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Injury patterns and the role of tendons in protecting neurovascular structures in wrist injuries

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ABSTRACT

Purpose: The purpose of this study was to evaluate the anatomical features of injured structures, investigate the protection provided by the specific tendon of each corresponding important neurovascular structure (radial artery, median nerve, and ulnar nerve/artery) and to compare the results among the three categories of wrist injuries.
Methods: This study included 114 patients who underwent primary repair for damaged wrist structures; 40 patients sustained accidental damage without intention (group 1), 40 had self-inflicted damage (group 2), and 34 patients had a stab or penetrating wound caused by a sharp instrument during a conflict or violent event involving another person (group 3). The basic demographic factors, distribution pattern, area, and depth of the injured structures were investigated and compared. The barrier roles of the flexor carpi radialis (FCR) for the radial artery, palmaris longus (PL) for the median nerve, and flexor carpi ulnaris (FCU) for the ulnar nerve were estimated.
Results: In group 1, FCU injury was the most common single-structure injury. In group 2, PL $\pm$ median nerve injuries were the most common. Multiple-structure injuries involving more than five structures occurred more frequently in group 3 than in the other groups. FCU $\pm$ ulnar nerve injuries were more common in group 3 than in the other groups. Radial-side structures were injured most frequently in group 3, and central-side injuries occurred most frequently in groups 1 and 2. Superficial- and middle-layer injuries occurred at similar frequencies among the three groups. Particularly, deep-layer injuries were most weakly related to group 2 injuries. The barrier effects of the FCR, PL, and FCU were confirmed, respectively.
Conclusions: Wrist soft tissue injuries showed particular patterns of injured structures and depths according to the injury mechanism. These patterns included features such as single-structure injuries and the locations and depths of multiple-structure injuries with or without neurovascular injuries. In addition, the roles of FCR, PL, and FCU in protecting important wrist neurovascular structures were confirmed.
Level of evidence: Therapeutic III

Introduction

Wrist injuries are a major clinical concern for hand surgeons. The causes of the injuries and degree of damage to the anatomical structures are varied [1–16]. Particularly, self-inflicted lacerations due to psychological problems show additional features associated with repetition and suicide attempts [3–9,11,13–17]. The epidemiology, injury patterns, psychological analysis, and method of psychological treatment in self-inflicted wrist injury patients have been reported. Some of these patients develop a “chronic wrist cutter” or “wrist-cutting syndrome” state.

Other than self-inflicted wrist injury, the wrist frequently incurs injuries caused by glass, falls, occupational procedures, traffic accidents, violent behaviour, or grinder/saw injuries. We classified these injury types into the following three categories (Fig. 1): (1) accidental damage without intention to injure (group 1), (2) self-inflicted damage regardless of the intention of a suicide attempt (group 2), and (3) stab or penetrating wounds by a sharp instrument during a conflict or violent event with another person regardless of its legality (group 3).

The purpose of the current study was to evaluate the anatomical features of injured structures and investigate the protection provided by tendons to important neurovascular

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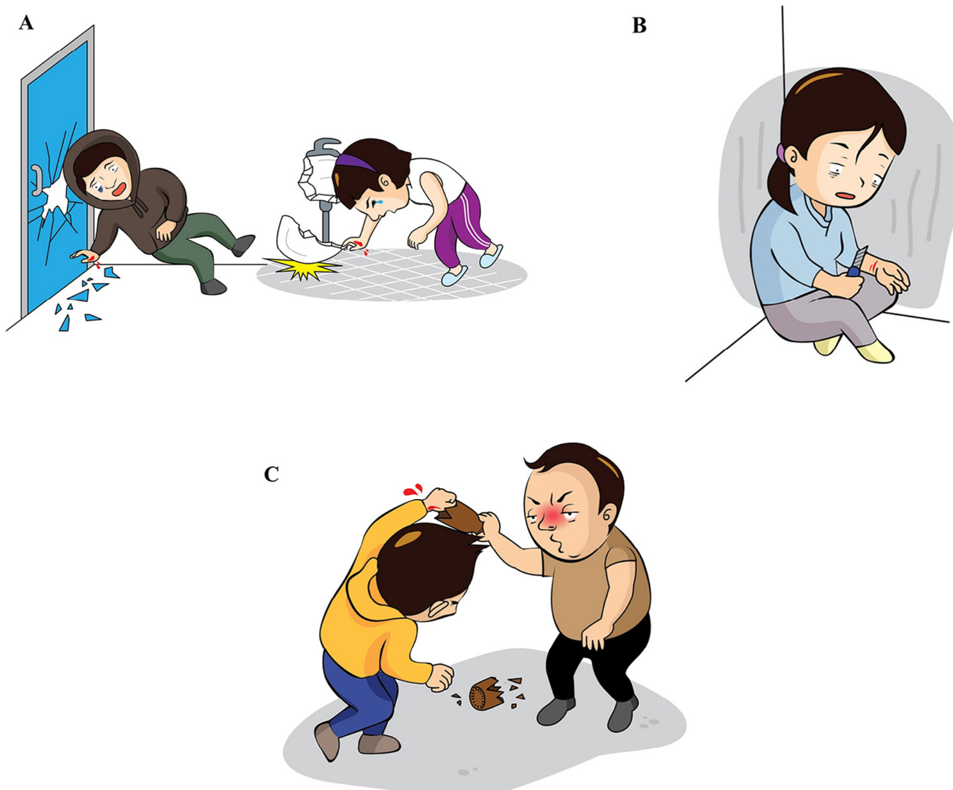

Fig. 1. (A) Accidental damage without intention to injure (group 1). (B) Self-inflicted damage regardless of the intention of a suicide attempt (group 2). (C) Stab or penetrating wounds by a sharp instrument during conflicts or a violent event with another person regardless of its legality (group 3).

structures (radial artery, median nerve, and ulnar nerve/artery) and to compare the results among the three categories. Our hypothesis was that statistical analysis of the injury patterns would elucidate features according to the injury mechanism or cause and the role of each tendon in protecting the major neurovascular structures in the wrist against an external slashing force.

Patients and Methods

Patient selection

Our Institutional Review Board approved the study, and all patients provided informed consent before participation. In total, 114 patients were enrolled from a cohort of 155 patients who had undergone primary repair for damaged wrist structures between March 2011 and July 2014.

The inclusion criteria were (1) normal healthy patients with an acute piercing, (2) penetrating, or stab wrist injury including tendon and neurovascular structures; (3) patients with injured structures in the volar side of the wrist; (4) the presence of a skin lesion 10 cm proximal to the distal wrist crease; (5) the availability of a complete medical record and radiological data; (6) and patients treated by a single orthopaedic/hand surgeon.

We excluded patients with (1) crushing or mutilating injury with loss of wrist soft tissue; (2) a history of trauma below the elbow such as a tendon injury, neurovascular damage, or fractures; (3) a history of surgery at the ipsilateral upper extremity before the current wrist injury; (4) a wrist lesion combined with fractures or open fractures; (5) extension of the lesion to the extensor compartment or to the palm area; an injury to a deformed forearm and wrist; (6) concurrent multiple-site lesions in addition to the wrist; (7) and skeletally immature patients.

Schematization of the wrist structure

We simplified the anatomy of the wrist structures based on axial T1-weighted magnetic resonance images of the wrists of 10 normal adults. These images were all taken from the axial cut at the 5-cm proximal plane, from the radial styloid tip. Next, using the homography transformation method [18], the relative location of each structure was drawn in a schematic manner. Each musculotendinous structure was represented as only the tendon portion for the schematic image. The relative location of each structure was marked as a mean value. The structures were designated serial numbers from the superficial layers (Fig. 2). A three-layer classification was created including the neurovascular structures, and additional classification of the radial, central, and ulnar areas was performed for the current analysis.

Structures 1, 2, 3, 4, and 5 were defined as the superficial layer. These were the palmaris longus (PL), flexor carpi radialis (FCR), third flexor digitorum superficialis (3-FDS), 4-FDS, and flexor carpi ulnaris (FCU), respectively. The intermediate layer comprised structures 6, 7, 8, 9, 10, and 11. These were the ulnar nerve, ulnar artery, 5-FDS, 2-FDS, median nerve, and radial artery, respectively. Structures 12, 13, 14, 15, and 16 were the flexor pollicis longus (FPL), second flexor digitorum profundus (2-FDP), 3-FDP, 4-FDP, and 5-FDP, respectively. Structures 2, 11, and 12 were designated as the radial area, and structures 1, 3, 4, 8, 9, 10, 13, 14, and 15 in the green circle were regarded as the central area. Structures 5, 6, 7, and 16 were defined as ulnar-side structures.

Definition of injury

We defined injury of a tendon as a complete laceration or a partial laceration of >60% of the cross-sectional area of the tendon [19]. This type of injury also indicates the repair of flexor tendons.