FEATURE ARTICLE

Distribution of Highly Prevalent Musculoskeletal Disorders and Their Association With Diabetes Complications in a Population of 140 Individuals With Type 1 Diabetes: A Retrospective Study in a French Diabetes Center

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Although they are usually not considered to be diabetes complications, musculoskeletal disorders (MSKDs) are common in individuals with type 1 or type 2 diabetes and can strongly interfere with daily diabetes care, especially in people using diabetes technologies. The authors of this retrospective study in a population of 140 patients with type 1 diabetes report the distribution of subtypes of MSKDs and speculate about the mechanisms involved. The authors emphasize the need for multidisciplinary care involving not only the diabetes care team but also orthopedic surgeons. This report should lead to large, prospective studies to increase knowledge about these under-studied complications.

An estimated 425 million individuals worldwide have diabetes, of whom about 10% have type 1 diabetes (1). Tight blood glucose control is crucial to prevent long-term diabetes-related chronic complications (2). The past 20 years have been marked by great improvements in insulin injection devices and insulin pump technology, the development of continuous glucose monitoring (CGM) systems (3), and, most recently, the widespread use of flash glucose monitoring (FGM) systems (4).

However, using these technologies requires some degree of strength, dexterity, and upper-limb mobility that might be impaired when musculoskeletal disorders (MSKDs) are present. MSKDs such as frozen shoulder (FS), tendinitis, carpal tunnel syndrome (CTS), and trigger finger are frequently observed in daily practice in patients with type 1 or type 2 diabetes. In addition to their major impact on daily life activities, these conditions can also greatly impair diabetes management and be associated with other major diabetes-related complications, at least in type 1 diabetes. At present, little is known about the underlying mechanisms, prevalence, and distribution by type of MSKDs in patients with type 1 diabetes.

In 2014, the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) research group published a cross-sectional study (5) analyzing the prevalence of MSKDs in 1,217 individuals with type 1 diabetes for a mean duration of 31 years and reported that 807 participants (66%) had at least one MSKD. Those subjects had been included in a landmark interventional randomized controlled trial in the early 1980s. More recently, both the T1D Exchange research group with an Internet-based study on a large cohort (6) and we (7) have reported real-life data. We also reported that having several MSKDs was associated with diabetic retinopathy and with a high cardiovascular (CV) risk assessed by taking a CV treatment (i.e., antihypertensive agent or statin) (7).

In this study, our objective was to analyze the distribution of the MSKD subtypes and speculate on the potential mechanisms accounting for the association of MSKDs with other diabetes complications.

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Patients and Methods

Study Population

The study population has been described elsewhere (7). Briefly, the study included 140 consecutive individuals with type 1 diabetes who were ≥18 years of age and were seen between 1 January 2017 and 31 August 2018 by a diabetologist in an outpatient care facility located in Dijon, France. All data were manually extracted from computerized files. Clinical files are protected using Amazon Web Services security that achieved Health Data Security certification from Agence Nationale des Systèmes d'Information Partagés de Santé (the French Governmental Agency for Digital Health) (8). The diabetologist was the only person who had access to the clinical files, and data were fully anonymized before being processed.

No authorization of any ethic committee is required for such retrospective studies in France, as long as patients receive information. In our study, all of the participants were informed in writing that the electronic records of their medical data could be used for research purposes. Data were collected and stored according to Article 13, Chapter III, Section 2, of the French National Committee for Information Technology and Liberty regulation (9).

Assessment and Classification of MSKDs

MSKD symptoms and history have been routinely searched and collected by the diabetologist. MSKD reports were based on the history section of participants' medical record, reports from orthopedic surgeons, or on patients' complaints and further physical examination. When needed, patients were referred to an orthopedic surgeon in the same outpatient care facility. The reported MSKDs in this study were listed as retractile disorders, including FS (i.e., adhesive capsulitis) and Dupuytren's disease (DD); entrapment syndromes, including nerve entrapment syndromes with CTS, ulnar tunnel syndrome, or Morton's neuroma; and tendon entrapment syndromes, including trigger finger (TF) and de Quervain's tenosynovitis. Medial or lateral epicondylitis were also considered, as well as other forms of tendinitis, including rotator cuff tendinitis, wrist tendinitis, and lower-limb tendinitis. As in the DCCT/EDIC research program (5) and the T1D Exchange registry (6), we did not consider muscle atrophy.

Assessment of Common Diabetes-Related Complications and Other Co-Factors

Common diabetes-related complications were reported according to individuals' medical record (i.e., according to the definitions used in daily clinical practice). Diabetic retinopathy included all stages of retinopathy recorded by the ophthalmologist. Diabetic nephropathy included the presence of confirmed micro- or macroalbuminuria or renal failure. Diabetic neuropathy was diagnosed clinically or according to electromyographic investigations. Cardiovascular disease (CVD) was defined by the presence of previous myocardial infarction or ischemic cardiomyopathy or a history of stroke or evidence of symptomatic peripheral artery disease. A1C values were calculated as the mean of the last three available values in the subject's record (i.e., as, basically, the previous year's mean value). BMI and smoking status were recorded at the most recent visit within the 20-month study period.

Statistical Analysis

Descriptive statistics were expressed as mean ± SD for quantitative variables or number and percentage for categorical variables in the overall population and according to both the presence or absence of MSKDs and the number of MSKDs. *P* values were obtained from χ^2 tests for categorical variables and from *t* tests for continuous variables.

Results

Table 1 summarizes the demographic characteristics of the overall population and the population with no evidence of MSKDs (MSKD−) and the population with one or more MSKDs (MSKD+) and details the characteristics according to the presence of only one MSKD (1 MSKD) or at least two MSKDs (2+ MSKDs).

Among the 140 participants, 40 (28.6%) had at least one MSKD, including 19 subjects (13.6%) who had at least two MSKDs. There was no difference in the presence of MSKDs according to participants' smoking status (i.e., never/former/current smoker). Diabetic retinopathy was present in all patients with MSKDs and other diabetes complications. Diabetic retinopathy, neuropathy, and CVD were observed more frequently in the MSKD+ population compared with the MSKD− population, and CVD was significantly more frequent in the 2+ MSKDs population; among the nine patients with CVD, seven had at least one MSKD and all but one had several MSKDs. Moreover, most of our patients with MSKDs (n = 32 [80%]) were treated with either an antihypertensive agent, a statin, or both and (n = 37 [92.5%]) had other complications (i.e., at least diabetic retinopathy) or were taking a CV treatment.

The distribution of the most frequent MSKDs (present in at least 30% of the MSKD+ population) is shown in Table 2.

TABLE 1 Characteristics of Patients With Type 1 Diabetes According to the Presence and Number of MSKD Components

	Total (n = 140)	MSKD− (n = 100)	MSKD+ (n = 40)	1 MSKD (n = 21)	2+ MSKDs (n = 19)
Age, years	43.4 ± 15.4	39.5 ± 15.3	53.0 ± 11.0†	52.4 ± 13.2	53.7 ± 8.2
Diabetes duration, years	22.5 ± 12.7	19.0 ± 11.5	31.2 ± 11.3†	29.8 ± 13.2	32.7 ± 8.9
Age at diabetes diagnosis, years	20.9 ± 12.9	20.5 ± 13.4	21.8 ± 11.4	22.6 ± 13.2	21.0 ± 9.1
BMI, kg/m^2	26.3 ± 4.5	25.9 ± 4.8	27.2 ± 3.8	26.4 ± 3.9	28.1 ± 3.6
Mean A1C, %*	7.6 ± 1.1	7.6 ± 1.0	7.6 ± 1.3	7.4 ± 1.6	7.7 ± 1.0
Men/women	67/73 (48/52)	49/51 (49/51)	18/22 (45/55)	11/10 (52/48)	7/12 (37/63)
CSII/MDI	92/48 (66/34)	71/29 (71/29)	21/19 (53/47)	15/6 (71/29)	6/13 (32/68)
FGM/SMBG	125/15 (89/11)	88/12 (88/12)	37/3 (93/7)	20/1 (95/5)	17/2 (90/10)
≥1 Complication	48 (34.3)	21 (21.0)	27 (67.5)‡	12 (57.1)	15 (79.0)
Diabetic retinopathy	43 (30.7)	16 (16.0)	27 (67.5)†	12 (57.1)	15 (79.0)
Diabetic nephropathy	10 (7.1)	5 (5.0)	5 (12.5)	4 (19.1)	1 (5.3)
Diabetic neuropathy	9 (6.4)	3 (3.0)	6 (15.0)‡	3 (14.3)	3 (15.8)
CVD	9 (6.4)	2 (2.0)	7 (17.5)†	1 (4.8)	6 (31.6)§
Smoking status					
Current smokers	19 (13.6)	16 (16.0)	3 (7.5)	2 (9.5)	1 (5.3)
Former smokers	36 (25.7)	21 (21.0)	15 (37.5)	10 (47.6)	5 (26.3)
Never smokers	85 (60.7)	63 (63.0)	22 (55.0)	9 (42.9)	13 (68.4)
Age at first MSKD diagnosis, years			47.3 ± 11.0	47.0 ± 13.2	47.5 ± 8.2

Data are mean ± SD or n (%). CSII, continuous subcutaneous insulin infusion; MDI, multiple daily injections; SMBG, self-monitoring of blood glucose. *Mean of the last three available values. †P <0.001 versus MSKD−. ‡P <0.05 versus MSKD−. §P <0.05 versus 1 MSKD.

The most frequent MSKD was FS, which was present in almost half of the MSKD+ population. When FS was present, it was bilateral in 47.4% of cases (9 of the 19 patients with FS). Among the patients with either tendinitis, CTS, or TF, more than one-third also had FS. CTS was an isolated MSKD in only one (7.7%) of the patients with CTS, and ∼70% of the patients with either tendinitis or TF also had other MSKDs. The four patients with DD in our population were all women, and all but one also had FS. The three patients with both DD and FS had bilateral FS.

Discussion

In this real-life retrospective study, we confirm the high prevalence of MSKDs in a population of individuals with type 1 diabetes. We also highlight for the first time the distribution of MSKDs and show the frequent association of MSKDs with other diabetes complications.

The prevalence of MSKDs in our population was about half that reported by the DCCT/EDIC research group (5), whose population had been selected initially in a randomized controlled trial, was older (mean age 52.2 ± 6.9 years), and had a longer diabetes duration (mean duration 31.1 ± 4.9 years) compared with ours (43.4 ± 15.4 and 22.5 ± 12.7 years, respectively). On the other hand, the MSKD prevalence in the T1D Exchange registry (31%) (6) was quite similar to the one we report (29%). Although the methodology differed among those three studies (5–7), all observed that half of patients with both type 1 diabetes and MSKDs had at least 2 MSKDs.

To our knowledge, this is the first report of the distribution of the main MSKDs in patients with type 1 diabetes. We observed that more than two-thirds of our patients with either tendinitis, CTS, or TF had other MSKDs, including FS for more than one-third of the patients. FS was present in almost half of the patients with MSKDs and was often bilateral. This condition can have specific consequences in patients with type 1 diabetes in that it can severely interfere with diabetes care and especially with the use of FGM because each sensor insertion and each scan requires shoulder motion. Although sensor insertion has to be

TABLE 2 Characteristics of Patients With the Most Frequent MSKDs Among the MSKD+ Population

	FS+ (n = 19 [47.5%])	Tendinitis+* (n = 15 [37.5%])	CTS+ (n = 13 [32.5%])	TF+ (n = 12 [30.0%])
Age, years	54.1 ± 9.2	49.1 ± 11.3	56.2 ± 8.3	55.9 ± 8.4
Diabetes duration, years	31.8 ± 12.8	28.5 ± 9.7	33.9 ± 8.6	33.9 ± 7.9
Age at diabetes diagnosis, years	22.3 ± 10.5	20.6 ± 9.5	22.3 ± 10.4	22.0 ± 9.2
BMI, kg/m^2	27.0 ± 3.9	28.5 ± 4.4	29.0 ± 3.7	26.3 ± 4.1
Mean A1C, %†	7.7 ± 1.7	7.3 ± 1.0	7.7 ± 1.1	7.5 ± 0.9
Men/women	7/12 (37/61)	8/7 (53/47)	5/8 (38/62)	3/9 (25/74)
≥1 Complication	12 (63.2)	10 (66.7)	11 (84.6)	9 (75.0)
Diabetic retinopathy	12 (63.2)	10 (66.7)	11 (84.6)	9 (75.0)
Diabetic nephropathy	2 (10.5)	1 (6.7)	2 (15.4)	1 (8.3)
Diabetic neuropathy	3 (15.8)	1 (6.7)	2 (15.4)	1 (8.3)
CVD	2 (10.5)	4 (26.7)	5 (38.5)	4 (33.3)
Smoking status				
Current smokers	2 (10.5)	2 (13.3)	0	0
Former smokers	5 (26.3)	3 (20.0)	5 (38.5)	5 (41.7)
Never smokers	12 (63.2)	10 (66.7)	8 (61.5)	7 (58.3)
Age at first MSKD diagnosis, years	48.5 ± 9.8	44.5 ± 11.8	49.7 ± 9.5	49.0 ± 8.0
1 MSKD	10 (52.6)	5 (33.3)	1 (7.7)	3 (25.0)
2+ MSKD	9 (47.4)	10 (66.7)	12 (92.3)	9 (75.0)
MSKD components				
FS	19 (100.0)	5 (33.3)	5 (38.5)	4 (33.3)
Tendinitis*	5 (26.3)	15 (100.0)	6 (46.2)	5 (41.7)
CTS	5 (26.3)	6 (40.0)	13 (100.0)	5 (41.7)
TF	4 (21.1)	5 (33.3)	5 (38.5)	12 (100.0)
Epicondylitis‡	3 (15.8)	4 (26.7)	4 (30.8)	5 (41.7)
DD	3 (15.8)	2 (13.3)	1 (7.7)	2 (16.7)
Morton's neuroma	1 (5.3)	1 (6.7)	3 (23.1)	1 (8.3)
de Quervain's tenosynovitis	1 (5.3)	1 (6.7)	1 (7.7)	1 (8.3)
Ulnar tunnel syndrome	1 (5.3)	1 (6.7)	1 (7.7)	1 (8.3)

Data are mean ± SD or n (%). CSII, continuous subcutaneous insulin infusion; CTS+, history of CTS; FS+, history of FS; MDI, multiple daily injections; TF+, history of TF. *Shoulder tendinitis (n = 10), wrist tendinitis (n = 3), hip or knee tendinitis (n = 2). †Mean of the last three values available. ‡Medial or lateral epicondylitis.

performed only every other week, the recommended scan frequency is >10 times daily, and much higher if possible (10). So far, the manufacturer of FGM devices has not validated the accuracy of sensors inserted anywhere except the back of the upper arm. Thus, bilateral FS could prevent adequate use of FGM for a long period of time.

Furthermore, FS and DD are often associated, and DD with contracture can reduce the ability to perform fingersticks for self-monitoring of blood glucose in patients who already cannot perform adequately FGM because of FS. Patients with FS could have an eightfold increased risk of DD (11). In our population, four patients had DD, including three with FS. It should be emphasized that all our patients with DD were women. This condition is usually more frequent in men (~80% of cases), and it could have an especially aggressive course in women (12).

The pathogenesis of retractile disorders and the reasons for the higher incidence among people with diabetes remain uncertain. Genetic predisposition was reported in DD, which has been associated, like type 1 diabetes and other autoimmune diseases, with the HLA DR3 and DR4 alleles (13).

The mechanisms of entrapment syndromes involving nerves or tendons are also complex. Entrapment syndromes occur where there is only a tiny space for the tendon to glide or for the nerve to go, such as in TF or CTS. However, the thickening of the sheath around the nerve or the tendon could also play an important role. For example, in nerve entrapment syndromes, the entrapment is partly the result of the accumulation of sorbitol, which leads, by osmotic effect, to an accumulation of fluids into the sheath (14).

The accumulation of advanced glycation end products (AGEs), especially in pericytes, could also play an important role. Although entrapment syndromes occur even in patients with good blood glucose control, their prevalence increases with rising A1C levels (5), and it can be supposed that sustained high blood glucose levels lead to AGE deposits into the collagen and to joint stiffness (15).

The excess of AGEs also leads to a thickening of the vascular wall and secondary excessive production of growth factors (16), inducing fibrosis (17). AGE accumulation is associated with other diabetes complications such as retinopathy (18) and CVD (19). This link could explain the association we observed between the presence of several MSKDs and having diabetic retinopathy or taking a CV treatment (7). We previously reported in the same study population that diabetic retinopathy was associated with the presence of MSKDs (odds ratio [OR] 4.8 [95% CI 1.2–18.9] for 1 MSKD and OR 18.0 [95% CI 3.1–104.4] for 2+ MSKDs) and that taking a CV treatment was independently associated with the presence of several MSKDs (OR 6.7 [95% CI 1.05–43.3]).

In this study, the mean A1C values of the different subgroups appear not to be associated with the presence or the number of MSKDs. However, because A1C does not reflect glucose variability, further studies should be designed to look at possible associations of CGM/FGM parameters and MSKD status.

Initial nerve or tendon abnormality, combined with entrapment, has been called "double crush syndrome" (20). In this syndrome, the nerve or tendon, which is enlarged because of the accumulation of sorbitol and AGEs in the sheath, is trapped in a tiny space. Ultrasound examination and macroscopic observations during surgery of yellow-colored, thickened nerves (21) confirm this hypothesis.

Because these mechanisms do not respond to corticosteroids, surgery appears to be the treatment of choice for entrapment syndrome in patients with diabetes (22). Moreover, corticosteroid injections can deteriorate blood glucose control—although it can be managed—and are less efficient in patients with either type 1 or type 2 diabetes, having only a 9% success rate at 1 year (23). Finally, it is mandatory for orthopedic surgeons operating on patients with type 1 diabetes to be skilled at using surgical approaches that do not require tourniquets to avoid additional tourniquet-induced neuropathy in patients with damaged nerves (24). All of these considerations and precautions are also valid for patients with type 2 diabetes.

There are limitations to our study. First, it was a real-life retrospective single-center study. However, the retrospective design should not have had any impact on our results regarding the distribution of MSKDs. The size of the population was limited, but this did not prevent us from observing the same prevalence of MSKDs as in the T1D Exchange registry (6). That study included a much larger population, with 1,911 of the 6,199 individuals in the T1D Exchange registry answering an Internet survey. Our study is, by design, representative of the people a diabetologist typically sees in clinical practice. Furthermore, we report the same proportion of patients with 2+ MSKDs as in the two published landmark studies (5,6).

Second, it is possible that some people did not spontaneously report MSKDs. However, because MSKDs interfere with daily life and diabetes treatment, it is likely that participants did report MSKDs in most cases. Moreover, with the exception of tendinitis, which could have been under-reported, entrapment syndromes usually lead to surgery, and it can be assumed that retractile MSKDs (FS and DD with contracture) pose such a heavy burden that they would have been reported. We did not have a control group, but the prevalence of MSKDs in a same-age general population was reported much lower than in our study (at 5.0%) (25). Additionally, the fact that only one diabetologist saw all of the subjects led to homogeneity in MSKD assessment.

Third, regarding the various components of MSKDs, we chose to include Morton's neuroma even though it has not been strictly associated with diabetes. Nevertheless, Morton's neuroma is considered to be a type of nerve entrapment (26), and, in our population, the three patients with Morton's neuroma also had at least CTS.

Finally, many patients in our population were treated with statins. Because toxic side effects of statins on tendons have been described (27), it could be argued that tendinitis was related to a statin side effect. However, only one of the 44 patients on a statin had isolated tendinitis (data not shown), making this hypothesis unlikely.

Conclusion

Beyond the reported prevalence and distribution of various MSKDs in individuals with type 1 diabetes, this study has several implications.

It shows how important it is for diabetologists and orthopedic surgeons to work close together in the management of outpatients with diabetes. Diabetologists should be aware of the frequency of MSKDs in patients with type 1 diabetes, look for symptoms, and make early referrals to an orthopedic surgeon when needed.

Conversely, because of the association between MSKDs and other diabetes complications, orthopedic surgeons should check that patients with diabetes have regular follow-up with a diabetologist and that they have had an eye examination and assessment of their CV risk factors. Moreover, they should be aware of the specific physiopathology of entrapment syndromes in patients with diabetes and of the long-term inefficacy of steroid injections. Finally, orthopedic surgeons operating on patients with diabetes must be skilled in minimally invasive techniques to avoid delayed tissue healing and infection and be skilled in surgical approaches that do not involve the use of tourniquets to avoid additional nerve damage.

Further large, prospective studies such as a large French cohort study of patients with type 1 diabetes that is planned to start soon (SFDT1 [Follow-Up of Patients With Type 1 Diabetes in France) are now required to advance our understanding of the mechanisms and prevention of these frequent but under-studied complications of type 1 diabetes.

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DUALITY OF INTEREST

The authors declare that there is no conflict of interest associated with this article. Outside of this work, S.P. has received consulting fees from Abbott, Air Liquide, AstraZeneca, Novo Nordisk, Sanofi, and VitalAire, and G.F. has received consulting fees from AstraZeneca, Danone, Merck Sharp & Dohme, and Roche Diabetes Care. No other potential conflicts of interest were reported.

AUTHOR CONTRIBUTIONS

S.P. was responsible for the original study design and data collection and wrote the manuscript. D.V. contributed to data interpretation and manuscript revision. G.F. was responsible for statistical analyses and manuscript revision. All authors read and approved the final submitted manuscript. S.P. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

REFERENCES

1. International Diabetes Federation. *IDF Diabetes Atlas*. 8th ed. Available from https://www.idf.org/e-library/epidemiology-research/diabetes-atlas/134-idf-diabetes-atlas-8th-edition.html. Accessed 18 August 2019

2. Nathan DM; DCCT/EDIC Research Group. The Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications study at 30 years: overview. Diabetes Care 2014;37:9–16

3. Borot S, Benhamou PY, Atlan C, et al.; Société francophone du diabète [SFD; French-Speaking Diabetes Society], Société française d'endocrinologie [SFE; French Society of Endocrinology]; Évaluation dans le diabète des implants actifs Group (EVADIAC; Assessment of Active Implants in Diabetes). Practical implementation, education and interpretation guidelines for continuous glucose monitoring: a French position statement. Diabetes Metab 2018;44:61–72

4. Bolinder J, Antuna R, Geelhoed-Duijvestijn P, Kröger J, Weitgasser R. Novel glucose-sensing technology and hypoglycaemia in type 1 diabetes: a multicentre, non-masked, randomised controlled trial. Lancet 2016;388:2254–2263

5. Larkin ME, Barnie A, Braffett BH, et al.; Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group. Musculoskeletal complications in type 1 diabetes. Diabetes Care 2014;37:1863–1869

6. Aleppo G, Kanapka LG, Foster NC, et al. T1D Exchange Clinic Network. Cheiroarthropathy: a common disorder in patients in the T1D Exchange. Endocr Pract 2019;25:138–143

7. Picard S, Vasilevski D, Fagherazzi G. Musculoskeletal disorders in patients with type 1 diabetes: an understudied group of diabetes complications that deserves further investigation. Diabetes Metab. Epub ahead of print on 31 January 2019 (DOI: 10.1016/j.diabet.2019.01.009)

8. Agence Nationale des Systèmes d'Information Partagés de Santé [French Governmental Agency for Digital Health]. Certification for health databanks. [In French] Available from https://esante.gouv.fr/labels-certifications/hds/certification-des-hebergeurs-de-donnees-de-sante. Accessed 18 August 2019

9. Commission Nationale de l'Informatique et des Libertés [French National Committee for Information Technology and Liberty]. Individual rights: information and access to personal data. [In French] Available from https://www.cnil.fr/fr/reglement-europeen-protection-donnees/chapitre3#Article13. Accessed 18 August 2019

10. Dunn TC, Xu Y, Hayter G, Ajjan RA. Real-world flash glucose monitoring patterns and associations between self-monitoring frequency and glycaemic measures: a European analysis of over 60 million glucose tests. Diabetes Res Clin Pract 2018;137:37–46

11. Smith SP, Devaraj VS, Bunker TD. The association between frozen shoulder and Dupuytren's disease. J Shoulder Elbow Surg 2001;10:149–151

12. Degreef I, Steeno P, De Smet L. A survey of clinical manifestations and risk factors in women with Dupuytren's disease. Acta Orthop Belg 2008;74:456–460

13. McCarty S, Syed F, Bayat A. Role of the HLA system in the pathogenesis of Dupuytren's disease. Hand (N Y) 2010;5:241–250

14. Sessions J, Nickerson DS. Biologic basis of nerve decompression surgery for focal entrapments in diabetic peripheral neuropathy. J Diabetes Sci Technol 2014;8:412–418

15. Holte KB, Juel NG, Brox JI, et al. Hand, shoulder and back stiffness in long-term type 1 diabetes; cross-sectional association with skin collagen advanced glycation end-products: the Dialong study. J Diabetes Complications 2017;31:1408–1414

16. Mojaddidi MA, Ahmed MS, Ali R, et al. Molecular and pathological studies in the posterior interosseous nerve of diabetic and non-diabetic patients with carpal tunnel syndrome. Diabetologia 2014;57:1711–1719

17. Sharma D, Jaggi AS, Bali A. Clinical evidence and mechanisms of growth factors in idiopathic and diabetes-induced carpal tunnel syndrome. Eur J Pharmacol 2018;837:156–163

18. McVicar CM, Ward M, Colhoun LM, et al. Role of the receptor for advanced glycation endproducts (RAGE) in retinal vasodegenerative pathology during diabetes in mice. Diabetologia 2015;58:1129–1137

19. Monnier VM, Sun W, Gao X, et al.; DCCT/EDIC Research Group. Erratum to: Skin collagen advanced glycation endproducts (AGEs) and the long-term progression of sub-clinical cardiovascular disease in type 1 diabetes. Cardiovasc Diabetol 2015;14:138

20. Rota E, Morelli N. Entrapment neuropathies in diabetes mellitus. World J Diabetes 2016;7:342–353

21. Dellon AL, Williams EH, Rosson GD. Intraoperative appearance of lower extremity peripheral nerves in diabetics and nondiabetics. Plast Reconstr Surg 2012;129:217e–219e

22. Chang CJ, Chang SP, Kao LT, Tai TW, Jou IM. A meta-analysis of corticosteroid injection for trigger digits among patients with diabetes. Orthopedics 2018;41:e8–e14

23. Kameyama M, Funae O, Meguro S, Atsumi Y. HbA_{1c} values determine the outcome of intrasheath injection of triamcinolone for diabetic flexor tenosynovitis. Diabetes Care 2006;29:2512–2514

24. Graham B, Breault MJ, McEwen JA, McGraw RW. Perineural pressures under the pneumatic tourniquet in the upper extremity. J Hand Surg [Br] 1992;17:262–266

25. Alvarez-Nemegyei J, Peláez-Ballestas I, Rodríguez-Amado J, et al. Prevalence of rheumatic regional pain syndromes in adults from Mexico: a community survey using COPCORD for screening and syndrome-specific diagnostic criteria. J Rheumatol Suppl 2011;86:15–20

26. Larson EE, Barrett SL, Battiston B, Maloney CT Jr, Dellon AL. Accurate nomenclature for forefoot nerve entrapment: a historical perspective. J Am Podiatr Med Assoc 2005;95:298–306

27. Ward NC, Watts GF, Eckel RH. Statin toxicity. Circ Res 2019;124:328–350