INTRODUCTION

Close to 800,000 people die of suicide every year, translating to 1.4% of deaths worldwide. For every completed suicide, there are 20 suicide attempts, frequently by wrist cutting. In surviving patients, the consequent effects on deep structures like arteries, nerves, and tendons can drastically impair hand function and thus the capacity to work and carry out hobbies increase the risk of further suicide attempts. To stop this vicious cycle, reliable epidemiological data on suicidal deep wrist injuries (DWIs) are needed to optimize surgical management. Previous studies, however, have focused on epidemiology, psychology, and functional outcome of suicidal DWIs or on accidental DWIs alone, but did not compare suicidal and accidental DWIs. Therefore, we currently do not know whether findings from samples with (predominantly) accidental DWIs can be generalized to suicidal DWIs.

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regulation will likely differ from patients aiming at death in cutting pattern, depth, and criteria for termination of cutting (fading of emotion versus subjective injury of vital structures), resulting in different injury patterns.

Consequently, the main objective of this study was to compare injury patterns of accidental versus suicidal DWIs with as little bias as possible.

SUBJECTS AND METHODS

Sample
This retrospective study included all patients admitted to the Clinic of Plastic Surgery, University Hospital of Schleswig-Holstein, Lübeck Campus, Germany, for acute treatment of a DWI from 2008 to 2016. T.K. and N.M. searched for the relevant International Classification of Diseases, 10th Revision (ICD-10) codes in the patient database of the Clinic of Plastic Surgery and collected data of the included cases from digital and analog archives of the Clinic of Plastic Surgery. Simultaneously but independently, A.L.W. compiled a list of all psychiatric consultations in the Clinic of Plastic Surgery in the study period, regardless of somatic diagnoses, and acquired the relevant data of these cases in the analog archive of the Department for Psychiatry and Psychotherapy. Both data sets were pseudonymized and patient identifying data were saved in a separate reference list. An independent trustee (A.L.W.), not involved in patient care, searched 2 reference lists for matches. Using the pseudonyms of successful matches, psychiatric data were then added to the surgical data set. The resulting data set was anonymized by deletion of both reference lists.

Procedure
Before data acquisition, the study protocol was approved by the Ethics Committee of the University of...
Lübeck (reference number 13-054) and registered at ClinicalTrials.gov (ID: NCT03038581; see Fig. 1).

**Operationalization**

Injuries were coded dichotomously, for example, partial injuries were coded like total injuries. Injuries of individual structures were aggregated into radial triad [median nerve, PL, flexor carpi radialis (FCR) tendon] and ulnar triad [ulnar nerve, ulnar artery, flexor carpi ulnaris (FCU)] according to the study by Noaman11 and Weinzweig et al.12 and into superficial [PL, FCR, third flexor digitorum superficialis (FDS) tendon, FDS4, FCU; Fig. 2], middle (ulnar nerve, ulnar artery, FDS5, FDS2, median nerve, radial artery), and deep layer [flexor pollicis longus (FPL) tendon, second flexor digitorum profundus, FP3, FP4, FP5] according to the study by Lee et al.4 Triads were deemed injured only when all individual structures in the triad were injured.

Numerical time point descriptions were categorized as follows: morning: 6:00 AM to 10:00 AM; noon: 10:00 AM to 2:00 PM; afternoon: 2:00 PM to 6:00 PM; evening: 6:00 PM to 10:00 PM; night: 10:00 PM to 6:00 AM.

The injuring object was categorized according to the type of injury typically caused, yielding the following categories: cutting tools (eg, knives, scissors, scalpels), shards (of glass, porcelain, Perspex, CDs, etc.), tearing machinery or tools (eg, circular saw, bread slicer), and thermal injuries (scalding with hot water, burns, etc.).

**Statistical Analysis**

All statistical analyses were carried out using SPSS version 23.0.0.1 for Windows (SPSS Inc., Chicago, Illinois, USA) except for post hoc power analysis, which was carried out using G*Power.15 Results were deemed significant when the type I error probability fell <0.05. Differences between complementary conditional frequencies (P (A | B) and P (A | -B) were considered significant if (1) the P value of the χ² omnibus test fell <0.05 and (2) the sum of the corrected residuals exceeded |1.96|.16 Cramér’s V was used as a measure of effect size in χ² tests. Power for χ² tests was calculated post hoc at 0.964, 0.985, and 0.994 for 4, 2, and 1 df, respectively, with the noncentrality parameter set to λ = 20. To identify potential predictors of outcome, we used stepwise regression, specifically the backward method to minimize suppressor effects (in logistic regression using the Wald statistic as criterion for elimination).

**RESULTS**

**Demographic and Clinical Characteristics**

Demographic and clinical characteristics of the sample are given in Tables 1 and 2, respectively. DWIs (19.7%) stemmed from suicide attempts, mostly in the context of a major depressive episode (66.6%, see supplementary materials 2), substance-related disorder (21.2%), and/or a reaction to stress (15.2%). Rates of alcohol intoxication at the time of the injury are given in Table 2. In addition,

| Table 1. Demographic Characteristic of the Sample |
| --- |
| **Cause of Injury** | **All** | **Accident** | **Suicide Attempt** | **Test Statistic** |
| | n | Age (y), mean (SD) | | | |
| | 183 | 41.7 (19.7) | 38.0 (18.3) | 56.9 (18.4) | $F(1, 181) = 30.94, P < 0.001, \eta^2 = 0.38$ |
| | Sex (%) | | | | |
| | Male | 77.6 | 80.9 | 63.9 | $\chi^2 (1) = 4.84, P = 0.028$ |
| | Female | 22.4 | 19.0 | 36.1 | |
| | Handedness (%) | | | | |
| | Right handed | 88.7 | 87.3 | 94.1 | |
| | Left handed | 11.3 | 12.7 | 5.9 | |
| | Ethnicity (%) | | | | |
| | White | 93.2 | 92.2 | 97.1 | |
| | Asian | 6.8 | 7.8 | 2.9 | |
| | Profession (%) | | | | |
| | Armed forces occupations | 1.0 | 1.3 | 0.0 | NS |
| | Managers | 3.0 | 2.3 | 4.0 | |
| | Professionals | 10.9 | 6.6 | 24.0 | |
| | Clerical support workers | 13.9 | 11.8 | 20.0 | |
| | Service and sales workers | 13.9 | 15.8 | 8.0 | |
| | Skilled agricultural, forestry, and fishery workers | 5.0 | 5.3 | 4.0 | |
| | Craft and related trades workers | 36.6 | 36.8 | 36.0 | |
| | Plant and machine operators, and assemblers | 4.0 | 5.3 | 0.0 | |
| | Elementary occupations | 7.9 | 9.2 | 4.0 | |
| | Employment status (%) | | | | |
| | Self-employed | 46.4 | 67.2 | 16.7 | $\chi^2 (3) = 24.0, P \leq 0.001$, corrected residuals = 4.9 and –4.9 |
| | Unemployment benefits or invalidity pension | 14.9 | 10.9 | 31.0 | $\chi^2 (3) = 24.0, P \leq 0.001$, corrected residuals = –2.7 and 2.7 |
| | Old-age pension | 20.8 | 20.2 | 48.3 | $\chi^2 (3) = 24.0, P \leq 0.001$, corrected residuals = –3.1 and 3.1 |
| | Other | 1.6 | 1.7 | 3.4 | |

Test statistic refers to the comparison between patients after accidents and patients after suicide attempts. NS, not significant.
3 patients in the suicide attempt subsample had intoxicated themselves with prescription drugs and 1 with illegal drugs.

**Injury Patterns**

On average, 4.3 (±3.8) anatomical structures (including PL) were injured per case (see also Table 2). The majority of DWIs involved ≥1 tendon [78.7%, one-sided $\chi^2 (1, 181) = 60.25, P < 0.001$; see also Table 3 and Fig. 3], nerve [62.8%, one-sided $\chi^2 (1, 181) = 12.07, P = 0.001$], and artery [60.7%, one-sided $\chi^2 (1, 181) = 8.31, P = 0.004$]. The middle layer of the anatomical structure was injured more often than the superficial or deep layer [McNemar’s $\chi^2 (1, 181) = 15.28, P < 0.001$ and McNemar’s $\chi^2 (1, 181) = 90.47, P < 0.001$]. The superficial layer was injured more often than the deep layer [McNemar’s $\chi^2 (1, 181) = 55.36, P < 0.001$].

Regarding protective structures, patients with intact FCR were less likely to have damage to the radial artery than those with damaged FCR [McNemar’s $\chi^2 (1, 181) = 7.70, P = 0.006$] (see Table 5 for frequencies and supplementary material 3 for test statistics), patients with intact PL were less likely to have damage to the median nerve [McNemar’s $\chi^2 (1, 181) = 21.80, P < 0.001$], and patients with intact FCU were less likely to have damage to the ulnar artery [McNemar’s $\chi^2 (1, 181) = 37.91, P < 0.001$]. In addition, patients with intact FCU were less likely to have damage to the ulnar nerve than patients with damaged FCU [McNemar’s $\chi^2 (1, 181) = 24.08, P < 0.001$].

**Differences in Injury Patterns Associated with Intentionality**

Bilateral injuries occurred almost exclusively in the context of a suicide attempt (91.7%), and isolated injuries of the dominant hand mostly in accidents (97.3%). Left-handed accident victims were more likely to injure their dominant than their nondominant hand [76.5%, $\chi^2 (1, 15) = 4.77, P = 0.029$].

Regarding the frequency of damage to arteries, nerves, and tendons, there were no differences between intentionality groups (all $P \geq 0.31$). However, patients who had attempted suicide were more likely to have injured the radial artery than accident victims (44.4% versus 25.2%, see Table 3 for test statistics). The frequency of injuries to the ulnar artery was lower in patients after suicide attempts than in accident victims (22.2% versus 38.1%), but this comparison did not reach significance. Also, patients who had attempted suicide were more likely to have an injury to >1 artery than accident victims (11.1% versus 2.7%). Double arterial injuries due to suicide attempts mostly involved both hands, whereas all double arterial injuries due to accidents involved only 1 hand. Taking handedness into account, patients after suicide attempts were more likely to have damage to the radial artery on the dominant hand (5.9% versus 25.4%), but more likely to have damage to the radial artery on the nondominant hand (44.1% versus 12.7%).

Regarding nerve injuries, patients after suicide attempts were more likely than accident victims to have damage to the median nerve (50.0% versus 29.9%), as likely to have damage to the superficial branch of the radial nerve (13.9% versus 12.2%) and less likely to have damage to the
Table 3. Injury Patterns

|                | Any Hand          |               | Dominant Hand       |               | Nondominant Hand  |               |
|----------------|-------------------|---------------|---------------------|---------------|-------------------|---------------|
|                | Total | Accident | Suicide | Attempt | Versus Suicide | Attempt | Total | Accident | Suicide | Attempt | Versus Suicide | Attempt |
| n              | 183   | 147     | 36      |         |               |         | 168   | 134     | 34      |         |               |         |
|               | %     | %       | %       | %       | %              | %       | %     | %       | %       | %     | %              | %       |
| n              |       |         |         |         | %              | %       |       |         | %       | %     | %              | %       |
| Radial triad  | 9.8   | 5.4     | 27.8    | 16.3    | ≤0.001°        | 0.30    | 6.0   | 3.0     | 17.6    | 10.4   | 0.005°         | 0.25    |
| Ulnar triad   | 14.8  | 17.0    | 5.6     | 0.9     | 0.0            | 4.18    | 6.0   | 6.0     | 11.2    | 5.9    |                |         |
| Superficial layer | 67.2 | 66.7    | 69.4    | 25.3    | 0.0            | 0.30    | 36.3  | 29.9    | 61.8    | 11.94  | 0.001°         | 0.27    |
| Middle layer  | 85.2  | 84.4    | 88.9    | 16.7    | 0.001°         | 0.25    | 46.4  | 37.3    | 82.4    | 22.23  | ≤0.001°         | 0.36    |
| Deep layer    | 29.0  | 31.3    | 19.4    | 5.9     | 0.001°         | 0.17    | 12.5  | 11.9    | 14.7    |        |                |         |
| Radial artery | 29.0  | 25.2    | 44.4    | 29.3    | 0.001°         | 0.22    | 19.0  | 12.7    | 44.1    | 17.38  | ≤0.001°         | 0.32    |
| Ulnar artery  | 35.0  | 38.1    | 22.2    | 5.9     | 0.001°         | 0.19    | 14.9  | 12.7    | 23.5    |        |                |         |
| Any artery    | 60.7  | 60.5    | 61.1    | 8.8     | 0.001°         | 0.23    | 31.5  | 23.9    | 61.8    | 18.02  | ≤0.001°         | 0.33    |
| >1 Artery     | 4.4   | 2.7     | 11.1    | 4.9     | 0.049°         | 0.16    | 1.2   | 0.7     | 2.9     |        |                |         |
| Superficial branch of radial nerve | 12.6 | 12.2    | 13.9    | 4.8     | 0.001°         | 0.29    | 8.3   | 7.5     | 11.8    |        |                |         |
| Median nerve  | 33.9  | 29.9    | 50.0    | 5.2     | 0.023°         | 0.17    | 17.9  | 18.7    | 14.7    | 16.1   | 9.7              | 0.001°  |
| Ulnar nerve   | 28.4  | 34.0    | 5.4     | 11.5    | 0.001°         | 0.25    | 16.7  | 20.9    | 8.53    | 8.53   | 0.004°         | 0.23    |
| Any nerve     | 62.8  | 64.4    | 55.6    | 17.6    | 0.041°         | 0.16    | 4.2   | 2.2     | 11.8    | 4.16   | 0.032°         | 0.19    |
| >1 Nerve      | 15.7  | 11.6    | 22.2    | 0.9     | 0.001°         | 0.22    | 13.1  | 9.0     | 29.4    | 9.97   | 0.004°         | 0.24    |
| PL            | 20.8  | 16.3    | 38.9    | 8.9     | 0.003°         | 0.22    | 10.7  | 8.2     | 20.6    | 15.5   | 11.9            | 6.33    |
| FCR           | 33.9  | 27.9    | 58.3    | 12.0    | 0.001°         | 0.26    | 12.5  | 11.9    | 14.7    | 15.5   | 11.9            | 6.33    |
| FCU           | 29.5  | 29.3    | 30.6    | 17.9    | 19.4            | 11.8    | 15.5  | 11.9    | 29.4    | 29.4   | 0.012          | 0.19    |
| FPL           | 13.1  | 12.2    | 16.7    | 7.7     | 8.2             | 5.9     | 4.8   | 3.0     | 11.8    |        |                |         |
| FS2           | 19.1  | 21.1    | 11.1    | 10.1    | 11.9            | 2.9     | 9.5   | 9.0     | 11.8    |        |                |         |
| FS3           | 23.0  | 23.8    | 19.4    | 13.7    | 14.9            | 8.8     | 10.1  | 9.0     | 14.7    |        |                |         |
| FS4           | 27.3  | 29.9    | 16.7    | 17.9    | 20.9            | 5.9     | 10.1  | 10.4    | 8.8     |        |                |         |
| FS5           | 21.9  | 25.2    | 8.3     | 12.5    | 15.7            | 0.0     | 10.7  | 11.2    | 8.8     |        |                |         |
| Any superficial flexor tendon | 37.2 | 39.5    | 27.8    | 29.2    | 26.1            | 11.8    | 16.1  | 14.9    | 20.6    |        |                |         |
| FD2           | 9.8   | 10.2    | 8.3     | 5.4     | 6.0             | 2.9     | 4.2   | 3.0     | 8.8     |        |                |         |
| FD3           | 11.5  | 12.2    | 8.3     | 7.1     | 8.2             | 2.9     | 5.4   | 4.5     | 8.8     |        |                |         |
| FD4           | 16.9  | 18.4    | 11.1    | 9.5     | 10.4            | 5.9     | 8.9   | 9.0     | 8.8     |        |                |         |
| FD5           | 14.2  | 15.6    | 8.3     | 7.1     | 9.0             | 0.0     | 8.3   | 8.2     | 8.8     |        |                |         |
| Any profound flexor tendon | 25.1 | 27.2    | 16.7    | 14.3    | 16.4            | 5.9     | 11.9  | 11.2    | 14.7    |        |                |         |
| Any extensor tendon | 17.5 | 16.3    | 22.2    | 8.3     | 8.2             | 8.8     | 10.7  | 9.7     | 14.7    |        |                |         |
| Any tendon    | 78.7  | 79.6    | 75.0    | 41.7    | 44.0            | 32.4    | 42.9  | 38.1    | 61.8    | 6.22   | 0.013          | 0.19    |

χ² values and corresponding values of \( P \) and Cramér's V (denominated with "V") are given for the comparison between accident victims versus patients after suicide attempts (\( P \) value of Fisher's exact test given when necessary, indicated by °) when reaching the significance level of \( \alpha \leq 0.05 \). Lighter/darker gray background = frequency lower/higher in patients after suicide attempt than in patients after accidents.

APB, abductor pollicis brevis; APL, abductor pollicis longus; ECRB, extensor carpi radialis brevis; ECRL, extensor carpi radialis longus; ECU, extensor carpi ulnaris; ED2–5, extensor digitorum 2–5; EDM: extensor digiti minimi; EII, extensor indicis 2; EPB, extensor pollicis brevis; EPL, extensor pollicis longus; FS2–5, flexor digitorum profundus 2–5.
ulnar nerve (5.4% versus 34.0%). Taking handedness into account, patients after suicide attempts were less likely to have damage to the ulnar nerve on the dominant hand (0.0% versus 20.9%), but more likely to have damage to the median nerve on the nondominant hand (41.2% versus 9.7%). Regarding isolated injuries after suicide attempts, the afflicted structure was mostly an artery (80%), more specifically the radial artery of the dominant hand (70%). In accidents resulting in an isolated injury, the type of the damaged structure was evenly distributed among arteries (32.3%), nerves (35.5%), and tendons (32.3%).

Regarding protective structures, results from accidental DWIs were similar to the whole sample (Table 4). Analogously, in suicidal DWIs with intact PL, damage to the median nerve was less frequent (27.3% versus 85.7%, $\chi^2 (1, 34) = 11.69, P = 0.001$), and in suicidal DWIs with intact FCU, ulnar artery injury was less frequent (8.0% versus 54.5%, $\chi^2 (1, 34) = 9.58, exact P = 0.005$) as was ulnar nerve injury (0.0% versus 18.2%), although the latter comparison did not reach significance. However, in suicidal DWIs with intact FCR, radial artery injury was more frequent than in suicidal DWIs with injury to the FCR (66.7% versus 28.6%, $\chi^2 (1, 34) = 5.14, P = 0.023$).

**Relative Influence of Predictors of Injury Patterns**

To compare the relative influence of the aforementioned variables on the frequency of injuries to specific important structures, we used backward binary logistic regression. Regarding the radial artery, patients with intact protective structure (FCR) were 0.4 times as likely to have injury to the radial artery (for test statistics, see Table 5) and patients after suicide attempt were 3.4 times as likely. Regarding the median nerve, patients with intact protective structure (PL) were 0.2 times as likely to have an injury to the median nerve and patients after suicide attempt were 2.4 times as likely (This coefficient did not reach significance.). Regarding the ulnar artery, patients with intact protective structure (FCU) were 0.1 times as likely to have an injury to the ulnar artery and patients after suicide attempts were 0.4 times as likely (This coefficient did not reach significance.).

**Differences in Injury Patterns Associated with Cut Orientation**

The majority of suicide attempts (81.8%) presented with transversely oriented cuts (ie, perpendicular to the axis of the forearm, see Table 2) and 30.3% with longitudinally oriented cuts. The subgroup with only longitudinal cuts (ie, without transverse cuts) consisted exclusively of isolated injuries. There were no injuries of tendons and less injuries of nerves (16.7% versus 70.4%, $\chi^2 (1, 32) = 5.93$, exact $P = 0.025$) but more injuries to the radial artery (83.3% versus 37.0%, $\chi^2 (1, 32) = 4.24$, exact $P = 0.039$, exact $P = 0.070$) than in the subgroup with transverse suicidal DWIs.

**DISCUSSION**

One in five DWIs in our study originated in a suicide attempt, in accordance with previous studies.4,10,12,17,18 Suicide attempts (94.5%) involved the nondominant hand, whereas in accidents, handedness had no effect on injured side, similar to previous findings.8,13 The preponderance of injuries to the nondominant hand in suicide attempts might be due to habitual usage of the dominant hand when using a tool such as a knife, leaving the unoccupied nondominant hand as potential target for cutting.

Suicidal DWIs were 3.4 times as likely to involve the radial artery and more likely to involve the radial triad (median nerve, PL, and FCR), but accidental injuries were more likely to involve the ulnar triad (ulnar nerve, ulnar artery, and FCU) and FS4/5 on the dominant hand. This pronounced ulnar-radial distribution of injuries according to intentionality is in accordance with some previous studies8,9 and might be a result of hand position at the time of injury: In an accident, reflective
pronation results in the ulnar wrist side protruding farthest outward and thus suffering most of the impact with the injuring object. In suicide attempts, most patients assumedly have enough anatomical knowledge to supinate their hand to injure an artery. This results in the radial side of the wrist pointing upwards and thus being most easily accessible.

Other studies, however, found a more even distribution of injuries, for example, Kabak et al., which might be due to sample differences, as two thirds of the injuries in Kabak et al. stemmed from punching through a window, when either inebriated or infuriated. Such cases would have been excluded from our study due to the impossibility of categorization of intentionality.

Regarding protective structures, intactness of PL and FCU was associated with intactness of the median nerve and ulnar artery/nerve, respectively, in both whole-sample and subgroup analyses, confirming previous findings. Regarding the FCR, its intactness was associated with fewer radial artery injuries in accident victims. Surprisingly, intactness of the FCR in suicidal DWIs was associated with a 2-fold increase in radial artery injuries but a decrease in median nerve injuries, maybe due to the cutting pattern.

Regarding orientation, longitudinal cuts were associated with more radial artery injuries, confirming its common appraisal as the more dangerous variant of suicidal DWI. However, longitudinal cuts involved less damage to tendons and nerves, and may therefore be associated with better functional outcome in survivors.

To the best of our knowledge, the present study has the biggest hitherto published sample size in the field and is one of the first to analyze injury patterns separately according to intentionality of the injury. We excluded self-inflicted injuries without suicidal intent, supposing that patients aiming at emotion regulation will differ from patients aiming at death in cutting pattern, depth, and criteria for termination of cutting (fading of emotion versus subjective injury of vital structures). Also, analysis of dominant versus nondominant sides (instead of right versus left) allowed us to avoid handedness as a confounding factor. However, an important limitation of our study is the retrospective design, leading to missing data. We refrained from correcting for multiple comparisons to prevent accumulation of type II error, thereby exposing our study to the risk of type I errors. Also, as stepwise multiple regression poses the dangers of over- and underfitting the model to the data, our predictor model is only exploratory and needs confirmation or falsification from other populations.

**CONCLUSIONS**

Suicidal and accidental deep wrist injuries (DWIs) differed in various aspects of injury pattern in our study. Suicidal injuries were mostly localized to the nondominant radial side, and accidental injuries to the ulnar side. Also, in suicide attempts, intactness of the so-called protective structure FCR was associated with more radial artery injuries. Thus, findings regarding injury patterns in accidental DWIs cannot be generalized as suicidal injuries, and future research should analyze these patient populations separately. Also, it remains to be investigated whether differences in injury patterns translate to systematic differences in functional outcome between accidental and suicidal DWIs.
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