

Computer assisted diagnosis of benign bone tumours

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Background. The aim of this study is to determine the correlation between computer-assisted diagnosis (CAD) of benign bone tumours (BBT) and their histological type.

Patients and method. Altogether 120 patients were included in two groups. The retrospective group comprised 68 patients in whom the histological type of BBT was known prior to computer analysis. The prospective group comprised 52 patients in whom the histological type of BBT was unknown prior to computer analysis. Computer program was efficient and easy to use.

Results. Average percent of histological type confirmed with CAD in the retrospective and prospective groups was 72.06% and 76.92%, respectively. Histological confirmation of CAD in specific BBT was 91.42% for enchondroma, 96.15% for osteoid-osteoma, and 98.08% for osteochondroma. Significantly lower percentage of CAD confirmation of fibroma, chondromixoid fibroma, osteoclastoma, desmoplastic fibroma and osteoblastoma due to their adverse biological character or complex anatomic localization is understandable.

Conclusions. The results speak in favour of the assumption that computer assisted diagnosis of bone tumours program may improve the diagnostic accuracy of the examiner.

Key words: bone neoplasms – pathology; diagnosis, computer - assisted

Introduction

Diagnosis and treatment of benign bone tumours (BBT) is a multidisciplinary task. Teams of diverse subspecialists are involved

in the process. Good quality plain X-rays may be most helpful in 9 of 10 cases. Bone scan, CT and MRI are additionally needed for the diagnosis, staging and decision making on the management of BBT. The diagnosis of histological type can be done exclusively by a pathohistologist.¹

In the second half of the 20th century, a digital revolution started in the USA. This led to a great advance in technology and data management. A new approach in diagnostics and decision-making process in medicine was

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inevitable. Warner was the pioneer in computer assisted diagnosis (CAD) of congenital heart diseases in 1961.² Lodwick in 1963 gave his preliminary results with computer assisted diagnosis of primary bone tumors.³ Many others followed him soon after: Hall in 1971, Buzdon in 1978, Virtama in 1979, Zafiroski in 1986.⁴⁻⁶ Our task in this study was to determine the correlation between computer-assisted diagnosis (CAD) of benign bone tumours (BBT) and their histological type.

Patients and methods

In this study, 120 patients with BBT were included. The observation period was 7 years. The patients were treated at the Clinic for Orthopaedic Surgery in Skopje. They were divided in two groups. The retrospective group comprised 68 patients in whom the histological type of BBT was known prior to computer analysis. The prospective group comprised 52 patients in whom the histological type of BBT was unknown prior to computer analysis. Of the total of 120 patients, 66 were males and 54 females. The age of patients ranged from 6 to 79 years old (mean 27.4 years). Two thirds

(78 patients) were in the second or third decade of their life. The follow-up was from 2 to 5 years (Table 1).

Osteochondroma was diagnosed in 34.16% (41) of patients and osteoid-osteoma in 35.0% (42) of patients. Enchondroma was found in 13.33% (16) of patients and 7.5% (9) patients were diagnosed with giant cell tumours. Fibroma, desmoplastic fibroma, chondroblastoma, chondromixoid fibroma, osteoblastoma, lipoma and hemangioma were found in 12 patients (10.0%). Enchondromas were 3 times more frequent in female patients while osteochondromas, osteoid-osteomas and giant cell tumours were more often diagnosed in male patients (Table 1).

Most of the authors are using Bayes' theorem of inverse probability as a basic tool for the mathematical model in the computer program. Thomas Bayes (1702-1761) was a minister who gave the basic mathematical values to the outcome and risk, thereby founding a scientific approach to forecasting.⁷

$$P_{y_1}(x_1, x_2, \dots, x_j) = \frac{P_{y_1} P_{x_1} y_1^{(1-P_{x_5} y_1)} \dots P_{x_j} y_1}{\sum_k P_{y_k} P_{x_1} y_k^{(1-P_{x_5} y_k)} \dots P_{x_j} y_k \text{ all } k}$$

Table 1. Patients included in the study and average follow-up

Benign bone tumors	Age (mean yrs)	Gender		Number of cases	%	Follow-up (yrs)
		M	F			
Osteoma	30	0	2	2	1.66	4.5
Osteoid-osteoma	18.3	30	12	42	35.0	5.3
Osteoblastoma	36.5	1	1	2	1.66	5
Enchondroma	40.7	4	12	16	13.33	3.6
Osteochondroma	21.7	24	17	41	34.16	3.3
Chondroblastoma	22	1	0	1	0.83	4
Chondromyxoid fibro.	24.5	0	1	1	0.83	3.5
Osteoclastoma (GCT)	33.8	5	4	9	7.50	4.4
Hemangioma	30	0	1	1	0.83	2
Fibroma	18.7	1	2	3	2.50	3.7
Desmoplastic fibroma	14	0	1	1	0.83	3
Lipoma	39	0	1	1	0.83	3
	Mean	Total		Total	Total	Mean
	27.4	66	54	120	100%	3.8

On y axis of probability matrix, all possible diagnoses (y_1, y_5, \dots, y_j) are given, on x axis, all radiological characteristics of the tumours (x_1, x_5, \dots, x_j) are shown. P is probability, and k is the number of possible diagnosis included in the matrix. For an absolutely correct probability, indefinite number of cases are needed (i), and all variables included should be completely independent.

An adequate vocabulary, based on the radiographic manifestations of BBT, is required for the communication with the computer program.³ The program is capable of predicting 34 different histological types of primary bone tumours and tumour like lesions.⁶ The greatest task with CAD is to achieve a correct histological type of the BBT and to follow two basic principles: (1) the prediction of the diagnosis must be correct in the highest possi-

ble number of cases (ideally in all of them), and (2) if there is a mistake in the prediction, it must not influence further treatment of the lesion in a way that could harm the patient. In the decision-making algorithm, both principles are included.⁸

We compare our prior experiences of radiographic manifestations of BBT with the radiographic manifestations of the new cases. The next task in the algorithm is to eliminate as many data (diagnosis) as possible during the decision-making process. In this process, the strongest criteria for eliminating or including a certain diagnosis are the radiological grade of tumour growth. Many lesions are seen only in the radiological grades of tumour growth Ia, Ib or Ic (Figure 1).⁴ During the analysis of the x-ray, the following data were included: age and gender, localisation of the

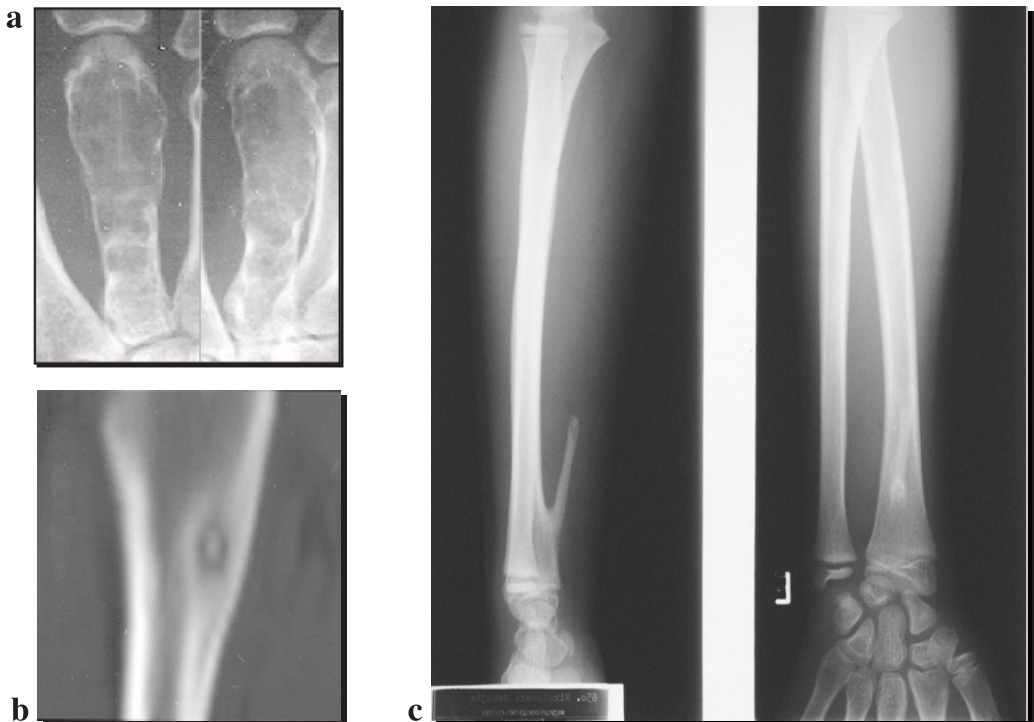


Figure 1. (a) enchondroma in the proximal phalanx of the third finger of the hand, presented with moderate pain until the fracture occurred; (b) CT imaging of osteoid-osteoma in the proximal femur, with typical "nidus"; (c) plain radiograph of the forearm showing osteochondroma of distal radius (almost not seen in frontal plane).

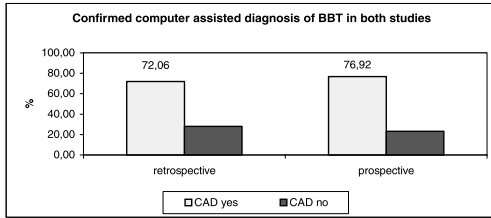


Figure 2. Percentage of confirmed computer assisted diagnosis (CAD) in the retrospective and prospective study.

BBT, bone destruction, destruction of the cortex, periosteal proliferation, tumour matrix mineralisation and size of the tumour.

Results

In this study CAD were compared to the final histological type of BBT. The results showed high statistical significance between the radiographic manifestations of BBT and histological type.

The percentage of confirmed CAD in the retrospective study was 72.06% and in the prospective study 76.92%. There was no statistically significant difference between these results ($\chi^2 = 0.36$; for $r = 0.34$) (Figure 2).

The analysis of different radiographic manifestations in correlation with confirmed CAD was made on a joined number of cases from both studies (retrospective and prospective); so, the results gave greater statistical significance. Highest percentage of CAD was seen in the lesions localised in the cortex of the bone (83.10%) compared to the lesions localized in the bone medulla (61.36%) and other localizations (60.00%). Analysed parameters showed high values of χ^2 test: $\chi^2 = 7.244455$; $r = 0.026723$ for $r < 0.05$.

The highest percentage of confirmed CAD in correlation with expansion of the cortex under the pressure of growing BBT showed lesions without expansion (78.89%). The highest percentage of unconfirmed CAD showed lesions with the expansion of the cor-

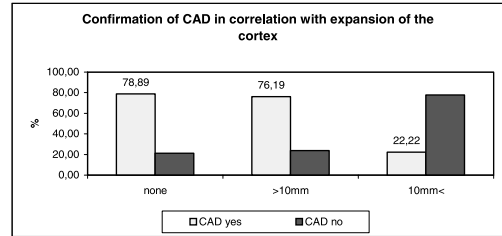


Figure 3. Percentage of confirmed computer assisted diagnosis (CAD) in correlation with the expansion of the cortex.

tex greater than 10 mm (77.78%). Analysed data revealed high statistical significance ($\chi^2 = 13.76689$; $r = 0.001025$ for $r < 0.05$) (Figure 3).

Size of the tumours was measured in millimetres of their longest diameter. Tumours were divided in the group with the confirmed CAD and the group with unconfirmed CAD. Standard error and standard deviation were higher in the group with unconfirmed CAD and average size of 41.8 mm. The values showed statistical significant difference for χ^2 test -21.68123; $r = 0.010638$ for $r < 0.005$.

Discussion

Most of the bone tumours originate from the medullar bone, destructing it prior to the growth of the lesion in the cortex. Unfortunately, this is not seen until 40-50% of the medullar bone is lost. In contrast to the medullar bone, the cortex shows even slightest destruction when appropriate x-ray projection is made. Slow growing and benign bone tumours produce a sclerotic reaction of the surrounding bone.⁹ Analysing these manifestations together with bone tumour matrix one can easily determine the radiological grade of tumour growth. Active, aggressive and malignant should be immediately treated and latent ("live me alone") bone tumours should be regularly inspected and followed.¹⁰ Working with this program for computer-assisted diagnosis of BBT appears to be easy, understandable and can be used by relatively

inexperienced examiner. The use of the program improves diagnostic accuracy significantly and results in improved patient management and cost-saving.⁵

CAD of BBT should be confirmed in the highest possible number of cases (ideally 100%). The average percent of confirmed CAD in retrospective study is 72.06% and in prospective study is 76.92%. This is slightly lower than those in previous studies of Enneking (77.9%) and Bumbasirevic (81.2%).^{4,9} In our study, for some specific benign bone tumours as enchondroma, osteochondroma and osteoid-osteoma, the confirmation is higher than 83.33%. There was no significant influence of the examiner on the results of CAD. The analysis of the results of fibroma, chondromixoid fibroma, osteoclastoma, desmoplastic fibroma and osteoblastoma and lesions localized on scapula and pelvis was inconclusive due to their adverse biological character, low number of cases or complexity of the analysis of the specific anatomic localization.

Best results of CAD were shown when lesions were localized in the cortex, in tumours without expansion of the bone and tumours with average size of 27 mm in diameter. The results support the assumption that the computer-assisted diagnosis of bone tumours program may improve the diagnostic accuracy of the examiner. This is due to an analytic, systematic and logic approach to the analysis of the radiographic manifestations of BBT. A slightly lower percentage of confirmed CAD in the retrospective versus prospective study speaks in favour of that conclusion.

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