorbidities</b>	
No	43 (50.6)
Yes	42 (49.4)
<b>Plate type</b>	
Short	42 (49.4)
Long	43 (50.6)
<b>Bone graft</b>	
No	31 (36.5)
Yes	54 (63.5)
	<b>Mean (SD)</b>
	<b>Maximum Minimum</b>
<b>Age (years)</b>	50.7 (11.3) 23 - 81
<b>Healing time (months)</b>	4.6 (2.1) 2 - 12
<b>Follow-up time (years)</b>	4.6 (1.6) 1 - 7

advanced collapse (SLAC), 12 cases of scaphoid nonunion advanced collapse (SNAC), 6 cases of Kienbock disease, 1 case of Madelung deformity, 1 case of spasticity in a patient with cerebral palsy and 1 sequela of a snake bite.

Considering the general characteristics of the sample, most participants were male (69.4%), non-smokers (80%), with a mean age of 50.7 years. Fifty-point-six percent of the individuals did not present comorbidities; 49.4% had short plate implantation and 63.5% of the procedures had bone grafting. The follow-up time ranged from 1 to 7 years, with a mean of 4.6 years; and the mean time of healing was 4.6 months, ranging from 2 to 12 months (► **Table 1**).

All patients presented significant pain and limitation of movements in the preoperative period and the mean time between the onset of the pathology until the time of surgery was 8.1 years (SD:6.01).

In three cases patients had pain in the ulnar side of the wrist following surgery and underwent a further operation using the Darrach procedure an average of 10 months after the first procedure. There was one case of surgical site infection which was resolved with mechanosurgical lavage and administration of intravenous antibiotic therapy. One patient was submitted to the removal of the plate 12 months after the procedure due to discomfort generated by the plate.

**Fig. 3** Peri-implant fracture.**Fig. 4** Postoperative radiographs of the above case.

Two patients with rheumatoid arthritis suffered periprosthetic fracture 10 months after the procedure, with arthrodesis already consolidated. In one, the solution was the proximal slipping of the plate (► **Figures 3 and 4**) and the other was treated conservatively with closed reduction, and immobilization and consolidation was observed after 3 months in both cases. In another case, the loosening of two distal screws was observed in the metacarpal 1 month after the procedure, being quickly resolved with a screw change and healing in 4 months.

In one patient (SNAC wrist) submitted to arthrodesis with a short plate, loosening of the screws in the carpal at 2 months was observed, and was resolved with a replacement with a



**Fig. 5** Radiographs after loosening of screws.



**Fig. 6** Postoperative radiographs of the above case.

long plate, with healing in 8 months (► **Figures 5 and 6**). The complication rate, therefore, was 10.5% (9 cases).

After analyses of the correlations between the mean time of consolidation in relation to gender, comorbidities, smoking, the etiology of the arthrosis, type of plate, and the use of grafts, only the variable smoking showed a statistically significant difference, with a mean time of healing in smokers of 5.8 months and in non-smokers of 4.2 months ( $p=0.03$ ). The other variables analyzed did not present any statistical significance, although the mean time of healing in procedures with long plates was slightly shorter than with the use of short plates (► **Table 2**).

## Discussion

In the 1990s, studies began to report healing rates close to 100% for wrist arthrodesis, most of which emphasized the importance of autologous bone grafting and the use of stable internal fixation methods.<sup>17–20</sup> In our sample, there was also 100% healing, but there was no difference in the time of

**Table 2** Influence on consolidation time

VARIABLES	Consolidation Time (months) Mean (SD)	p value <sup>a</sup>
<b>Sex</b>		
Female (n = 26)	4.5 (1.8)	0.89
Male (n = 59)	4.6 (2.2)	
<b>Smoking</b>		
No (n = 68)	4.2 (1.7)	<b>0.03</b>
Yes (n = 17)	5.8 (2.9)	
<b>Comorbidities</b>		
No (n = 43)	4.6 (2.2)	0.90
Yes (n = 42)	4.5 (2.0)	
<b>Plate type</b>		
Short (n = 42)	4.9 (2.4)	0.18
Long (n = 43)	4.3 (1.7)	
<b>Graft</b>		
No (n = 31)	4.6 (2.4)	0.93
Yes (n = 54)	4.6 (1.9)	
<b>Rheumatoid arthritis</b>		
No (n = 69)	4.6 (2.2)	0.49
Yes (n = 16)	4.2 (1.4)	

<sup>a</sup>Student t test (comparison between means).

consolidation or the frequency of complications associated with the use of grafts.

However, there were some complications related to implant design, such as irritation or synovitis, and in one case removal of the implant was required.<sup>21,22</sup> In our sample, the complication rate was 10.5% (9 cases), the vast majority of which were unrelated to the implant (three due to pain in the ulnar corner of the wrist, one infection, and two peri-implant fracture after trauma), only one case of discomfort generated by the plate and two cases of the loosening of screws in the early postoperative phase, all resolved after a further intervention. We believe that the use of low-profile locking plates contributed to these good results.

In respect of the different types of plates used (with or without fusion of the carpometacarpal joint), recent studies present comparable rates in respect of healing and complications,<sup>23</sup> pain, grip strength and DASH functional scores (Disabilities of the Arm, Shoulder, and Hand), with a greater range of motion in the carpometacarpal (CMC) with the use of short plates, improving hand kinematics.<sup>24</sup> Furthermore, we did not find any differences in healing rates or complications according to the type of plate used. There was a non-statistically significant longer mean time for healing of long plate surgeries (4.9 months) when compared to short plate surgeries (4.3 months).



Previous studies have demonstrated the impact of smoking on hand surgery suggesting that it is associated with complications related to surgical wound delayed consolidation after osteosynthesis of the distal radius,<sup>25,26</sup> and an increase in the rate of nonunion after arthrodesis of the hand and wrist.<sup>27</sup> In our sample, we observed an increase in the meantime for healing in smokers (5.8 months) compared to nonsmokers (4.2 months), a factor that was statistically significant, although the healing rate did not change.

Our study presents some limitations such as its retrospective nature, which limits the information to that obtained from the analysis of medical records and radiographs in the review consultations, and the lack of clinical data such as muscle grip strength and functional scores such as DASH in pre-and postoperative evaluations. However, it is a very large and uniform sample, because all the patients received the same implant in the same hospital in a period of only 6 years. In addition, the sample comprised patients with diverse causes of wrist arthrosis.

In conclusion, our result show that wrist arthrodesis performed with the Aptus® 2.5 Trilock Wrist Fusion Plate (Medartis AG, Basel, Switzerland) in our hospital had a 100% consolidation rate with a very low rate of implant-related complications and without differences related to graft placement, carpalcarpal joint fusion, comorbidities, or the demographic data of the patients. In addition, it is important to note that smoking increased the healing time but did not lead to nonunion.

#### Ethical Approval Declaration

Ethical approval to report this case was obtained from ETHICS COMMITTEE of INSTITUTO NACIONAL DE TRAUMATOLOGIA E ORTOPEDIA JAMIL HADDAD (INTO).

#### Informed Consent Declaration

Dismissal of free and informed consent was made.

#### Contributorship Details

Giovanni Guedes, Pedro Siestrup, and Rafael Barbosa wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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#### Declaration of Conflicting Interests

The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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