Translational key points between radiology, physical examination and hand surgery

Ph.D. Thesis Booklet

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1.Introduction

5.1.1. What is the topic?

Wrist ligamentous injuries and carpal tunnel syndrome are common pathologies in hand surgery. The focus of this research is finding key points in the diagnostic process of these conditions, where efficacy could be improved.

5.1.2. What is the problem to solve?

Diagnostic accuracy of wrist magnetic resonance imaging (MRI) is spread on a large scale. Studies reported the sensitivity of MRI for triangular fibrocartilage complex (TFCC) injuries between 60% and 98.3%, but the reason behind these differences remained unsolved thus far. Currently, the gold standard diagnostic method for ligamentous injuries is wrist arthroscopy. However, the invasiveness and the 1.2% – 7.94% complication rate of this method, as well as its limited availability justify the demand for precise non-invasive imaging for these lesions.

Carpal tunnel syndrome (CTS) occurs at 10% of the patients presenting at a hand surgeon's clinic. The large number of patients calls for an objective screening method, to distinguish between severe and non-severe cases.

5.1.3. What is the importance of the topic?

Effective diagnosis of these conditions is of great importance for physicians and patients alike.

For wrist ligamentous injuries, beside the findings of the physical examination, the result of the MRI is also a potential indicator for surgery. Accurate imaging can prevent unnecessary interventions and help both patients and physicians to prepare for the surgery and the recovery period, manage expectations and treatment planning.

Following carpal tunnel release, the recovery of the median nerve is correlated to the severity of the disease. An objective screening method for severe carpal tunnel syndrome can accelerate the diagnosis and surgical treatment of the selected patients, contributing to better long-term results.

5.1.4. What would be the impact of our research results?

Adequate information about the limits of wrist MRI, both in regard of technical conditions and the anatomic location of the suspected injury, would contribute to a more cautious diagnostic approach, and awareness of the potential error-rate of this imaging modality.

The application of two-point discrimination (2PD) measurement as a screening method during physical examination would form and objective basis to advance the necessary preoperative examinations and the date of the planned surgery for patients with potentially severe CTS, to reduce the chance of irreversible changes.

2. Objectives

2.1. Study I. – Investigating the diagnostic accuracy of MRI for wrist ligamentous lesions

The aim of our study was to determine the diagnostic accuracy of native MRI for ligamentous lesions of the wrist, such as TFCC, scapholunate (SL) and lunotriquetral (LT) ligament injuries and to analyse the underlying influence of technical characteristics, namely field strength, application of fat saturation, 3D sequences, and wrist coils.

2.2. Study II. - Assessing the role of two-point discrimination measurements as a screening method for severe CTS

The objective of our second study was to find out whether 2PD measurement could be used as a screening method to assess the severity of carpal tunnel syndrome.

3.Methods

3.1. Study I. - Investigating the diagnostic accuracy of MRI for wrist ligamentous lesions

This systematic review and meta-analysis was conducted according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. It also followed the Prisma in Exercise, Rehabilitation, Sport medicine and SporTs science (PERSiST) guidelines. The study protocol was registered in the PROSPERO database (registration number: CRD42021282031). Minor deviation from the protocol occurred due to the lack of sufficient data for a subgroup analysis.

The systematic search was executed on the 22nd of October 2022 and was updated on the 12th of February 2024, using MEDLINE (via PubMed), EMBASE, and Cochrane Central Register of Controlled Trials (CENTRAL) databases. Prospective and retrospective observational studies and experimental studies were eligible. We have included studies reporting about the diagnostic accuracy of wrist MRI compared to the gold standard wrist arthroscopy for suspected TCC, SL, LT or ulnotriquetral ligament injuries of adult patients. Studies using intravenous contrast material or arthrography were excluded.

Pooled sensitivity (se) and specificity (sp) values, positive and negative predictive values (PPV, NPV) as well as positive and negative likelihood ratios (LR+, LR-) with 95% confidence intervals were calculated for the overall estimate from all included studies and for selected subgroups based on technical conditions and anatomic location of the suspected injury.

3.2. Study II. - Assessing the role of two-point discrimination measurements as a screening method for severe CTS

The post-hoc cross sectional analysis of prospectively collected data between 2015 and 2019 investigated the role of 2PD in the diagnosis of CTS. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations. It was approved by the Hungarian Scientific and Research Ethics Committee of the Medical Research Council (30/2023). Adult patients who underwent nerve release surgery for CTS at the Department of Orthopaedics at Semmelweis University, who had preoperative electrophysiological (EMG-ENG) or nerve ultrasound examination and had complete documentation of the detailed physical examination with 2PD measurements were eligible for inclusion.

Relationship between 2PD and the results of ENG, of nerve ultrasound, age and sex of patients, the duration of their symptoms and the results of patient questionnaires was examined using Pearson correlation. Diagnostic efficacy, sensitivity, specificity, diagnostic odds ratio and positive and negative likelihood ratios were calculated at different 2PD thresholds for severe CTS.

4.Results

4.1. Study I. - Investigating the diagnostic accuracy of MRI for wrist ligamentous lesions

Following the selection protocol, 37 eligible articles were included to our study. MRI had an overall sensitivity of 0.74 (0.66 – 0.80) and an overall specificity of 0.84 (0.75 – 0.90) for diagnosing wrist ligamentous injuries. The overall PPV was 0.78 (0.70 - 0.85), while the NPV was 0.80 (0.76 – 0.84). Positive likelihood ratio was 4.51 (2.87 - 7.10), while negative likelihood ratio was found to be 0.31 (0.24 – 0.41). Higher filed strength was associated with an increasing tendency in diagnostic accuracy; however, differences between accuracy measures were not significant.

Based on the location of the suspected injury, MRI was proven to be the most accurate in the diagnosis of TFCC peripheral tears, where sensitivity was 0.90 (0.66-0.98), specificity was 0.95 (0.88-0.98). The reliability of MRI for this condition was reflected in the predictive values; PPV was 0.92 (0.82 – 0.97), NPV was 0.93 (0.81 - 0.98), as well as in the likelihood ratios; LR+ was 18.31 (7.69 – 43.62), while LR- was 0.11 (0.03 – 0.40).

MRI diagnosis was the least sensitive for suspected LT ligament injuries (se: 0.41 (0.25 – 0.60)), though specificity remained high (sp:

0.93 (0.81 – 0.98)). Predictive values were also decreased compared to the diagnosis of TFCC peripheral tears, PPV was 0.66 (0.37 – 0.87) and NPV was 0.83 (0.79 – 0.88). Likelihood ratios showed a moderate shift in probability for a correct diagnosis, as LR+ was 6.18 (1.90 – 21.42), while LR- was 0.63 (0.43 – 0.84).

Two-tailed z tests showed no significant difference in accuracy between the subgroups based on anatomic location of the suspected injury.

4.2. Study II. - Assessing the role of two-point discrimination measurements as a screening method for severe CTS

Overall, 81 patients (59 women, 22 men) met our inclusion criteria. 2PD values and severity categories showed significant correlation with the severity of CTS, classified according to the three ENG severity categories (r=0.29, (0.07 – 0.48) and r=0.26 (0.03 – 0.45). Severity based on ultrasound examination measurements however did not show significant correlation with 2PD values and categories. Highest 2PD values were measured along the second digital nerve (7.5 ± 3.64 mm).

Patients with 4 mm or less 2PD all had mild CTS, while patients with moderate CTS had 2PD values varying between 5 and 15 mm, with most of them (25.5 %) having a 2PD value of 8 mm. The optimal

diagnostic accuracy for severe CTS (0.69 (0.59 – 0.79)) was found at a threshold of 9.5 mm. This value had a sensitivity of 0.65 (0.45 – 0.81) and a specificity of 0.71 (0.58 – 0.82). The diagnostic odds ratio for severe CTS was 4.688 (1.664 – 13.203).

5. Conclusions

MRI is a clinically reliable imaging modality in the preoperative diagnosis of wrist ligamentous injuries. Observed tendencies suggest highest accuracy in diagnosing TFCC injuries and decreased performance of low field imaging. However, significant differences were not detected between the examined subgroups based on technical conditions and anatomic location.

2PD measurement is quick, easily applicable diagnostic method, that has the power to act as a screening examination for potentially severe carpal tunnel syndrome, despite its lower accuracy compared to the gold standard electrophysiological examination. Its objective and cost-effective characteristic makes it ideal for follow-up evaluation of the sensory function of the hand as well.

6. Bibliography

Publications related to the thesis

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D1, IF: 5.4

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