

# Three-year (2017–2019) activity report of the Replantation Service for amputated hands in Poland

## Raport z trzyletniej (2017–2019) działalności Serwisu Replantacyjnego dla amputacji rąk w Polsce

### Authors' Contribution:

A – Study Design  
B – Data Collection  
C – Statistical Analysis  
D – Manuscript Preparation  
E – Literature Search  
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### ABSTRACT:

This article summarizes the activity of the Replantation Service for hand amputations in Poland in years 2017–2019. Over this period, a total of 551 cases of total and subtotal amputations as well as other complex injuries to the hand were referred to the referenced centers. Of these, 330 referrals were accepted and 221 rejected, for various reasons. Among these accepted, there were 165 total (50%) and 131 subtotal (40%) amputations; 34 patients (10%) had other severe hand injuries. The vast majority of the patients constituted young and middle-age males. The most common was amputation of several digits and thumbs – a total of 251 cases (76%), followed by transmetacarpal – 30 (9%), forearm – 23 (7%) and wrist – 20 (6%) amputations. Replantation of the amputated extremity was performed in 138 patients (42%), revascularization in 98 (30%) and in 45 (14%) primary repair of complex injuries. In 26 cases (8%), coverage of tissue defects was performed, and in 23 (7%) primary terminalization. The survival rate was on average 65% for replantations and 85% for revascularizations. Comparing to the previously reported period 2013–2017, the number of treated patients was similar, but the structure of injuries differed: the number of digital amputations increased (by 22 cases), whereas the number of proximal amputations (hand, forearm and arm) dropped significantly (by 50 cases). The importance of the Replantation Service, an informal structure, in saving limbs of severely mutilated patients was emphasized.

### KEYWORDS:

hand replantation, microsurgery, outcome measurement

### STRESZCZENIE:

W pracy przedstawiono podsumowanie działalności Serwisu Replantacyjnego dla amputacji rąk w Polsce w latach 2017–2019. W analizowanym okresie do Serwisu zgłoszono 551 przypadków amputacji i innych rozległych urazów kończyn górnych, z czego 330 zaakceptowano do operacji, a w 221 przypadkach, z różnych powodów, odmówiono przyjęcia. Wśród 330 przyjętych było: 165 (50%) amputacji całkowitych, 131 (40%) prawie całkowitych i 34 (10%) przypadki inne, ciężkie, zagrażające utratą kończyny urazy. W przeważającej liczbie ofiarami byli mężczyźni w młodym i średnim wieku. Najwięcej było amputacji kilku palców i kciuków – 251 (76%), następnie amputacji na poziomie: śródrezcza – 30 (9%), przedramienia – 23 (7%) i nadgarstka – 20 (6%). U 138 chorych (42%) z całkowicie amputowanymi kończynami lub palcami wykonano replantację, u 98 (30%) – rewaskularyzację, a u 45 (14%) – naprawę rozległych uszkodzeń (pierwotna rekonstrukcja). W 26 przypadkach (8%) wykonano pokrycie ubytków płatami, a w 23 (7%) nie podjęto próby replantacji i zaopatrzoneo kikut kończyny. Przeżywalność replantowanych i rewaskularyzowanych części kończyn wynosiła śr. 65% dla replantacji i 85% dla rewaskularyzacji. W porównaniu do raportu z okresu 2013–2016, liczba leczonych chorych była podobna, ale różniła się struktura urazów: więcej było przypadków amputacji palców – o 22, za to znacznie mniej – o 50 – amputacji proksymalnych: ręki, przedramienia i ramienia. Przedstawiony raport podkreśla znaczenie nieformalnej struktury, jakim jest Serwis Replantacyjny w ratowaniu kończyn ciężko okaleczonych pacjentów.

**SŁOWA KLUCZOWE:** mikrochirurgia, replantacja ręki, wyniki leczenia

## INTRODUCTION

In 2010 the Board of the Polish Society for Surgery of the Hand initiated the so-called Replantation Service (abbreviated as the Service), which was identified as a “readiness to provide advice and help in cases of some upper extremity amputations”. In the first two years of its operations, the Service consisted of three

centers located in Trzebnica, Poznań and Szczecin. In succeeding years, four more centers in Kraków, Gdańsk, Elbląg and Wrocław joined, and currently there are seven branches involved in this activity. Four of those are trauma and orthopedic departments (Poznań, Gdańsk, Wrocław and Elbląg), two general surgery departments (Trzebnica and Szczecin) and one plastic surgery and burns treatment department (Krakow).

Tab. I. Activity of the Replantation Service over the period 2017–2019.

PARAMETER	KRAKÓW	TRZEBNICA	SZCZECIN	POZNAŃ	GDAŃSK	WROCŁAW	TOTAL
Number of referrals*	-	121	109	78	91	-	551*
Number of admissions	128	68 (56%)	59 (54%)	31 (40%)	14 (15%)	30	330
Number of refusals**	-	53 (44%)	50 (46%)	47 (60%)	71 (85%)	-	221
Sex M/F	118/10	51/17	55/4	30/1	12/2	27/3	293/37
Age in years (av.)	41	45 (16–72)	43 (22–73)	41	42 (6–67)	41 (4–70)	42 (4–73)
Extremity R/L	69/59 54/46%	51/17 75/25%	33/26 56/44%	13/18 42/58%	7/7 50/50%	17/13 57/43%	190/140 57%/43%

\* Number of referrals without cases of refusals from the Kraków and Wrocław centers

\*\* Number of refusals without the Kraków and Wrocław centers

Tab. II. Types of injuries accepted for surgery.

STRUCTURE OF INJURIES	KRAKÓW	TRZEBNICA	SZCZECIN	POZNAŃ	GDAŃSK	WROCŁAW	TOTAL
Total amputation	78	20	35	11	9	12	165
Subtotal amputation	46	32	14	20	4	15	131
Crushing	4	8	2	-	-	-	14
Extensive wound	-	8	8	-	1	3	20
Total	128	68	59	31	14	30	330

Tab. III. Tools causing amputation/injury.

INJURY TOOL	KRAKÓW	TRZEBNICA	SZCZECIN	POZNAŃ	GDAŃSK	WROCŁAW	TOTAL
Circular saw	66	49	32	25	5	-	177
Industrial machine	52	10	21	4	9	-	96
Ax	10	9	4	2	-	-	25
Other	-	-	2	-	-	-	2
Total	128	68	59	31	14	-	300

Every day, there was one department which stood ready to admit patients from the whole country, admit referrals for hand amputation, thumb amputation and multiple digit amputation. Furthermore, it also took account of certain cases of crushing and scalping injury of the hands that require a microsurgical management, or repair of damaged skin tissue with grafts.

In 2014 and 2018, two reports were published, which concerned the activity of the Replantation service from the period 2010–2013 and 2014–2016, respectively [1, 2].

The aim of the present study is to summarize the activities of replantation centers in three subsequent years extending from 2017 to 2019.

## RESEARCH MATERIAL AND METHODOLOGY

Data for this paper was obtained from surveys sent to all centers participating in activity of the Service. We collected data from six units, because the branch in Elbląg never sent back the questionnaire. The obtained data was compiled and presented in the form of Tab. I.–VI.

## RESULTS

In the period 2017–2019, there were 551 cases of amputations, partial amputations or other extensive upper extremity-threatening injuries referred to six centers participating to the Service's activities. Of those cases, 330 referrals were accepted, and 221 were rejected. Tab. I. presents these data broken down into individual departments operating in the Service. The data contains no evidence of the number of referrals and refusals from Kraków and Wrocław, therefore the total accept/reject ratio was not calculated. Amputations were predominantly (89%) experienced by young and middle-aged males. In 16 cases (5%), amputation concerned children, of which the youngest was 4 years old.

The structure of injuries is shown in Tab. II. The 330 admitted cases included: 165 (50%) total amputations, 131 (40%) subtotal amputations, and 34 (10%) other severe, threatening limb-loss injuries such as crush injuries and extensive lacerations.

The majority of amputation or extensive trauma cases were caused by a circular saw – 177 (54%) and an industrial or agricultural machine – 96 (29%) (Tab. III). The term “industrial machine” includes devices such as milling machines, grinders, drills, guillotines and presses.

Tab. IV. Level of the amputation, excessive wound, crush or degloving injury.

AMPUTATION LEVEL	KRAKÓW	TRZEBNICA	SZCZECIN	POZNAŃ	GDAŃSK	WROCLAW	TOTAL
<b>Digits (number of patients)</b>	73	25	21	24	1	11	155
<b>Thumb</b>	40	22	14	5	6	9	96
<b>Metacarpus</b>	5	13	7	1	1	3	30
<b>Wrist</b>	1	7	7	1	-	4	20
<b>Forearm</b>	8	1	8	-	4	2	23
<b>Elbow/shoulder</b>	1	-	-	-	-	1	2
<b>Multi-level</b>	-	-	2	-	2	-	4
<b>Total</b>	128	68	59	31	14	30	330

Tab. V. Types and numbers of the procedures performed.

TYPE OF SURGERY	KRAKÓW	TRZEBNICA	SZCZECIN	POZNAŃ	GDAŃSK	WROCLAW	TOTAL
<b>Replantation</b>	71	20	19	10	6	12	138
<b>Revascularization</b>	17	32	14	15	5	15	98
<b>Reconstruction</b>	16	10	15	1	-	3	45
<b>Coverage with graft</b>	13	6	5	1	1	-	26
<b>Terminalization</b>	11	-	6	4	2	-	23
<b>Total</b>	128	68	59	31	14	30	330

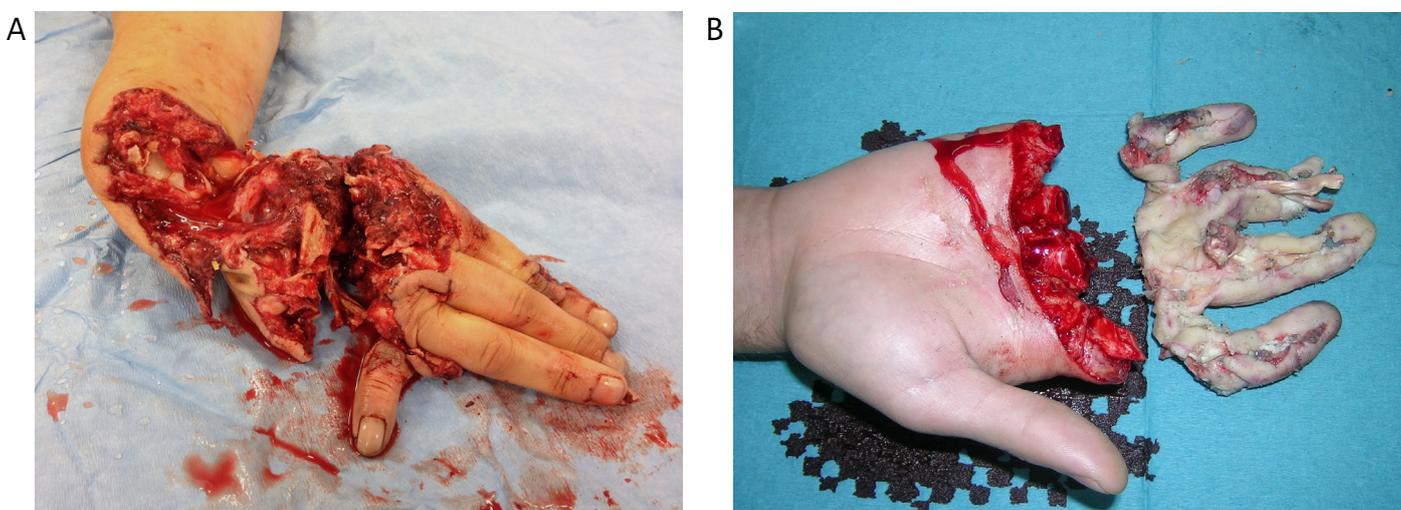


Fig. 1. (A) Near-total crushing amputation of the hand and wrist. A non-replantable case; (B) complete amputation of digits II-IV in the press/guillotine. A non-replantable case.

The level of amputation is shown in Tab. IV. Digital amputations involving the thumb were the most numerous 251 (76%); there were 96 (29%) thumb amputations alone. It must be stressed that the term “digital amputation” mostly meant the amputation of several, at least three, fingers in one person. In 75 cases (23%) the injuries involved the level from the metacarpus to the shoulder, with the highest number of amputations involving the metacarpus – 30 cases (9%), forearm – 23 (7%), and wrist – 20 (6%). Two patients had an extremity amputated at shoulder height, and four suffered an injury at several different levels of the extremity, meaning that the amputated part had at least one additional extensive wound.

Tab. V. illustrates the number of individual operations performed in patients admitted to the Service. In 138 patients (42%) a completely

amputated extremity, digits or thumb were replanted, in 98 (30%) subtotally amputated parts, hanging on a non-vascularized piece of skin, muscle or tendon were revascularized, and in 45 (13%) cases, extensive, complex injuries in the extremity, which was not completely ischemic, were primarily repaired. In 26 cases (8%) of crushing injuries followed by necrosis of soft tissues, defects were managed with flap coverage. In 23 patients (7%), no attempt of replantation was made, but only the digit/extremity stump was managed, most often due to extensive damage of the amputated part (Figs. 1A., B.).

It is obvious that in cases of amputation and other extensive extremity injuries, surgery does not always allow for preserving the limb. Tab. VI. shows the effectiveness of treatment in individual

**Tab. VI.** Effectiveness of the treatment assessed by a survival rate of the operated extremities or digits.

TYPE OF SURGERY	KRAKÓW	TRZEBNICA	SZCZECIN	POZNAŃ	GDAŃSK	WROCLAW*	TOTAL
<b>Replantation</b>	67/88 76%	13/20 70%	12/19 63%	6/10 60%	5/6 83%	-	36/55 65%
<b>Revascularization</b>		28/32 88%	11/14 78%	12/15 80%	5/6 83%	-	56/66 85%
<b>Reconstruction</b>	-	100%	100%	100%	-	-	100%

\*Lack of data on the effectiveness of treatment from the Wrocław center.



**Fig. 2.** (A) Near-total amputation of the metacarpus; (B) the hand a few days after surgery; (C) fixation of the metacarpal bones with K-wires visible in the hand X-ray.

centers. The number of cases in the first row of the table does not correspond to the number from the previous tables, because it is reduced by terminalizations (only supply of the stump) when no attempt to replant has been made. The effectiveness rate of 75% of replantation and revascularization is a good result given the unfavorable mechanism of injury (crush, avulsive) in some cases, a long transport time that sometimes causes surgery to begin after 8 hours of injury, as well as accepting an increasing number of referrals with questionable chances of successful replantation.

Cases of hand amputations and the results after replantations performed in the Szczecin center are shown in Figs. 2A.–C. and 3A.–G.

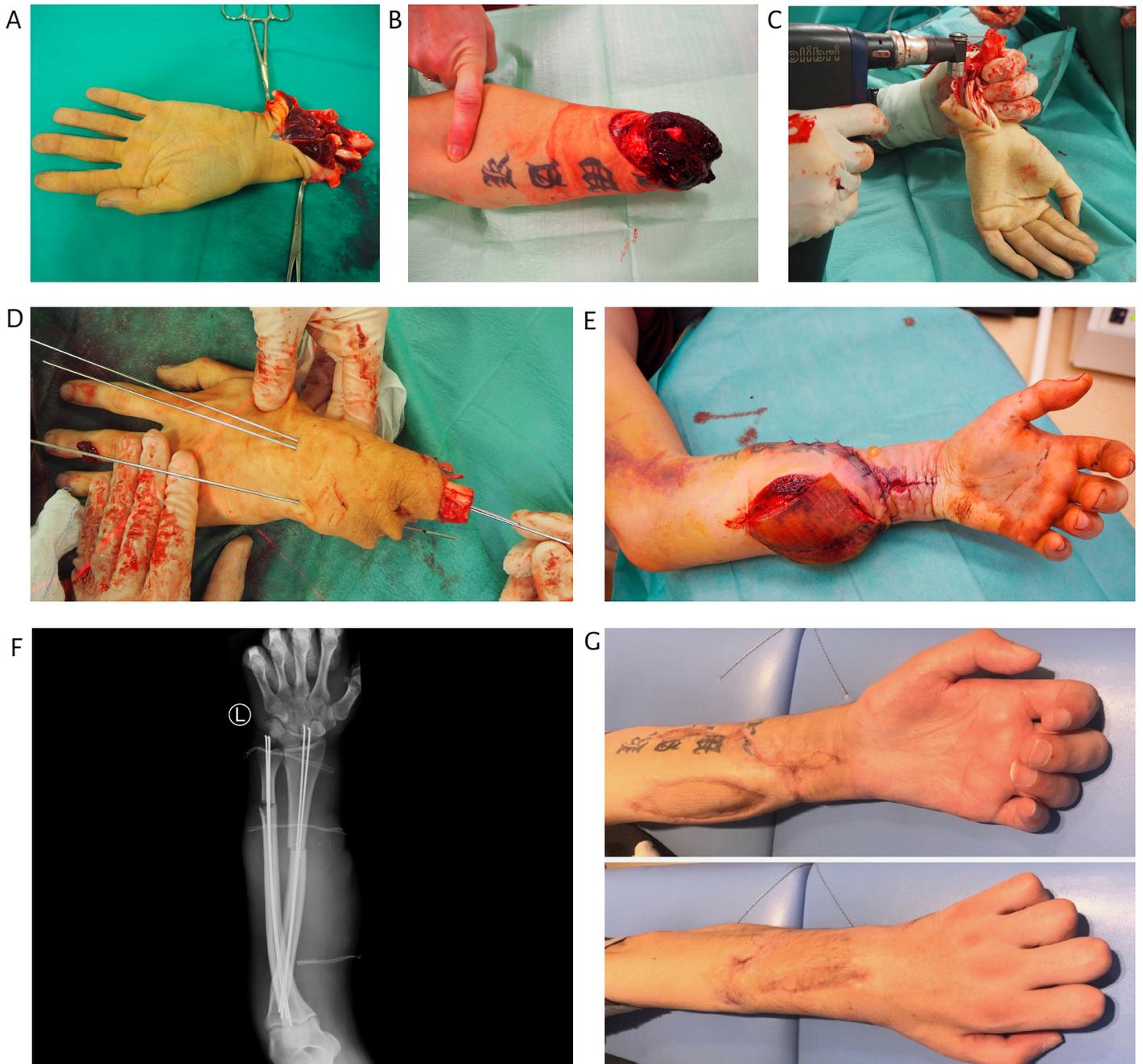
## DISCUSSION

Two previous reports including periods 2010–2012 and 2013–2016 illustrate data from 6 years of the Service's activity [1, 2]. The comparison of data from these three periods is shown in Tab. VII. Over the last two periods, the number of amputations and extensive wounds of the upper extremity treated in the Service centers was comparable. The structure of injuries was different: the three reported periods have a noticeable upward trend in the number of digit and thumb amputations, i.e. by 88 between the second and first periods and by 22 between the third and second periods, while the number of proximal amputations decreased: the hand and wrist by 42, and forearm and arm by 8, between the third and the second reporting period. The survival rate of limb replantations has been staying at the same level in the periods 2013–2016 and 2017–2019. These trends suggest an improvement in work safety in wood processing plants, where the majority of “large” amputations is taking place, with stable trends in carelessness in handling small cutting tools: circular saws, milling machines and “flex machines”, which cause most of all digital amputations. This is also the consequence of the ready availability (low price) of such machines, which are quite helpful in finishing

works in construction and home DIY. This mainly concerns high-speed, non-stationary, but portable “flex” machines with a ceramic cutting disc. It often happens that such hand-held tools hit a knot in the board or some metal element and “bounce off”, fall out of the holder and cut off the user's fingers.

## EPIDEMIOLOGY OF AMPUTATION AND INDICATIONS FOR REPLANTATION

In Western Europe and the United States, extremity amputations are much rarer than in developing countries [3, 4]. This is due to the use of more advanced technologies in the industry that eliminate work with hazardous equipment, the tradition of observing safe working practices, but also the reduced prevalence of dangerous devices (circular saws, flex saws) among the population. There are also some variations of indications for replantation in different countries. In the countries of the “old” European Union, there is a tendency to replant even single amputated digits, which is not necessarily the case in the USA. In one American publication, the percentage of attempts to replant single digits was 12% (813 of 6,890 amputations), and in another 16% (550 of 3,340 amputations) (Friedrich et al., 2011). In developing countries, single digit replantations are rare, primarily due to the lack of dedicated microsurgery centers. According to the regulations of the Polish Replantation Service, single digital amputation is not an indication for replantation and such cases are rejected by most of the Service centers. These surgeries are performed in some centers on patients from their parental voivodeship, when the organizational arrangements (access to the operating theater, the possibility of anesthesia, the presence of a microsurgeon) make this possible. In the current reporting period, we can notice a change in this tendency: more and more centers are accepting for treatment cases of single digits amputated in a favorable mechanism, e.g., by guillotine. This tendency is driven by the noticeable reduction of “major” (proximal) amputations referred to the Service.



**Fig. 3.** (A) Total amputation of the forearm in the press/guillotine. Amputate; (B) stump which had a hemostatic cord tightened for several hours leading to muscle necrosis; (C) preparing for replantation in the hand: shortening and aligning the stump of the radius bone; (D) preparing for replantation in the hand: K-wires inserted intramedullary into the radius and ulna in the amputate; (E) a few days after limb replantation. Normal appearance of the replanted hand and significant swelling of the forearm after fasciotomy. This is the result of a cord tightened on the stump during transport; (F) x-ray of the forearm showing bone fixation with K-wires; (G) forearm 4 months after replantation.

## LITERATURE REVIEW ON THE ACTIVITIES OF THE REPLANTATION SITE IN DIFFERENT COUNTRIES

The available literature contains a number of publications on the results of hand and digit amputation performed in one center. However, there are few papers on the organization and operation of the replantation service on a national scale and the presentation of data from this activity. While reviewing the literature, the authors found the following items.

In 2020, data on hand replantation performed in Finland between 1998 and 2016 were published [5]. A total of 2,434 replantations and revascularizations of the amputated upper extremities were performed over a 19-year period, the majority (95%) in two university

centers of Helsinki and Kuopio. The victims were more often male – 77%, than female – 13%, aged 20–39 years (frequency 1.4–5.0 per 100,000 per year) and 40–59 years (frequency 1.8–4.8 per 100,000 per year). Most of the injuries (67%) occurred at home and 33% in work settings. An average of 128 operations per year (range 82–166) were performed in the analyzed period. The most frequent procedures were finger revascularization (including the thumbs) – 1150 (47%), and replantation of totally amputated digit – 713 (29%). A total of 365 (20%) revascularizations and 79 (3%) replantations at the metacarpal or wrist levels were performed, as well as 74 (3%) revascularizations and 27 (1%) forearm replantations were performed in this period. Because the cited work was based on the analysis of data from the Finnish National Hospitalization Register, the effectiveness of surgeries performed was not

**Tab. VII.** Comparison of data from three periods of the Replantation Service activity.

PARAMETER	PERIOD 2010–2012	PERIOD 2014–2016	PERIOD 2017–2019
<b>Number of admissions</b>	290	354	330
<b>Number of total amputations</b>	100	167	165
<b>Number of subtotal amputations</b>	113	142	131
<b>Number of patients with amputation of digits, including thumbs</b>	141	229	251
<b>Number of hand and wrist amputations</b>	84	92	50
<b>Number of above-wrist amputations</b>	50	33	25
<b>Survival after operations</b>	159/178 89%	222/286 78%	159/209 76%

stated. The number of cases in which an attempt at replanting was not made was not provided as well. Independently of this, the paper represents one of the few statistical studies on replantation performed nationwide and covering a long period of time [5].

Saito et al. presented the results of the analysis of the replantation service activity in Japan in the period 2004–2015 (12 years) [6]. The data came from the Japan Trauma Data Bank. During this period, 1,240 upper extremity amputations were reported, of which 510 (41%) were replanted. The overwhelming majority (92%) of the patients were males, mean age 46 years. The authors analyzed the evolution of the availability of the replantation service on a national scale: in 2004, nearly 30% of patients with amputated extremities were referred from the primary care hospital to a reference center, while in 2015 this share was only 16%, which means a significant expansion of the network of centers performing replantation and organization of transport from the site of the accident directly to the reference hospital. The authors noted the lack of a uniform algorithm of indications for replantation in Japan, which resulted in differences in the proportion of replantations in relation to the number of amputations in individual centers [6]. The data from this study show a significantly reduced number of upper extremity amputations in Japan compared to Poland or Finland.

Friedrich et al. analyzed the data from the American registry (Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project) concerning the number of injuries and methods in managing patients who suffered amputation of the upper extremity throughout the United States in 3 years: 2001, 2004, and 2007 [7]. During the years mentioned, there were 9,400 amputations recorded in the relevant registry, which means that the average is 3,130 injuries per year. Of this number, an attempt at replanting was made in only 1,360 patients (14%), and the remaining patients underwent digit or limb termination. This means that an average of approx. 450 replantations per year was performed in these years in the USA. The mean age of patients who received digit/limb replantation was 36 years, while for those who underwent stump surgery – 44 years. Replantations were performed significantly more often in large university hospitals (on average 19%) than in small, regional ones (average 7%). The performance or refusal of replantation was also impacted by the type of insurance: patients who were uninsured and did not have funds to cover the costs of treatment, as well as those with “cheap” insurance policies, usually underwent terminalization, and those with more favorable insurance could count on replantation. This was directly related to the costs and duration of hospital treatment, which were incomparably higher in the cases of replantation [7].

Shale et al. analyzed data from the US National Trauma Data Bank on thumb amputations and methods of their treatment in the USA in 2007–2010 [8]. There were 3,340 thumb amputations (835 per year) reported in this period, of which 550 (16%) included attempts at replanting. Most replantations (n = 427 people; 20%) were performed in large university hospitals, while the replantation attempt rate in regional hospitals was 10%. In 85% of cases, operations were successful and the replanted thumbs survived, with replantation success rates similar between large and small regional hospitals [8].

Chang et al. (2015) analyzed data from the Taiwan National Health Insurance Bureau on digital amputation and treatment in Taiwan in 2008 [9]. There have been 2,358 cases of amputation in that year, 79% in males and 21% in females, with the average age of 39. The incidence of these injuries was 1.2 per 100,000 per year. The majority of amputations was recorded for the 45–54 age group. The majority of injuries (69%) was caused by circular saws and industrial machinery. The attempt at replanting the digit was made significantly more often in cases of amputation of the thumbs than in long fingers and in private hospitals and large university centers, than in regional ones. A negative factor influencing the success of replantation was the age of patients > 65 years, and a positive factor - the center's experience (> 20 replantations per year) [9]. As illustrated by these data, the percentage of replantation attempts carried out in our country is much higher than in, for example, the USA.

## FINAL REMARKS

Since the beginning of the Replantation Service in 2009, successive presidents of the Polish Society of Hand Surgery have made attempts to formalize its activity and put it into organizational framework so as to create a system that would operate similarly to the transplantation service. The discussions conducted with the officials of the Ministry of Health and the National Health Fund for almost 10 years never led to any arrangements, mainly due to the reluctance of decision-makers to finance these services separately as highly specialized procedures (e.g., such as organ transplants). This implies that since its inception in 2009, the Replantation Service has remained an informal structure, to some extent charitable, established by a group of enthusiasts who save human health by spending numerous (night) hours in the operating room, usually as part of a low-paid shift at the hospital. In spite of the growing difficulties related to the SARS COVID-19 epidemic, the Service has managed to continue its activities in 2020.

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