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Original Research Article

Preoperative assessment of skin tumor thickness and structure using 14-MHz ultrasound

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ABSTRACT

Objective: The aim of this study was to compare the relationship between skin tumor thickness and homogeneity and to evaluate the accuracy of 14-MHz ultrasound while measuring the thickness of different skin tumors.

Material and methods: The ultrasonographic and histological analysis of 72 skin tumors was performed. Preoperative vertical tumor thickness (*T*) and structure of 12 melanomas, 34 melanocytic nevi and 26 basal cell carcinomas was assessed by 14-MHz ultrasonography. After the tumors were excised the vertical thickness measurement (Breslow index, p*T*) was performed by pathologist. According to the histological thickness all skin tumors were divided to thin (≤1 mm) and thick (>1 mm). The accuracy of the 14-MHz ultrasound measurements and correlation between the ultrasonographic and histological tumor thickness were estimated.

Results: Homogeneous structure was assessed for all thin (≤1 mm) and the majority (81.3%) of thick (>1 mm) melanocytic skin tumors. Nonhomogeneous structure was estimated in thin and thick basal cell carcinomas, accordingly 42.9% and 31.9%. Measurements of *T* and p*T* correlated moderately in thick (>1 mm) tumors ($r = 0.694$), while in thin (≤1 mm) tumors correlation was low ($r = 0.336$). Moderate correlation between ultrasonographic and histological thickness was computed for melanocytic skin tumors as well as for basal cell carcinomas ($r = 0.564$ and $r = 0.690$).

Conclusions: Medium frequency ultrasound is not a reliable tool for the precise measurement of thin (≤1 mm) skin tumors. Ultrasonography using a 14-MHz frequency transducer enables more precisely to measure the thickness of basal cell carcinoma than melanocytic skin tumors. The 14-MHz ultrasound is support tool to suggest the morphologic type of skin tumor.

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1. Introduction

Ultrasound is a noninvasive technique that provides complementary information to the clinical examination of various skin lesions, especially skin tumors. Ultrasonographic assessment of skin tumor margins, thickness, echo pattern and its location may aid the diagnosis, plan the treatment or detect subclinical recurrence of the tumor after treatment.

The prediction of surgical margins of skin melanoma and performance of sentinel lymph node biopsy are based on the tumor thickness assessed according to Breslow [1–3]. Excisional biopsy with histological analysis is the best way to determine the precise tumor thickness. However, it may damage the lymphatic vessels, altering the pattern of tumor drainage, particularly in anatomic regions with ambiguous lymphatic circulation (e.g., neck and trunk) [4–6].

Basal cell carcinomas (BCCs) are more accurately identified and measured ultrasonographically, often yielding the larger measurements than those obtained at clinical examination which can be particularly important at locations with a higher risk of recurrences, mainly face [7–9]. According to the 7th edition of the American Joint Committee on Cancer Classification (AJCC), the thickness more than 2 mm of BCC has been included as one of the high-risk factors for tumor staging [10]. Ultrasound allows the surgical planning of BCC to be adapted by identifying the extent of the tumor. It can also help to monitor the early detection of recurrence of BCC [11–13].

In previous studies investigators have evaluated good accuracy of the ultrasonography with higher than 20-MHz scanners to determine the margins and thickness of BCC and skin melanoma [4,5,8,14]. Assessment of skin melanoma thickness using transducers of 100-MHz frequency has better agreement with histology compared to 20-MHz ultrasonography. There is the tendency of 20-MHz device to overestimate tumor thickness because of several factors, e.g. tumor regression, lymphocytic infiltration [15]. However, in case of 100-MHz ultrasonography, the ultrasonic penetration depth is limited to 1.5 mm [5]. In the recent years technologic advances have improved the quality of the more commonly available ultrasonic scanners having frequency close to 15 MHz, allowing axial and lateral resolutions of 0.1 mm in superficial planes at those frequencies [16]. There are reported data showing higher agreement between ultrasonically and histologically determined thickness in thicker (>2 mm) skin melanomas and lower in thinner (1–2 mm) skin melanomas while using a 14-MHz ultrasound transducer [17]. Other investigators give a high accuracy of 10-MHz ultrasound measurements when evaluating skin melanomas of >1 mm thickness [18]. The thickness of BCC can be accurately estimated when using a 7–15-MHz ultrasound transducer [7]. Higher frequency ultrasonography can show nonhomogeneously scattered internal echoes in basal cell carcinoma and homogeneous reflex pattern in melanoma [11,19]. There is insufficient information about the effectiveness of 14-MHz ultrasound when estimating the homogeneity of skin tumors.

According to these controversial results we designed a study to evaluate the accuracy of 14-MHz ultrasound for the preoperative assessment of the thickness and structure of melanocytic skin tumors and BCC.

2. Material and methods

A total of 72 patients (26 men and 46 women) with clinically and dermatoscopically identified melanocytic tumors and BCCs in various locations before the excision were included in the study. The study was carried out from January 2010 through 2011. The tumor structure and thickness were evaluated ultrasonographically before surgical treatment. The maximum tumor thickness (*T*) measurements were made in B-scan from the lower edge of the entry echo to the inferior boundary of the echo-poor region representing the tumor (Figs. 1 and 2). Vertical tumor thickness of 34 melanocytic nevi, 12 melanoma and 26 basal cell carcinoma was preoperatively assessed using a 14-MHz Toshiba Xario XG ultrasonic scanner (Tokyo, Japan). All skin tumors were surgically excised and processed for routine histopathology. The vertical distance from the uppermost level of the stratum granulosum in the epidermis to the lowest point of the tumor (Breslow index, p*T*) was recorded in mm. The pathologist who measured the tumor thickness did not know the thickness of the lesion estimated by ultrasonography. According to the histological thickness (p*T*) all skin tumors were divided to thin (≤1 mm) and thick (>1 mm). Melanocytic skin tumors (melanocytic nevi and melanoma) were analyzed together in one group. Distribution of internal echoes (homogeneous or nonhomogeneous) was assessed in skin tumors according to the morphological analysis of an ultrasonographic structure by Altmeyer and Hoffman [19]. Analyses were conducted using SPSS statistical software (version 13.0, SPSS for Windows). The descriptive summary statistics and techniques include frequencies, means, standard deviations, standard errors and graphs. The nonparametric Wilcoxon test, Spearman correlation coefficient, and chi-square test (χ^2) were used for statistical analysis. The data were given as mean values and 95% confidence interval (95% CI) as deemed appropriate. Sensitivity, specificity, and accuracy of the 14-MHz ultrasonography method were calculated when using standard descriptions and formulas for these values given under Table 2.

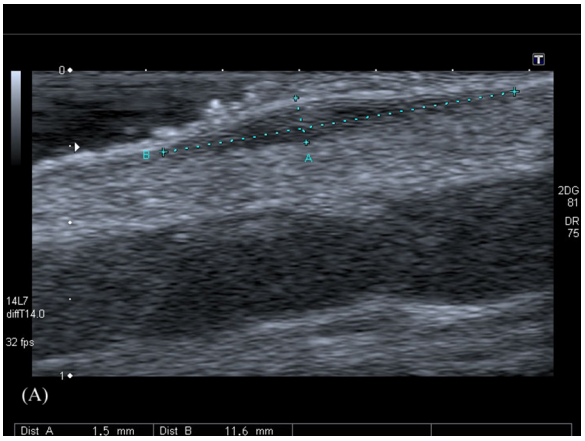

Fig. 1 – 14-MHz ultrasound image of skin melanoma (*T* = 1.5 mm).

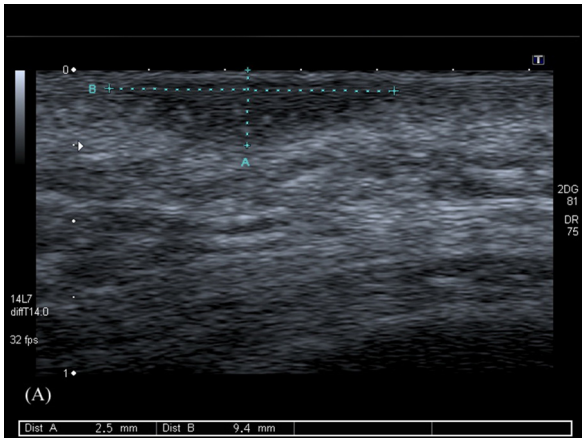

Fig. 2 – 14-MHz ultrasound image of basal cell carcinoma (T = 2.5 mm).

3. Results

The mean age of 72 patients enrolled in this study was 49.29 years (range, 18–80 years). The locations of the investigated 72 skin tumors are presented in Table 1. Most cases of melanocytic nevi were located on trunk, while skin melanoma on the trunk or lower extremities, and BCC on the head, the face, or the trunk, correspondingly.

Histologically there was estimated the thickness of ≤1 mm in 37 lesions and >1 mm in 35 tumors. The 14-MHz ultrasound measurements of skin tumors showed a sensitivity of 79.3%, a specificity of 67.4%, NPV of 82.25%, PPV of 62.2%, and accuracy of 72% (Table 2). When estimating by 14-MHz frequency ultrasonic transducer 12/72 skin tumors had nonhomogeneous structure and 60/72 homogeneous structure. Homogeneous structure was assessed for all thin (≤1 mm) and the majority (81.3%) of thick (>1 mm) melanocytic skin tumors. Nonhomogeneous structure was estimated in thin (≤1 mm) and thick (>1 mm) basal cell carcinomas, accordingly 42.9% and 31.9%.

The mean thickness of thin (≤1 mm) tumors using a 14-MHz frequency ultrasonic transducer was 0.71 mm (95% CI, 0.65–0.78) compared to 1.14 mm (95% CI, 0.86–1.43) determined by histometry. The ultrasonographic mean thickness of thick (>1 mm) tumors was 2.07 mm (95% CI, 1.76–2.37) compared to 2.5 mm (95% CI, 1.95–3.05) determined histologically. The comparison of *T* and p*T* measurements showed a low correlation of 0.336 in thin (≤1 mm) skin tumors and a moderate correlation of 0.694 in thick (>1 mm) lesions (Table 3). The thickness measured by a 14-MHz ultrasonic transducer had a good correlation for basal cell carcinoma ($r = 0.690$), although a lower accuracy ($r = 0.564$) for melanocytic tumors (Table 4). Ultrasonographic measurements correlated well with the histological data in thick (>1 mm) melanocytic skin tumors and basal cell carcinoma ($r = 0.783$

Table 1 – Location of skin tumors assessed by 14-MHz ultrasonography.

Location	Melanocytic nevi	Melanoma	Basal cell carcinoma
Head and face	3	2	10
Trunk	24	4	9
Upper extremities	2	2	2
Lower extremities	5	4	2
Other	0	0	3
Total	34	12	26

Values are numbers.

Table 2 – Thickness of skin tumors measured using 14-MHz ultrasonography versus histological measurements.

Ultrasound measurements	Histological measurements		All	Prognostic value
Melanocytic tumors	p*T* ≤1 mm	p*T* >1 mm		
≤1 mm	19 (*a*)	11 (*b*)	30	63.3% (PPV)
>1 mm	4 (*c*)	12 (*d*)	16	75% (NPV)
All	23	23	46	
Basal cell carcinoma	p*T* ≤1 mm	p*T* >1 mm		
≤1 mm	4 (*a*)	3 (*b*)	7	57.14% (PPV)
>1 mm	2 (*c*)	17 (*d*)	19	89.47% (NPV)
All	6	20	26	
Skin tumors of both types	p*T* ≤1 mm	p*T* >1 mm		
≤1 mm	23 (*a*)	14 (*b*)	37	62.2% (PPV)
>1 mm	6 (*c*)	29 (*d*)	35	82.25% (NPV)
All	29	43	72	

p*T*, histological thickness; PPV, positive predictive value; NPP, negative predictive value.
For melanocytic tumors: sensitivity $a/(a + c) = 19/(19 + 4) = 82.6\%$, specificity $d/(d + b) = 12/(12 + 11) = 52\%$, NPV $d/(c + d) = 12/(4 + 12) = 63.3\%$, PPV $a/(a + b) = 19/(19 + 11) = 75\%$, accuracy $(a + d)/(a + b + c + d) = 31/46 = 67\%$.
For basal cell carcinomas: sensitivity $a/(a + c) = 4/(4 + 2) = 66.7\%$, specificity $d/(d + b) = 17/(17 + 3) = 85\%$, NPV $d/(c + d) = 17/(2 + 17) = 89.47\%$, PPV $a/(a + b) = 4/(4 + 3) = 57.14\%$, accuracy $(a + d)/(a + b + c + d) = 21/26 = 80\%$.
For skin tumors of both types: sensitivity $a/(a + c) = 23/(23 + 6) = 79.3\%$, specificity $d/(d + b) = 29/(29 + 14) = 67.4\%$, NPV $d/(c + d) = 29/(6 + 29) = 82.85\%$, PPV $a/(a + b) = 23/(23 + 14) = 62.2\%$; accuracy $(a + d)/(a + b + c + d) = 52/72 = 72\%$.

Table 3 – Correlation between the histological and ultrasonographic estimation of thin and thick skin tumors using a 14-MHz frequency transducer.

Thickness (pT) of skin tumors	Number	Mean ultrasonographic tumor thickness (mm) (95% CI)	Mean histometric tumor thickness (mm) (95% CI)	Spearman correlation coefficient (r)
Thin (≤1 mm)	37	0.71 (0.65–0.78)	1.14 (0.86–1.43)	0.336
Thick (>1 mm)	35	2.07 (1.76–2.37)	2.50 (1.95–305)	0.694

pT, histological thickness in mm.

Table 4 – Correlation between the histological and ultrasonographic estimation of melanocytic tumors and basal cell carcinomas using a 14-MHz frequency transducer.

Skin tumors	Number	Mean ultrasonographic tumor thickness (mm) (95% CI)	Mean histometric tumor thickness (mm) (95% CI)	Spearman correlation coefficient (r)
Melanocytic tumor	46	1.19 (0.93–1.45)	1.81 (1.31–2.31)	0.564
Basal cell carcinoma	26	1.68 (1.31–2.06)	1.79 (1.43–2.15)	0.690

Table 5 – 14-MHz ultrasonography thickness agreement with histology in thin and thick melanocytic tumors and basal cell carcinomas pT, histological thickness in mm.

Skin tumors (pT)	Number	Mean ultrasonographic tumor thickness (mm) (95% CI)	Mean histometric tumor thickness (mm) (95% CI)	Spearman correlation coefficient (r)
Melanocytic skin tumor (≤1 mm)	30	0.70 (0.63–0.76)	1.14 (0.80–1.48)	0.417
Basal cell carcinoma (≤1 mm)	7	0.79 (0.56–1.01)	1.16 (0.56–1.75)	0.860
Melanocytic skin tumor (>1 mm)	16	2.13 (1.64–2.61)	3.06 (1.96–4.17)	0.783
Basal cell carcinoma (>1 mm)	19	2.02 (1.60–2.44)	2.03 (1.61–2.45)	0.720

Table 6 – Ultrasonographic and histological thickness of skin tumors according to their structure estimated using a 14-MHz frequency transducer.

Skin tumors	Number	Mean ultrasonographic tumor thickness (mm) (95% CI)	Mean histometric tumor thickness (mm) (95% CI)	Spearman correlation coefficient (r)
Homogenic structure	60	1.28 (1.05–1.52)	1.74 (1.37–2.10)	0.580
Nonhomogenic structure	12	1.82 (1.25–2.38)	2.14 (1.16–3.13)	0.717

and $r = 0.720$, respectively). While thin (≤1 mm) melanocytic tumors showed a weak ultrasonographic and histological correlation ($r = 0.417$), correspondingly in thin (≤1 mm) basal cell carcinomas it was insignificant ($P = 0.860$) (Table 5). The correlation between T and pT in skin tumors of nonhomogeneous structure was stronger ($r = 0.717$) than in those of homogeneous structure ($r = 0.580$) (Table 6). A strong correlation of T and pT was obtained in nonhomogeneous basal cell carcinomas ($r = 0.760$), while the groups of homogeneous basal cell carcinoma and homogeneous melanocytic skin tumors had a moderate correlation ($r = 0.603$ and $r = 0.567$, accordingly). There were only a few cases of nonhomogeneous melanocytic skin tumors (Table 7).

4. Discussion

The ultrasound of 100-MHz frequency allows detailed visualization of the upper skin layers especially the horny layer and small structures in it while 20-MHz ultrasound is valuable to discriminate between the viable epidermis and papillary dermis and tumor cell nets especially in BCC [20]. Due to higher frequencies ultrasound provides higher resolution but sacrifices tissue penetration so the ultrasonic transducers from 7.5 up to 12–15 MHz are commonly used in clinical practice to estimate the skin tumor thickness [5,14,17,21]. When the tumors extend beyond the dermis-subcutis border, the demarcation may become difficult because apart from connective tissue septae, the subcutaneous fatty tissue is also hypoechogenic. In most studies for evaluation of skin lesions the investigators have used an ultrasonic transducer of 20 MHz [22–33]. In the current study we have investigated the possibility of using a 14-MHz ultrasonic transducer for measuring skin tumor thickness before the surgical excision. Our results have shown the ability of a 14-MHz ultrasonic transducer to distinguish thick tumors better than thin though in the studies of Vilana et al. and Music et al. the 10-MHz and 12–15-MHz ultrasonic transducers can reliably discriminate between thin (≤1 mm) and thick (>1 mm) skin melanocytic tumors [18,34]. Several factors could influence our results. A

Table 7 – Ultrasonographic and histological thickness of melanocytic tumors and basal cell carcinomas according to their structure estimated using a 14-MHz frequency transducer.

Skin tumors	Number	Mean ultrasonographic tumor thickness (mm) (95% CI)	Mean histometric tumor thickness (mm) (95% CI)	Spearman correlation coefficient (*r*)
Homogenic melanocytic tumor	43	1.14 (0.88–1.41)	1.72 (1.23–2.20)	0.567
Non-homogenic melanocytic tumor	3	1.93 (0.00–3.86)	3.13 (0.00–10.34)	NA
Homogenic basal cell carcinoma	17	1.64 (1.15–2.12)	1.78 (1.30–2.27)	0.603
Non-homogenic basal cell carcinoma	9	1.78 (1.04–2.52)	1.81 (1.16–2.46)	0.760

NA, not applicable.

larger sample size normally should lead to a better estimate of accuracy as in the study it was found to be worthless when measuring thin skin tumors. In our study the anatomic localization of skin tumors was different and most of the skin tumors were located on a head, face and trunk. Ultrasonographic determined tumor thickness may exceed the measurement of histological sections partly due to the shrinkage of tissue processed for histology or probe pressure during the ultrasound scanning. A similar situation occurs while scanning a recurrent BCC because of the scar formation caused by a previous cutaneous surgery [8,14,35]. In our study when analyzing skin tumors according to the different morphology higher correlation was estimated between the histological and ultrasonographic thickness in basal cell carcinomas than in melanocytic tumors. Bobadilla et al. proved the strong correlation between the 7–15-MHz ultrasound depth measurements and histological measurements when estimating 25 facial basal cell carcinomas [7]. In the other studies the clinical dimensions (without histology) and ultrasonographic measurements of basal cell carcinomas were compared and the stress was put on lateral measurements of basal cell carcinomas but not thickness [8,9].

Considering melanocytic skin tumors, there was an estimated higher correlation between the histological and 14-MHz ultrasonographic examination in thick (>1 mm) melanocytic tumors compared to thin (≤1 mm). Gamblicher et al. observed the lower accuracy for ultrasonographic measurements of melanocytic skin lesions with a tumor thickness smaller than 1 mm using 20-MHz ultrasound while Lassau et al. determined the strong correlation between the thickness assessed by 20-MHz ultrasound and histology in 27 thin (≤1 mm) melanomas [5,36].

An inflammatory infiltrate or melanocytic nevus structures underlying tumor is an important source of overestimation. The inflammatory process weakens viable tissue causing the decreased echogenicity than of normal skin, contributing to the increased size of a skin tumor [27,35,36]. Similarly to the other studies [18], the melanocytic skin tumors were mainly visualized as homogeneous (hypoechogenic) structures within the hyperechogenic dermis. BCCs were evaluated more heterogenic tumors (showed a mixed echogenicity). When comparing the BCCs of different homogeneity there was identified better correlation between 14-MHz ultrasonographic and histological thickness in nonhomogeneous BCCs.

Our study had several limitations. We did not assess the reproducibility of the ultrasonographic (*T*) and histological (p*T*) measurements (intraobserver variability). Skin tumors were of different localization, and the low number of basal cell carcinomas did not support the estimation of significant correlation between ultrasonographic and histological thickness in that group. Despite that, the study attempted to compare histological and 14-MHz ultrasonographic thickness of skin tumors and made no assessment as to how this might affect the treatment of skin tumors.

5. Conclusions

We conclude that 14-MHz ultrasound is not a reliable tool for the precise measurement of thin (≤1 mm) skin tumors thickness and it enables more precisely to measure the thickness of BCCs than melanocytic skin tumors. 14-MHz ultrasound is a support tool in diagnosing skin tumors as structure of thin (≤1 mm) skin tumors could suggest the morphologic type of tumor. The homogeneous structure is specific for melanocytic skin tumors, while homogeneous and nonhomogeneous structure is characteristic for BCCs.

Conflict of interest

The authors state no conflict of interest.

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