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Research Article

Visualization of Dupuytren's Contracture Borders Spread According to MRI Data

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Abstract

Dupuytren's Contracture (DC) is a fibro-proliferative tumor according to ICD 10 - fascial fibromatosis of unknown etiology (M 720), accompanied by a stable bending contracture of fingers. In CD in the postoperative period extremely high rate of surgical complications is observed: intraoperative (injury of blood vessels, nerves, tendons), general postoperative (hematoma, necrosis, odema, stiffness, etc.), late postoperative (recurrence, spread, progression). In the last case according to the data of different authors, complications frequency is depend upon the degree (from partial up to the total) and the accuracy of excision of the affected aponeurosis palmaris. One of the problems in choosing the type of operation and technology is the complexity of the cutoff determination boundaries of the affected CD. Up to now there is no suitable for use in the practical CD surgery algorithm of the affected aponeurosis palmaris spread non invasive visualization in a particular patient. The most appropriate method for the solution of this problem is a method of MRI. The technology of identifying the boundaries of surgery of the affected aponeurosis palmaris in Dupuytren's contracture by means of MRI has been elaborated. It has been shown that MRI is a highly informative method in the assessment of topographic anatomy of aponeurosis palmaris in normal and CD states. PD, T1, T2 - weighed images allow objectively to visualize the border areas of the affected aponeurosis in I - III stages of CD. PD fsat (fat tissues signal saturation) MRI mode is not recommended for use.

Introduction

Dupuytren's Contracture (DC) - is a benign fibro-proliferative tumor, according to IDC X - fascial fibromatosis of an unknown aetiology (M 720), accompanied by a stable bending contracture of hand's fingers [1]. Treatment is reduced to elimination of the bending contracture of hand's fingers and to restoration of hand's function. The majority of physicians for the achievement of good results of cure prefer an operative method of treatment. The operative method of DC treatment is simultaneously both the most preferable and the oldest; it has been offered by Cooper in 1822.

However, for today still there is no uniform tactics of the technique of operations, techniques of the excision and a range of excision of the Aponeurosis Palmaris (AP).

Existing methods of the operative treatment of DC can be divided on two basic groups: palliative (excision of the transformed ligament of AP through small cuts on a palm and fingers, a hypodermic section), radical (from partial to total excision of the pathologically transformed ligament of AP).

Extremely high frequency of operational complications are observed at DC in the case of surgical cure: intraoperative (injure of vessel, nerve, tendons) up to 46 % [2], postoperative (hematoma, necrosis, a suppuration, stiffness etc.) up to 22,3 % [3], long term postoperative (recurrence , spread, progressing) - up to 93,75 % [4] which, according to literature, depend on degree (from partial to total) and accuracy of the AP excision [5]. One of the problems in choosing the type of operation and technology is the complexity of the cutoff determination boundaries of the affected CD.

The most adequate method of solving the given problem is the method of MRI. In MRI a strong correlation of the registered signals source (magnetic nucleus of the biochemical substance) location with its resonance frequency and phase occurs. In the other methods, such as microscopy, ultrasonic and x-ray researches, only change of amplitude and a phase of the disseminated wave under the influence of investigated object is used as the source of information. The magnetic field, radio-frequency pulses and a pulse gradient of a magnetic field are necessary for the excitation of atoms of organism, in our case of protons.

Respectively, the times of ^{1}H-NMR relaxation (T_1, T_2) reflect changes of the state of ions of metals, diamagnetics, high-molecular weight compounds [6] and low-molecular weight ligands [7]. Indicators of Protons Density (PD), relaxation times (T_1, T_2) are defined by the properties of the molecules, constituents of tissues, to form a water shell and by the thickness of water layer [8] that is in turn determined by the conformation and structure of sites of the biochemical structures

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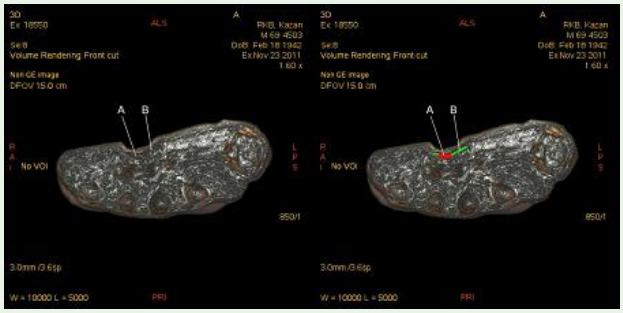

Figure 1: Patient A., age 58. Diagnosis: Dupuytren's contracture, left hand, I grade, 4th finger. Affected part of AP is assigned by letter A, normal part of AP is assigned by letter B, and they were highlighted artificially.

exposed in a water phase. Introduction in clinical practice of MRI has essentially expanded possibilities of diagnostics of various changes of radiocarpal joint and hand, thanks to possibility of reception of the contrast image of soft tissues [9]. MRI finds application in the examination of hand: joints, hyaline shells, swelling around the tendon, necrosis, and bones fractures are visualized well [10].

In clinical practice often speak about T_1 - T_2 - images and proton images. However, in the latter case, correctly to use terms «T_1, T_2 - weighed image» or «the image weighed on pro-ton density» (is more exact - «the intermediate-weighed image») because actually this image depends on all three factors with the prevalence of influence of one of them.

However, till now there is no suitable to application in the surgery of DC an algorithm of the visualization of spread of affected AP in the individual patient.

Research objective: to elaborate a technology of the identification of the borders of operative cure of the affected AP at DC.

Materials and Research Methods

The diagnosis of DC was exposed on the basis of A.P. Bejul's [11] classification, more detailed by L.N. Brjantseva [12]. The latter in a disease severity assessment additionally consider the extent of the palm skin affection.

Object of research

50 patients with DC. The clinical characteristic of patients with DC: gender - men 45, women 5. 1. Age 37 - 72 years. 2. Residing: urban/ 37, rural/ 13. 3. Physical job, the experience / men 10 - 40 years, women / 5 - 30 years. 4. Bad habits: smoking / 32, alcohol / 16. 5. Complicated heredities in the family of father / 9. 6. Presence of Ledderhoze disease / 2. 7. Presence of the super joints pillows / 27. 8. The accompanying and suffered diseases: an osteochondrosis of the cervical region of a back-bone/12, heart attack / 2, chronic hepatitis / 1. 9. The operations and traumas: fracture of a clavicle and gall bladder removal / 1, fracture of shin / 1, bronchial asthma and glauco-ma / 1. 10. The household anamnesis: physical job/ 48, playing sports / 31. 11. The onset of disease: chronic / 50. 12. Prescription of occurrence of disease / 2 - 20 years. 13. Affect on both hands/ 47. 14. Degree of DC (I - III): I / 6; II / 11; III / 33.

We have used MRI system Vantage (XGV Exelart) with the intensity of magnetic field 1.5 T, head coil. Used pulse sequences were the following, PD (density of protons) and projections axial, coronae, PD fsat (with suppression of a signal from adipose tissue) - axial, coronae, T1 - axial, coronae, T2 - axial, coronae. Duration of examination was 40 minutes.

Statistics

Data were presented as median and 95% confidence interval.

Results and Discussion

In a preliminary part of our researches we have made an attempt to solve a task in a view of the present work in an automatic mode, since the commercial software allows to create 2D or 3D images of the goal object, based on registered signals in various operating modes of the device, in particular the image of blood vessels. However, these technologies have restrictions.

We present the clinical example of the automatic calculation by means of a standard program of MRI system. Method of the maximal intensity of projection has been used (Figure 1).

On the image of a cross-section slice (Figure 2) it is visible that there is no contrast between the affected and normal sites of AP (left image) what does not allow in an automatic mode to achieve the object.

Thus, each slice had been analyzed separately. The subsequent reconstruction of 2D images based on the received coordinates was required. 2D image is a target since for the surgeon the borders of affected AP are essential.

After that we have spent comparative identification of borders of spread of the affected AP in 3 ways (Figure 3): 1) before operation 2) during operation 3) according to MRI which was performed before operation.

1. Preoperative measurement of the Area Cooperta Aponeurosis Palmaris1 (ACAP) at patients with DC: visually and manually defined borders of pathological process, high-lighted the contours of pathological process on a hand by means of marker. Length and width of pathological process were measured. Finally geometry and ACAP were defined.

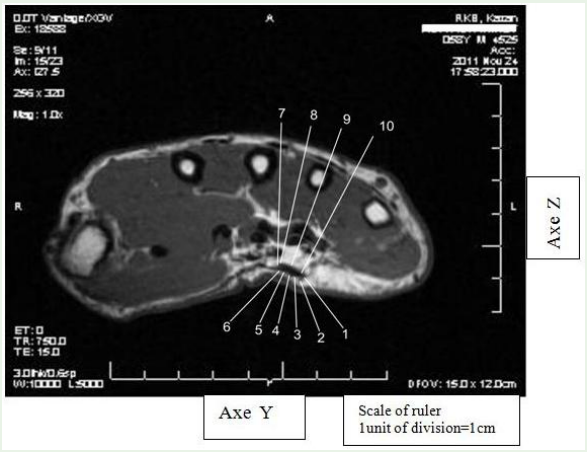

Figure 2 A: Patient F, age 58. Diagnosis: DC of the right hand, I grade, 4 - 5 fingers. The area of affected aponeurosis palmaris (1-10), pulse sequence PD, projection axial.

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Figure 2 B: Patient F, age 58. Diagnosis: DC right hand, I grade, 4 - 5 fingers. The area of affected aponeurosis palmaris (1-15), pulse sequence PD, projection coronae.

2. Intraoperative measurement of ACAP at patients with DC: measured length and width of pathological process, sterile. Defined geometry and ACAP.

3. Definition of ACAP at patients with DC by means of MRI technology (Figures 2,3):

3.1. The geometry of the affected area of AP was defined: the initial starting line for the images was carpi iuncturam, the zero value of 3D systems of coordinates was designated. Coordinate «X» (scale-ruler) passes along the hand, coordinate «Y» (scale-ruler) passes across the hand, the coordinate «Z» (scale-ruler) is perpendicular to the axes X and Y.

Examination level was up to metacarpophalangeal iuncturam, with the step of tomograms $3 \cdot 10^{-3}$ m; 20 - 25 tomograms in axial and 18 - 20 tomograms in coronae projections were registered. Duration of examination was 30 minutes.

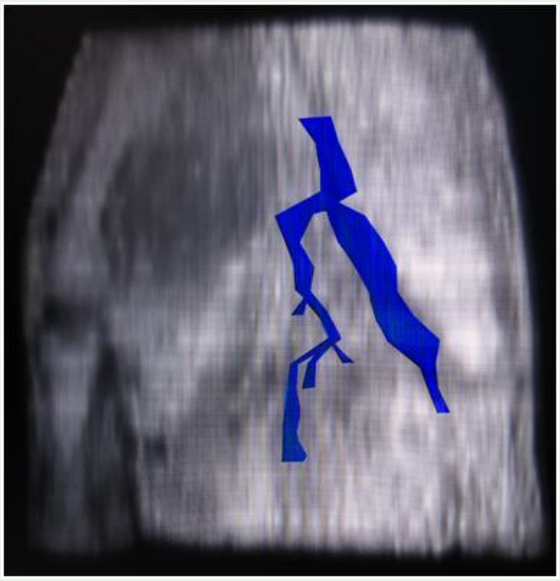

Figure 3: 2D construction of geometry of the affected sites of AP transferred to the MRI image of patient's hand.

3.2. Coordinates of points of the current slice of AP corresponding to the border of affected AP were defined. As a criterion of the AP affect a thickening equal or more than 1 x 10^{-3} m (Figures 2 A,B) was accepted.

3.3. On the basis of the summary of received coordinates 2D construction of geometry of the affected sites of AP was generated, which later was transferred on to the MRI image of patient's hand on the scale of 1:1 (Figure 3). Duration of procedure didn't exceed 10 minutes. Then image (Figure 2) was delivered to surgeon.

The most clear boundary of ACAP was visualized in an axial projection, in modes PD, T_1, T_2, and application of mode PD fsat has worsened the result of visualization (Table 1).

4. Comparison of the area of projections ACAP received at various modes MPT was performed by the transfer of obtained measurements onto the photo of patient's hand on the scale of 1:1 (Table 2, Figure 4).

In all cases of the comparative analysis with MRI data the registered area (%) revealed before/during operation were less (Table 2): PD (-27,99/-57,15), PD fsat (-2,34/-24,7), T_1 (-27,08/-55,35), T_2 (-23,63/-61,89).

Table 1: Comparative measurement of the ACAP (10^{-4} m^2) in DC - before operation, during operation and *in vivo* by means of MRI before operation.

DC, grade	Method of ACAP measurement					
	Before operation	During operation	MRI, mode			
			PD	PD fsat	T_1	T_2
I grade. n = 6	2,32[1] (1,48-3,97)[2]	1,35 (0,80-2,61)	4,79 (2,66-5,99)	3,8 (2,14-6,32)	4,79 (2,56-5,97)	4,4 (3,00-5,27)
II grade. n = 11	3,59 (3,19-4,39)	2,49 (1,43-4,37)	7,38 (4,04-9,27)	2,93 (1,57-4,87)	7,27 (4,13-9,14)	5,56 (2,96-7,97)
III grade. n = 33	3,69 (1,47-5,69)	3,37 (2,14-4,03)	4,51 (3,64-6,80)	4,2 (3,63-5,00)	4,55 (3,67-6,90)	4,47 (4,15-5,29)
I-III grades. n = 50	3,59 (2,57-4,16)	2,49 (1,85-3,27)	4,51 (4,20-6,61)	3,8 (3,06-4,79)	4,55 (4,20-6,59)	4,47 (3,88-5,67)

Note: n- number of patients, 1 - median. 2 - 95% confidence interval.

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Table 2: Divergence of the ACAP values (%) revealed before operation, during operation from the ones obtained *in vivo* by means of MRI before operation.

Grade	MRI mode			
	PD	PD fsat	T1	T2
I grade n = 6	-27,99*[1] / -57,152*[2] ((-6,82) – (-61,19))[1,3] ((-49,04) – (-71,82))[2,3]	-36,57 / -58,08 ((-10,98) – (-54,79)) ((-54,82) – (-64,36))	-27,08 / -55,35 ((-3,60) – (-60,94)) ((-47,75) – (-71,19))	-23,63 / -61,89 ((-1,24) – (-62,35)) ((-39,71) – (-77,01))
II grade n = 11	-48,51 / -54,7 ((-12,14) – (-64,16)) ((-46,69) – (-66,58))	+15,38 / -9,41 ((86,36) – (-24,65)) ((-3,29) – (-15,73))	-48,09 / -55,53 ((-13,43) – (-62,96)) ((-46,84) – (-66,33))	-39,04 / -42,99 ((11,61) – (-57,78)) ((-38,46) – (-54,97))
III grade n = 33	-21,13 / -45,26 ((-3,10) – (-62,81)) ((-21,93) – (-57,95))	-2,34 / -24,7 ((23,85) – (-60,03)) ((-6,39) – (-49,98))	-22,24 / -46,04 ((-7,31) – (-61,54)) ((-26,11) – (-55,98))	-17,37 / -24,63 ((11,13) – (-63,07)) ((-19,06) – (-51,15))
I-III grades n = 50	-27,99 / -57,15 ((-10,87) – (-59,20)) ((-36,45) – (-68,22))	-2,34 / -24,7 ((42,27) – (-55,68)) ((-5,06) – (-59,80))	-27,08 / -55,35 ((-11,48) – (-58,44)) ((-37,94) – (-66,80))	-23,63 / -61,89 ((3,00) – (-56,91)) ((-29,46) – (-63,99))

Notes: n - number of patients,*- median. 1- data obtained before operation, 2 - data obtained during operation, 3 - 95% confidence interval.

It is important that visual and manual preoperative measurement of ACAP is featured by a smaller deviation from MRI than intraoperative. Among the MRI modes the least deviation from the maximal size of ACAP is revealed at use of PD fsat - 2,34 %, (Table 2) that in addition confirms the lowest information content of the given MRI mode at ACAP identification.

Conclusion

The technology of identifying the boundaries of surgery of the affected aponeurosis palmaris in Dupuytren's contracture by means of MRI has been elaborated. It has been shown that MRI is a highly informative method in the assessment of topographic anatomy of aponeurosis palmaris in CD states. PD, T_1, T_2 - weighed images allow objectively to visualize the border areas of the affected aponeurosis in I - III stages of CD. PD fsat (fat tissues signal saturation) MRI mode is not recommended for use.

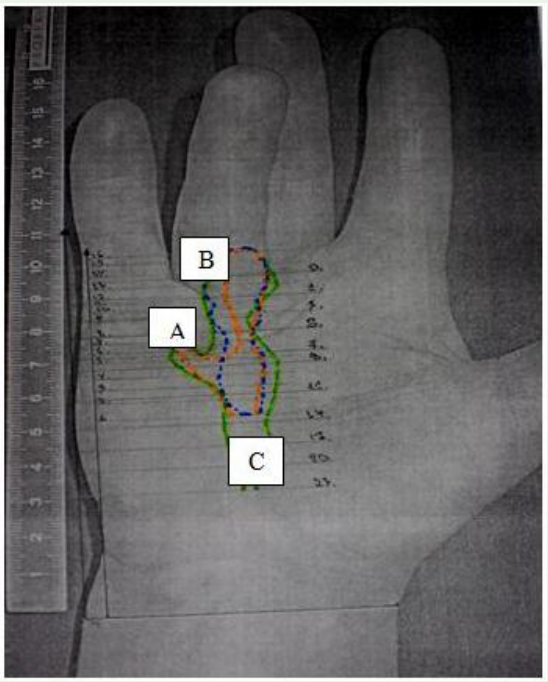

Figure 4: Patient D, age 52. Diagnosis DC, right hand, I grade, 3-4 fingers. ACAP area was defined A - before operation, orange, B - during operation, blue, C - *in vivo* MRI, before operation, green.

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