The presence of effusions between the volar plate of the proximal interphalangeal joint and the flexor digitorum tendon is a common phenomenon: a single-center, cross sectional study

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Abstract

Aim: In clinical practice, an anechoic signal was often exhibited between the volar plate (VP) of the proximal interphalangeal joint (PIPJ) (PIPVP) and the flexor digitorum tendon (FDT) on ultrasound, which suggests the presence of effusions (PIPVP-FDT effusions). The purpose of this study was to investigate the prevalence of PIPVP-FDT effusions and to explore the possible mechanism preliminarily. Material and methods: A single-center, cross sectional study in hand osteoarthritis (HOA) patients, rheumatoid arthritis (RA) patients and healthy controls was conducted. Ultrasound examination was performed by the same real-time scanner with 18-MHz linear array transducer. Bilateral interphalangeal joints (IPJs) of the thumb, 2nd, 3rd, 4th and 5th PIPJs were examined. The PIPVP-FDT effusions was defined as an anechoic signal between the PIPVP and FDT in two perpendicular ultrasound planes. Results: In total, 200 patients with HOA, 78 patients with RA and 101 healthy controls were eligible for the study. 37.6% of healthy controls and 35.0% of HOA patients showed PIPVP-FDT effusions, while only 11.5% of RA patients had PIPVP-FDT effusions (p<0.001). The 2nd, 3rd and 4th PIPJs showed more PIPVP-FDT effusions, while the IPJs of the thumbs and 5th PIPJs showed less PIPVP-FDT effusions (p<0.05). Furthermore, the prevalence of PIPVP-FDT effusions in different age groups were similar in HOA patients and healthy controls. Conclusion: To the best of our knowledge, this paper is the first to demonstrate that the presence of PIPVP-FDT effusions is a very common phenomenon in HOA patients and healthy individuals, and may be unrelated to inflammation, degeneration and age. Keywords: effusion; ultrasound; volar plate; proximal interphalangeal joint

Introduction

The volar plate (VP) of the proximal interphalangeal joint (PIPJ) (PIPVP) which is composed of a membranous, flexible, proximal part and a cartilaginous, thicker, menisocid distal part is an important part of the joint [1]. It reinforces the volar aspect of the capsule and protects the PIPJ from hyperextension, lateral displacement, and torsional forces [2]. Under normal physiological conditions, the VP provides a smooth sliding surface for the flexor tendon (FDT) [1], and both of them participate in the grasping activity of the hand [2].

In recent years, ultrasound has become a popular imaging tool for evaluating the lesions of hand joints [3,4]. The different structures of PIPJ have different reflecting capabilities that determine their appearance on the ultrasound image. Each structure has its own characteristic and can be clearly observed by a high-frequency ultrasound transducer. The VP on ultrasound is often an isoechogenic and homogeneous structure underlying the FDT [1,5], while longitudinal imaging of FDT shows a typical network of linear hyperechoic fibrillar patterns on ultrasound when the insonation angle is 90º [6]. In general, there should be no abnormal echo signal between PIPVP and FDT on ultrasound. However, an anechoic signal is often exhibited between PIPVP and FDT on ultrasound.
in clinical practice, which may suggest the presence of effusions (PIPJVP-FDT effusions) [7]. The prevalence and mechanism of PIPJVP-FDT effusions have not yet been reported. Therefore, the purpose of this study was to investigate the prevalence of the PIPJVP-FDT effusions by ultrasound in different groups, including patients with hand osteoarthritis (HOA), patients with rheumatoid arthritis (RA) and healthy controls and to further explore the possible mechanism of its occurrence preliminarily.

Material and methods

Patients enrollment

A single-center, cross sectional study in HOA patients, RA patients and healthy controls was conducted at the outpatient clinic of the Department of Rheumatology and Immunology, the Second Affiliated Hospital of Soochow University from June 2017 to February 2018. The diagnosis of HOA patients in this study met the following two points: pain, swelling and (or) morning stiffness in PIPJs, and cortical protrusion (i.e. step-up) observed in two perpendicular ultrasound planes at the PIPJ margin. However, HOA patients were excluded from this study when they were combined with other joint diseases or connective tissue diseases, such as RA, psoriatic arthritis, gout, undifferentiated arthritis, systemic lupus erythematosus, unexplained tendinitis and tenosynovitis of the hand. The RA patients with PIPJs involvement fulfilled the classification criteria of 2010 American College of Rheumatology/European League Against Rheumatism [8]. RA patients complicated with other joint diseases or connective tissue diseases, such as HOA, psoriatic arthritis, systemic lupus erythematosus, were excluded. It should be emphasized that health volunteers were excluded if they met any of the following: recent joint pain, swelling pain, or morning stiffness in PIPJs; cortical protrusion observed in two perpendicular ultrasound planes in PIPJs; cortical defect observed in two perpendicular ultrasound planes in PIPJs; synovial hypertrophy or synovial fluid within articular cavity or flexor tendon sheath of hand on ultrasound. This study was approved by the Human Ethics Review Committee of the Second Affiliated Hospital of Soochow University and written informed consent was obtained from each patient and healthy control, according to the World Medical Association Declaration of Helsinki, revised in 2000, Edinburgh.

Ultrasound examination

Ultrasound examination was performed by the same real-time scanner (MyLab30, Esaote, Italy) with a 8-MHz linear array transducer by a specialized in musculoskeletal ultrasonography who was blinded to other clinical information. All the participants were seated with their hands relaxed in a neutral position on a table. Bilateral interphalangeal joints (IPJs) of the thumb, 2nd, 3rd, 4th and 5th PIPJs were examined. Each joint was scanned in longitudinal plane and transverse plane. The PIPJVP-FDT effusions was defined as an anechoic signal between the volar plate of the proximal interphalangeal joint and flexor digitorum tendon in the same individual, which suggests the presence of effusions. E, effusion; FDT, flexor digitorum tendon; VP, volar plate.

Statistical analysis

All variables were analyzed based on IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp. Continuous variables were presented as means and standard deviation (normal distribution) or median and range (non-normal distribution). Categorical variables were reported as absolute frequency and percentage from the sub/group. The normality was tested by the Shapior-Wilk test. Since the number of joints with PIPJVP-FDT effusions in the patients and controls were non-normal distributed, their differences among HOA, RA and control groups were tested by the Kruskal-Wallis test and the subsequent pairwise comparison. The results of the pairwise comparison were adjusted by the Benjamini-Hochberg method. The correlation of the PIPJVP-FDT effusions number between the right and left hands in each patient was analyzed by Spearman rank correlation analysis and the difference was tested by the Wilcoxon signed-rank test. Chi-square test was used to compare the prevalences of PIPJVP-FDT effusions in different joints and different groups. The significance level was set at p<0.05.

Results

In total, 200 patients with HOA, 78 patients with RA and 101 healthy controls were eligible for the study. Although the average age of HOA and RA group was
older than the healthy group (p<0.05), there were no sex differences. We found that 37.6% (38 out of 101) of healthy controls and 35.0% (70 out of 200) of HOA patients showed PIPJVP-FDT effusions, while only 11.5% (9 out of 78) of RA patients had PIPJVP-FDT effusions (p<0.001). The total number of PIPJVP-FDT effusions was 139 in 38 healthy controls and 165 in 70 HOA patients, but only 25 in 9 RA patients (Table I).

The differences of the PIPJVP-FDT effusions number among HOA, RA and control groups were analyzed. The results of pairwise comparison showed that compared with that in RA patients, the median of PIPJVP-FDT effusions number was larger in HOA patients (p=0.001) and healthy controls (p<0.001) (fig 2), but there were no differences between HOA patients and healthy controls (p>0.05).

As the total number of PIPJVP-FDT effusions in RA patients was too few, we analyzed only the characteristics of PIPJVP-FDT effusions in HOA patients and healthy controls. The correlation between right and left hand PIPJVP-FDT effusions was studied and the Spearman correlation coefficient was 0.690 (p<0.01). The difference of the PIPJVP-FDT effusions number between right and left hands was tested, and the results showed that there were no significant statistic differences (p>0.05) (Table II). The 2nd, 3rd and 4th PIPJs showed more PIPJVP-FDT effusions, while the IPJs of the thumbs and 5th PIPJs showed less PIPJVP-FDT effusions (Table III).

We further analyzed the effect of age on the presence of PIPJVP-FDT effusions in HOA patients and healthy controls. An age value approximating the average age was served as the grouping point. The prevalence of PIPJVP effusions in HOA patients with age < 55 and ≥ 55 years were 36.6% and 33.6% (p>0.05), respectively. In healthy controls, there were also no differences in the

Table I. Characteristics of baseline demographic and PIPJVP-FDT effusions

|                      | HOA patients (n=200) | RA patients (n=78) | Controls (n=101) |
|----------------------|----------------------|-------------------|-----------------|
| Female sex, n (%)    | 162 (81.0)           | 57 (73.1)         | 79 (78.2)       |
| Age (years), mean ± SD | 56.8 ± 12.2†          | 50.9 ± 16.3‡       | 43.6 ± 12.8     |
| Patients with PIPJVP-FDT effusions, n (%) | 70 (35.0) | 9 (11.5)‡       | 38 (37.6)       |
| Total number of PIPJVP-FDT effusions, n | 165 | 25 | 139 |

† p<0.05 compared with controls; ‡ p<0.001 compared with controls; † p<0.05 compared with OA patients; § p<0.001 compared with OA patients; HOA, hand osteoarthritis; RA, rheumatoid arthritis; PIPJVP-FDT effusions, effusions between volar plate of the proximal interphalangeal joint and flexor digitorum tendon.

Table II. The number of PIPJVP-FDT effusions in the right and left hands

|                      | HOA          | Control       |
|----------------------|--------------|---------------|
| Right hand PIPJVP-FDT effusions, n (%) | 83 (50.3) | 72 (51.8) |
| Left hand PIPJVP-FDT effusions, n (%)  | 82 (49.7) | 67 (48.2) |
| Total number, n | 165 | 139 |

HOA, hand osteoarthritis; RA, rheumatoid arthritis; PIPJVP-FDT effusions, effusions between volar plate of the proximal interphalangeal joint and flexor digitorum tendon.

Table III. The number of PIPJVP-FDT effusions in proximal interphalangeal joints

|                      | HOA          | Control       |
|----------------------|--------------|---------------|
| PIPJVP-FDT effusions in IPJs, n (%) | 2 (1.2) | 2 (1.4)‡     |
| PIPJVP-FDT effusions in 2nd PIPJs, n (%) | 40 (24.2)† | 35 (25.2)† |
| PIPJVP-FDT effusions in 3rd PIPJs, n (%) | 69 (41.8)‡ | 45 (32.4)‡ |
| PIPJVP-FDT effusions in 4th PIPJs, n (%) | 44 (26.7)‡ | 40 (28.8)‡ |
| PIPJVP-FDT effusions in 5th PIPJs, n (%) | 10 (6.1) | 17 (12.2)† |
| Total number, n | 165 | 139 |

† p<0.05 compared with IPJs in the same group; ‡ p<0.05 compared with 5th PIPJs in the same group; HOA, hand osteoarthritis; IPJs, interphalangeal joints; PIPJs, proximal interphalangeal joints; RA, rheumatoid arthritis; PIPJVP-FDT effusions, effusions between volar plate of the proximal interphalangeal joint and flexor digitorum tendon.

Fig 2. The distribution of effusions number in RA patients, HOA patients and healthy controls. HOA, hand osteoarthritis; RA, rheumatoid arthritis.
prevalence of PIPJVP effusions between age < 45 years and ≥ 45 years (34.7% versus 40.4%, p>0.05).

Discussion

In our study, we investigated the characteristics of PIPJVP-FDT effusions in HOA patients, RA patients and healthy controls by ultrasound. The prevalence of PIPJVP-FDT effusions in healthy controls was comparable with that in HOA patients and significantly higher than that in RA patients. Moreover, compared with that in RA patients, the median of the PIPJVP-FDT effusion number was larger in HOA patients and healthy controls, but there were no differences between HOA patients and healthy controls (p>0.05). Furthermore, age made no differences in the prevalence of PIPJVP-FDT effusions in HOA patients and healthy controls. Therefore, the presence of PIPJVP-FDT effusions is a very common phenomenon in HOA patients and healthy individuals, and may be unrelated to inflammation, degeneration and age.

Our study also showed that the prevalence of PIPJVP-FDT effusions in 2nd, 3rd and 4th PIPJs were higher than that in IPJs and 5th PIPJs. The IPJs have a narrower range of movement, the 5th PIPJs have the lower motion intensity and the middle three fingers can produce a more powerful mechanical force in grasping, holding and twisting [9,10]. The above analysis may explain why the three middle PIPJs are more likely to produce PIPJVP-FDT effusions. Therefore, the occurrence of PIPJVP-FDT effusions may be related to the intensity of joint movement. In addition, the anatomical structure of the thumb is distinctly different from the other fingers, so the different anatomy may also contribute to the different prevalence of effusions.

The intensity of joint movement may also interpret the differences in PIPJVP-FDT effusions among different groups. RA patients often suffer from severe hand joint pain, dysfunction and even deformity, thus significantly restricting the movement of hand joints [11]; therefore, RA patients had the lower prevalence and median number of PIPJVP-FDT effusions. In HOA patients, the movement intensity of hand joints decreased only slightly due to pain and morning stiffness, so there were no significant differences in the prevalence and median number of PIPJVP-FDT effusions between HOA patients and healthy controls.

Although we did not study the role of the dominant hand in the pathogenesis of PIPJVP-FDT effusions, considering that more people are right-handed, there should be more PIPJVP-FDT effusions in the right hand than in the left hand. Surprisingly, the present study showed that the number of PIPJVP-FDT effusions in the left and right hands was similar; moreover, there was a correlation between the left and right hands in the presence of PIPJVP-FDT effusions. These results suggest that the appearance of PIPJVP-FDT effusions may not be associated with the amount and duration of joint movement, which is supported by the fact that the prevalence of PIPJVP-FDT effusions in younger participants was comparable with that in older people in HOA patients and healthy controls.

A limitation of this study is the lack of homogeneity regarding the age in the three study groups. Ultrasound is more sensitive than conventional radiography in the diagnosis of HOA [12-14]. What’s more, the average age in the HOA group is more than 50 years old. Therefore, it is very difficult to find age-matched controls without PIPJ osteophytes on ultrasound. Moreover, we have verified that age has no effect on the presence of PIPJVP-FDT effusions, so the impact of age differences among three groups may be negligible. Another limitation is the larger female group in the HOA population. HOA patients were recruited through outpatient clinics, suggesting that more women are willing to seek help from doctors than men. This factor contributes to the fact that women outnumber men in our study. In addition, the prevalence of HOA in females is indeed significantly higher than that in males. A Framingham analysis of incidence of HOA showed an age-standardized prevalence of 44.2% in women and 37.7% in men, respectively [15]. At age 63 years, the HOA prevalence was 86% in females and 67% in males, and the difference was statistically significant (p=0.005) [14]. In addition, our study could not demonstrate the validity and interobserver reliability of PIPJVP-FDT effusions on ultrasound, so these will need further investigation in a new cohort study.

In conclusion, to the best of our knowledge, this is the first study that demonstrated that the presence of PIPJVP-FDT effusions is a very common phenomenon in HOA patients and healthy individuals and this may be related to the movement intensity and the anatomical structure of joint rather than inflammation, degeneration and age. However, the exact mechanism and significance of PIPJVP-FDT effusions remain unknown and further investigations are required.

Conflicts of interest: none.

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