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ARTICLE

Upper extremity replantation and revascularization in Finland between 1998 and 2016

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ABSTRACT

Emergency replantation and revascularization operations of upper extremity injuries demand considerable resources, but their actual occurrence is unknown. This study evaluated all emergency replantations and revascularizations in the upper extremity in Finland from 1998 to 2016. A total of 2,434 operations were identified within the study period. The average number of operations per year was 128 which corresponds with 2.4 operations per 100,000 person years. Operations were most common in persons aged 20 to 59 years and the rate of operations ranged from 1.4 to 5.0 per 100,000 person years. Thirteen percent of the patients were women and 87% were men. This study shows rates of emergency replantation and revascularization operations in upper extremity injuries and proves that the rates have been constant over the past 19 years in Finland.

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Introduction

A replantation is defined as restoration of a complete amputation of the injured part and an operation is determined as revascularization if there is any tissue, for example, skin, nerve, or tendon, in continuity (i.e. amputation-in-continuity), but there is no circulation distal to the injury because of damage to arterial structures. Thus, in both occasions an emergency vascular repair may be indicated in order to restore the viability of the tissue distal to injury.

There are differences in the incidence of amputation injuries of upper extremity and in the indications for replantation surgery in different regions. For example, in a regional cohort from the USA, the incidence of digital amputations was 2.13/100,000 person-years [1] and the estimated incidence of hospitalization due to digital amputation was 1.1/100,000 person-years [2]. However, not all of these patients underwent emergency vascular repair. A study from the USA identified 6,891 patients with finger amputations and of 813 (12%) these patients underwent replantation [3] and another study reported 3,341 traumatic thumb amputations with 550 (16.5%) attempts to replantation [4]. There are only limited long-term epidemiological studies of replantation or revascularization surgery and the actual nationwide rates of these operations are unknown. However, successful execution of these emergency operations demand collaboration and substantial resources [5], and it is important to know the current rates and trends of operations in order to plan for efficient operative workflow.

The objective of this study was to evaluate the rates of all upper extremity surgical replantation and revascularization operations between 1998 and 2016 in Finland. The secondary objectives were to analyze rates of operations in different age groups and examine the distribution of patients by sex and injury type.

Materials and methods

The patient data was identified from the nationwide Finnish National Hospital Discharge Register (NDHR) which includes information from all Finnish hospitals. NDHR data contains patients' age, sex, International Classification of Diseases (ICD) codes for primary and other diagnosis, operative treatment, day of arrival and the external cause for injury. By law, all Finnish healthcare institutions, including private, public and third sector units, have mandatory responsibility to collect and forward information of all patients to the Finnish NDHR. Consequently, the Finnish NDHR has excellent coverage and accuracy [6–9].

The inclusion criteria for our study was a traumatic amputation, or amputation-in-continuity, of any part of upper extremity which was treated with an emergency replantation or revascularization between 1998 and 2016. The coding for different operative treatments is mandatory and defined in the Finnish version of The Nordic Medico-Statistical Committee (NOMESCO) classifications of surgical procedures. Patients were identified according to the operative treatment codes indicating replantation or revascularization surgery, and accordingly, we included all patients who underwent replantation of wrist or a hand (NDP10), replantation of single digit including thumb (NDP12), replantation of multiple digits (NDP18), revascularization of wrist or a hand (NDP30), revascularization of digit or digits (NDP32), replantation of forearm (NCP10), revascularization of forearm (NCP30) and replantation of upper extremity proximal to elbow (NBP10) [10]. Patients of all ages were included in the study and there were no exclusion criteria for the participants.

The primary outcome variable was the number of traumatic amputation of the upper extremity which was treated with replantation or emergency replantation or revascularization surgery in each year within the study period. The rate of operation was calculated with the absolute numbers of each type of operations which

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were adjusted for the total population of Finland in each year. Linear regression was used to test for trends over time and $p < 0.05$ was considered significant. In order to account for differences in the rate of surgeries in patients of different ages we calculated also the incidence rate for each operation for age groups 0–19 years, 20–39 years, 40–59 year and over 60 years. The operation rates were similarly adjusted for the actual population in different age groups in each year, because of different total population and changes in different age groups. The annual mid-populations for all ages were obtained from the Official Statistics of Finland, a statutory electronic population register. The other outcomes were the absolute number of operations and distribution by sex and number of occupational accidents.

In 1998 there were 5,160,000 citizens in Finland and in 2016 the number of citizens was 5,503,000 [11]. The rates of operations were based on the entire population of Finland and there was no rationale for confidence intervals or other estimate statistics, because the study population was not a cohort but the entire Finnish population [12,13]. The study was conducted according to the instructions of the Institutional Review Board of the Pirkanmaa Hospital District, Finland.

Results

A total of 2,434 upper extremity replantation or revascularization operations were identified within the time period from 1998 to 2016 in Finland. Thirteen percent ($n = 319$) were women and 87% ($n = 2115$) were men. The ratio of men to women remained quite constant during the 19-year study period (in men number of operations ranged from 70 to 140 per year and in women from 6 to 31 per year). Most (76%, $n = 1,858$) of the operations were performed in two university hospitals which have a microsurgical team on call. Altogether 95% ($n = 2,310$) of the operations were performed in university hospitals and 5% ($n = 124$) were operated in other hospitals. The median age of patients was 43 years (range from 0 to 85 years) and there were no significant changes in the annual median age over the 19-year period.

The average total number of operations per year was 128 (range from 82 to 166) which corresponds with 2.4 operations per 100,000 person years (range from 1.5 to 3.2 per 100,000 person years, Figure 1). The most common operations were revascularization of digit or digits (NDP32, $n = 1,150$), replantation of single digit (NDP12, $n = 514$), revascularization of wrist or a hand (NDP30, $n = 365$) and replantation of multiple digits (NDP18, $n = 199$) (Figure 2). These four operations were the most common in all age groups (Figure 3). The rates for more proximal operations were lower: replantation of wrist or a hand (NDP10, $n = 79$), revascularization of forearm (NCP30, $n = 74$), replantation of forearm (NCP10, $n = 27$) and replantation of upper extremity above the elbow (NBP10, $n = 26$).

The operations were most common in persons aged 20 to 59 years. Rate in persons aged 20–39 years range from 1.4 to 5.0 per 100,000 persons-years and rate in persons aged 40–59 years range from 1.8 to 4.8 per 100,000 persons-years. In the youngest age group 0–19 years and in the age group over 60 years, rate of operations ranged from 0.7 to 2.7 per 100,000 persons-years and from 1.0 to 2.8 per 100,000 persons-years, respectively. Over the 19-year study period there were variation from year to year in the rate of these operations in all age groups, but no trend over the study period (Figure 4).

The ICD-10 external cause code for injury type was available for 67% of the patients ($n = 1,703$), and of those, 33% ($n = 556$) were occupational accidents and 67% ($n = 1,147$) were non-occupational accidents. During the 19-year study period, the rate of vocational accidents has not changed significantly (range from 0.2 to 1.0 per 100,000 person years).

Discussion

We found that the rate of replantation and emergency revascularization has been constant over the 19-year study period in Finland. Operations of distal parts, such as digits, have been the most common procedures, and particularly men aged 20 to 59 years were the most likely patients. The indications for replantation and emergency revascularization of the upper extremity injuries are well established and have been consistent during the study period in Finland, and therefore, it could be argued that the occurrence of major upper extremity amputations has been steady. Replantation surgery requires significant resources but satisfactory outcome can be crucial to patient. For example, an upper extremity amputation may reduce patients' autonomy, ability for work and disrupt social life [14,15]. The reported success

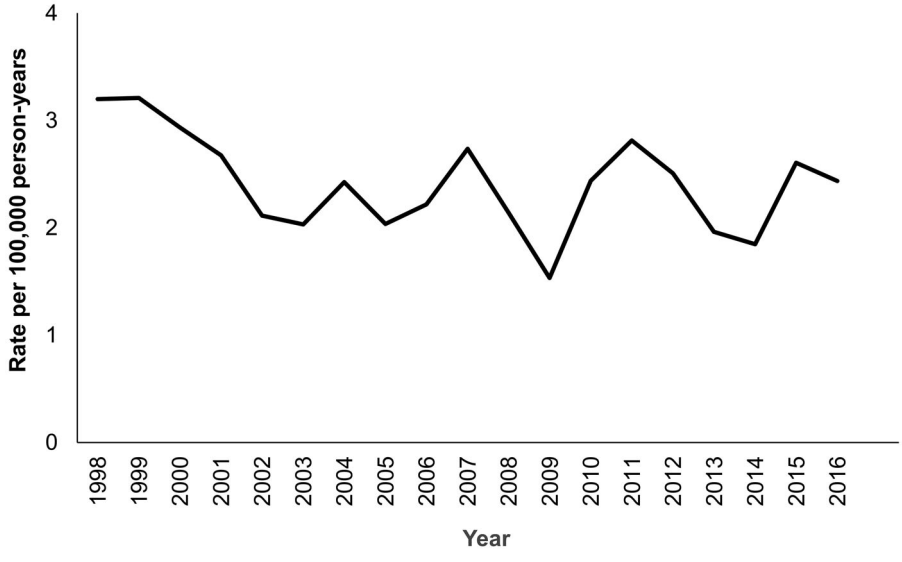

Figure 1. Rate of all operations in each year.

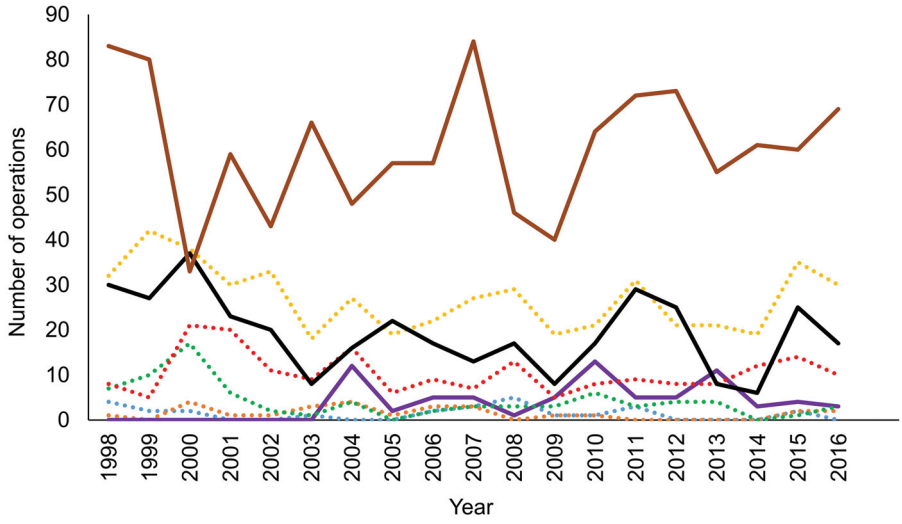

Figure 2. Number of operations in each year: replantation of wrist or a hand (green dotted line), replantation of single digit including thumb (yellow dotted line), replantation of multiple digits (red dotted line), revascularization of wrist or a hand (black line), revascularization of digit or digits (brown line), replantation of forearm (orange dotted line), revascularization of forearm (purple line) and replantation of upper extremity proximal to elbow (blue dotted line).

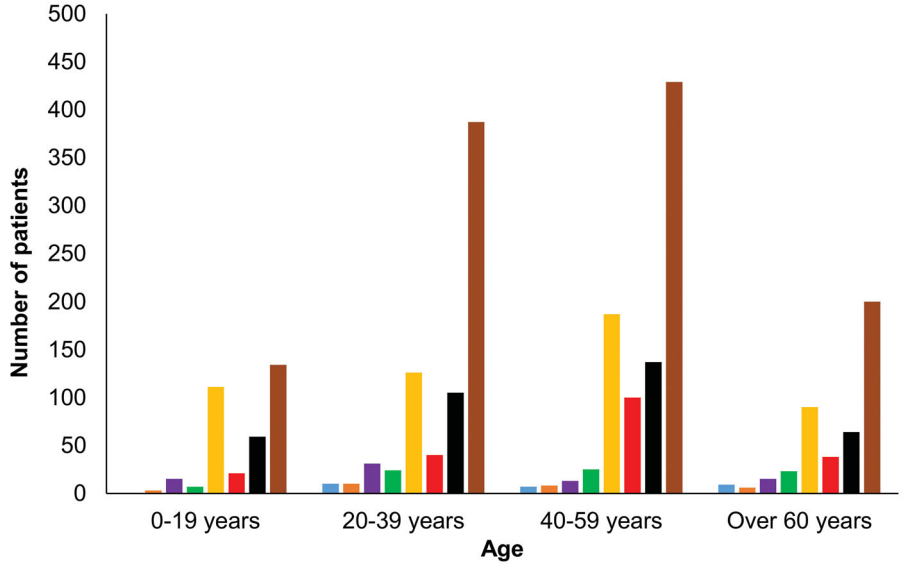

Figure 3. Number of patients in each age group: replantation of wrist or a hand (green bar), replantation of single digit including thumb (yellow bar), replantation of multiple digits (red bar), revascularization of wrist or a hand (black bar), revascularization of digit or digits (brown bar), replantation of forearm (orange bar), revascularization of forearm (purple bar) and replantation of upper extremity proximal to elbow (blue bar).

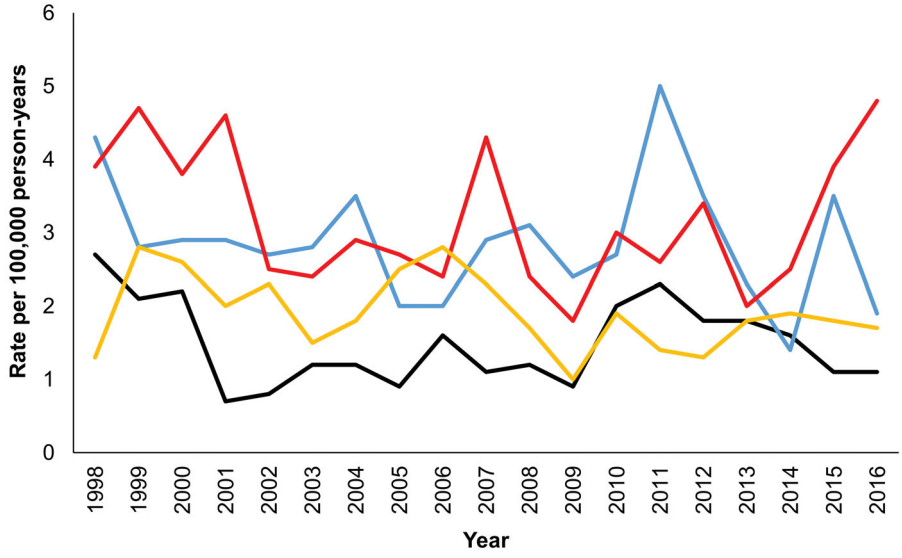

Figure 4. Rate of different operations by age groups: 0–19 years (black line), 20–39 years (blue line), 40–59 years (red line) and over 60 years (yellow line) in each year.

rates of revitalization of amputated parts are on average over 80% [4,14,16] and in the cohorts majority of patients have been satisfied with the outcomes [17–20]. Therefore, knowing the actual demand and possible trends of replantation and revascularization surgery is important in order to plan for effective collaboration and resource use in the microsurgical units [5].

To our knowledge, there are only few long-term population-based analyses of emergency microsurgical repair of upper extremity injuries. The main strength of our study was the valid and accurate database. The Finnish NDHR provides reliable data of all amputations of upper extremity treated with a replantation or revascularization in Finland during a 19-year period [6–9]. Nevertheless, a limitation of the study is the possibility of incorrect recording of diagnosis or operations. Particularly, there were changes in the procedure classification system in 1996 and we decided to omit years 1996–1997, because of higher probability of incorrect coding during the transition period.

The general indications for upper extremity replantation include loss of thumb, amputation of two or more digits, amputation proximal to metacarpophalangeal joint, and any amputation in children [21]. In Finland these indications have remained constant during the last decades. In adults, replantation at or distal to distal interphalangeal joint or any single finger replantation is not typically performed. Fingers are the most susceptible parts of hands to amputations because those are exposed and severe injury of smaller structures requires less energy. In our study, digital replantation and revascularization rates were higher than operations for more proximal injuries although single digit injuries (other than thumb) and vascular injuries at or distal to distal interphalangeal joint are not indications for microsurgical operations in Finland. This finding is in agreement with data from the USA [3], France [22], Poland [23] and Sweden [24]. In our study, the rate of replantation and revascularization surgery was constant over time, while, for example, in the USA the rate of replantation operations is decreasing despite unchanged incidence of amputations [25].

Majority of the patients were men, and the proportion of men is similar in reports from other countries. In a study from Sweden 84% of replantation patients were men [24], in the study from US 87% were men [3], and in a study from Taiwan 80% were men [26]. The finding may be due to the differences between sexes in job descriptions and leisure activities.

In our data one-third of upper extremity amputation external injury codes were occupational accidents and the rate has not changed over time. That seems to be consistent with other research from France which found less than half of patients who underwent replantation had work-related amputation accident [22]. The incidence of occupational accidents treated with replantation and revascularization surgery should decline because of improvements in safety of work environments. One plausible explanation for constant incidence is the rapidly increasing use of power tools and semi-automatic devices for many tasks, which in the past were done without high power equipment. Examples of such tasks include construction, farm work, gardening, food preparation, transportation of goods, and waste disposal. It must be noted that because of missing data on the injury type that information is less accurate than the other domains of our study data. There was change in the coding system for the cause of external injury type coding system and data from time period 1998–2001 probably includes some amount of incorrect coding. Nevertheless, it is likely that most occupational accidents have been recorded correctly over the study period because of the mandatory occupational health insurance and related reimbursements, which depend on accurate patient record.

Our study provides the rates of different emergency replantation and revascularization operations in upper extremity injuries and shows that the rates have been constant over the past 19 years. The rate of these operations is influenced by both the incidence of amputation injuries and guidelines of microsurgical practice.

Disclosure statement

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