

## Sonoelastography for Skin Evaluation in Sclerodermic Patients

### Abstract

**Background:** The objective of the study is to evaluate elastography ultrasound findings in patients with scleroderma (SS) and to clarify the effectiveness of elastosonography to differentiate scleroderma lesions from any skin lesion considering tissue elasticity. **Methods:** Thirty-six SS patients definite diagnosis of systemic sclerosis according to American College of Rheumatology criteria and 36 healthy subjects were enrolled. Volar aspect of the middle forearm and arm in addition to the dorsal aspect of the fingers were evaluated by sonoelastography. The RGB (red, green, blue) image is a three-dimensional matrix. A color image RGB is an  $M \times N \times 3$  array of color pixels. The total pixels, total blue pixels, and blue index compared between SS cases and controls. **Results:** Mean age of patients was  $41.3 \pm 10.3$  years and mean age of controls was  $39.8 \pm 9.3$  years. Mean-modified Rodnan skin score of the whole body was 11.9 and mean duration of disease was 6.2 years. Mean total blue pixels in the arm were significantly different between cases and controls. Mean total image pixels, total blue pixels, and blue index in the forearm were significantly different between cases and controls. Elastography findings in the finger were not significantly different between cases and controls. **Conclusions:** Sonoelastography could be used for evaluating skin of forearm in sclerodermic cases which will be helpful for disease evaluation in clinical course.

**Keywords:** Elasticity imaging techniques, scleroderma, skin

### Introduction

Systemic sclerosis (SSc) is an autoimmune disease. It is characterized by inflammation, progressive thickening, and fibrosis of the skin and internal organs.<sup>[1,2]</sup> The clinical course of the disease has wide range: from limited form which involves only skin and peripheral vessels to diffuse form which leads to skin and internal organ fibrosis.<sup>[2]</sup>

Conventional ultrasound techniques are useful to assess the skin thickness and its echogenicity<sup>[3]</sup> but evaluation of skin elasticity is not possible by conventional probes. So, ultrasound elastography which is based on the degree of tissue displacement in response to compression and decompression of the external forces could be applied to assess skin elasticity.<sup>[4]</sup> Sonoelastography is a new sonographic technique that has been applied to assess qualitative assessment of the target tissue.<sup>[5]</sup> Soft tissues move more than stiff tissues in response to compression and de-compression. So, they show different colors. This technique has been applied for different tissues such as breast, thyroid, pancreas, and liver.<sup>[4]</sup>

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Little studies exist on its application for skin. We designed this study to clarify the effectiveness of elastosonography to differentiate scleroderma lesions from any skin lesion considering tissue elasticity.

### Methods

This cross-sectional study was conducted in Imam Hospital (affiliated hospital of Tehran University) between August 2012 and August 2014. Thirty-six patients with definite diagnosis of SSc according to American College of Rheumatology criteria<sup>[6]</sup> and 36 healthy controls (age and sex matched cases) enrolled. Exclusion criterion was suspicious overlap syndrome.

All participants asked to fill informed consent forms before study entrance. The study had been approved by TUMS (Tehran University of Medical Sciences) ethical committee. Patients were examined by an expert rheumatologist and modified Rodnan skin score (mRSS) was recorded. Presence of digital ulcers, telangiectasia, Raynaud's phenomenon, dysphagia, cough, and respiratory distress were recorded, too.

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### Quick Response Code:



An expert radiologist in the field of elastoscans (with 6 years of experience) performed all US evaluations (both gray scale and elastoscan) by means of a 12-MHz (MYLAB 70 XVG, Esaote Co., Genoa, Italy) linear array transducer. The performance was blinded to clinical data.

Volar aspect of the middle forearm and arm in addition to the dorsal aspect of the fingers were evaluated. To obtain images, the probe was placed on the target site and light compression (1–2 circles of the spiral indicator) was applied to prevent pressure artifacts. Both gray scale and elastographic images acquired during probe movement and gray scale images were shown on the left-hand side of the screen while elastograms were on the right side.

The colors ranged from red to blue; blue indicated harder tissues while red indicated softer tissues.

### Red, green, and blue color model

The RGB color model is the simplest model to display color images. The model consists of primary spectral component of red, green, and blue that is the result of mixing a wide range of colors. The RGB model can be displayed using Cartesian coordinates in a cubic space [Figure 1] in which the three primary colors of red, green, and blue are positioned at the three angles. The black is located at the center of coordinates with the white being located in the farthest angle of the cube. The secondary colors of yellow, cyan, and magenta are located in the other three angles.<sup>[7]</sup> In this color system, the intensity of different colors can be displayed on a scale of 0–255. Thus, for example, the pure red can be displayed as (255, 0, 0) in which the color intensity of green and red channels are zero. Likewise, the color green and pure red can be depicted as (0, 255, 0) and (0, 0, 255), respectively.<sup>[7,8]</sup>

In RGB color model, a specific color could be made by different combinations of each color component. Thus, in some specific application where the purpose is to choose a

specific range of color spectrum, it will be difficult to use the image processing.<sup>[8]</sup>

### YCbCr color model

With the advancement of image processing techniques, YCbCr model has been widely used in image processing and digital video images. In this model, the luminance data are saved by component Y and color data in color-difference components by components Cr and Cb, which are known as chroma components.

The Cb component indicates the difference between the blue component and a reference value, whereas Cr component reveals the difference between the red component and a reference value. To obtain YCbCr value components, the values of RGB model in the range of 0–255 are used. Therefore, the values of YCbCr component can be achieved from equation (1).<sup>[8-10]</sup>

$$Y = 0.299 R + 0.587 G + 0.114 B$$

$$Cr = R - Y$$

$$Cb = B - Y$$

### Segmentation

In Figure 2, an ultrasound image of skin layers including gray image (left) and color image (right) are shown. In the right image, the areas of interest (region of interest [ROI]) are determined manually by a skilled radiologist using black lines. The color image on the right has been used for segmentation. The image size is  $480 \times 630 \times 3$  pixels. The color and its intensity in the image are symptomatic of the tissue stiffness in that skin area. The soft and hard tissues are shown by red and blue, respectively.

As discussed earlier, the color point in RGB image is a combination of three components of red, green, and blue. Therefore, a point depicted by color blue in the visual range of the human eye can be composed of different combinations of three components. Thus, in the RGB space, it is difficult to select color spectrum with blue

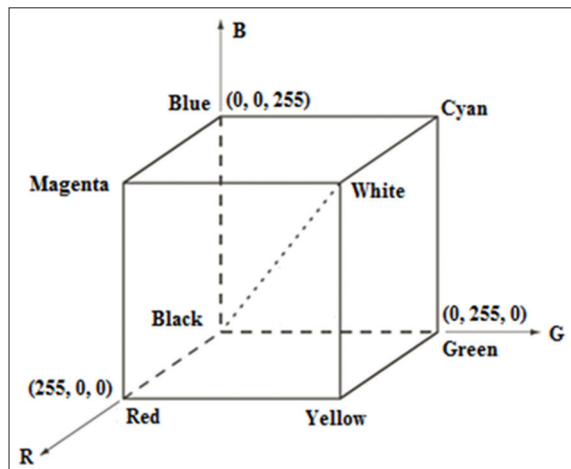


Figure 1: RGB color model

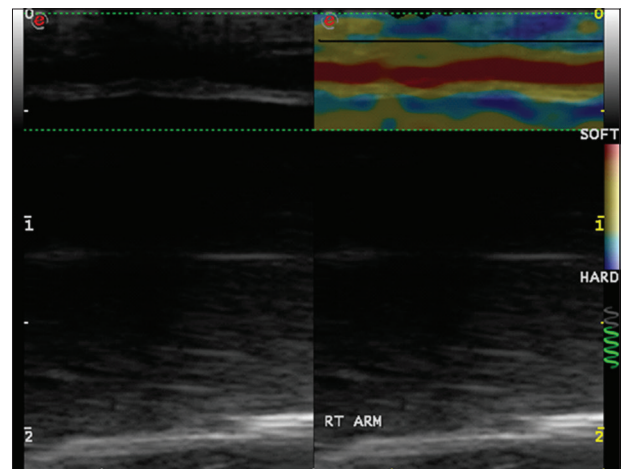


Figure 2: Selected regions by radiologist in the forearm of a patient

points. On the other hand, the components of YCbCr color space are more dependent than the RGB components.<sup>[2]</sup> In the proposed method, therefore, to identify the areas in blue, the Cb component in YCbCr color model is used. As discussed in YCbCr model, component Cb carried the data of color blue. Therefore, for the segmentation of blue region, first the region marked by a black line is selected. Then, in the ROI, the entire points in which the value of the Cb component is greater than 149 are selected. Why is this cutoff score? Figure 3 has shown the result of selecting blue regions in the ROI. It should be noted that the threshold number 149 was calculated experimentally based on the images available. For the components Y and Cr, no threshold or limit was considered. Finally, the area of selected blue regions is calculated to be used as a feature for differentiating healthy individuals from patients.

All data were analyzed using SPSS software version 20 (SPSS Inc., Chicago, IL, USA). Data were presented as mean ± SD for continuous or frequencies for categorical variables. Continuous variables were compared by means of independent sample *t*-test. *P* value less than 0.05 was considered as significant.

### Results

Thirty-six SS patients and 36 healthy subjects were enrolled [Table 1].

Six participants in each group were male. Mean age of patients was 41.3 ± 10.3 years and mean age of controls was 39.8 ± 9.3 years (*P* = 0.05). The type of the disease was limited in 16 (44.4%) and diffuse in 55.5%. Mean mRSS of the whole body was 11.9 (minimum 6 and maximum 22) and mean duration of disease was 6.2 years.

Mean total blue pixels in the arm were significantly different between cases and controls [Table 2].

Mean total image pixels, total blue pixels, and blue index in the forearm were significantly different between cases and controls [Table 3].

Elastography findings in the finger were not significantly different between cases and controls [Table 4].

### Discussion

The result of current study showed that total blue pixels were significantly higher in arm and forearm of cases than

controls and blue index was significantly higher in forearm of cases than controls. This could be indicative of reduced skin elasticity in sclerodermic cases than healthy controls.

In a previous study, Iagnocco *et al.* evaluated 18 women with SS and 15 controls. They applied sonoelastography for forearm and found homogeneous blue area in forearm of all patients which was related to dermis. In contrast, in controls, they detected only green pattern with sporadic areas of light blue.<sup>[1]</sup> As our results show, total blue pixels and blue index were significantly higher in cases than controls which is in agreement with their findings.

Like our results which show no significant differences between total blue pixels and blue index of cases and controls, Iagnocco *et al.* reported variable and changeable colored areas on dorsal aspect of the fingers in both groups.<sup>[1]</sup>

Geso *et al.* evaluated 22 patients with SS. They applied sonoelastography on the dorsal aspect of their second finger in the dominant hand and investigated high correlation between B mode sonography findings and elastography as well as high intra-class correlation coefficient.<sup>[11]</sup>

It should be considered that finger sonoelastography has some limitations, for instance presence of bone structures

**Table 1: Clinical findings in patients**

	Frequency (%)
Digital ulcers	15 (41.7)
Telangiectasia	19 (52.8)
Raynaud's phenomenon	34 (94.4)
Dysphagia	24 (66.7)
Cough	13 (36.1)
Respiratory distress	16 (44.4)

**Table 2: Sonoelastography findings in the arm in cases and controls**

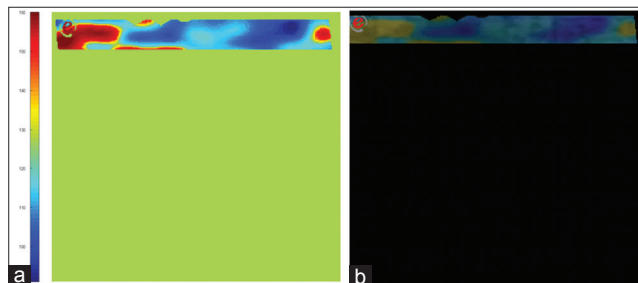
	Controls	Cases	<i>P</i>
Total image pixels	7015.8±5490	8366.5±2210.5	0.05
Total blue pixels	5238.5±1839	6456.5±1830	<0.001
Blue index	0.78±0.15	0.78±0.16	0.8

**Table 3: Sonoelastography findings in the forearm in cases and controls**

	Cases	Controls	<i>P</i>
Total image pixels	6198.3±2536	8279±1850	<0.001
Total blue pixels	5537.3±2494	6727±1420	<0.001
Blue index	0.87±0.083	0.82±0.12	<0.001

**Table 4: Sonoelastography findings in the fingers in cases and controls**

	Cases	Controls	<i>P</i>
Total image pixels	4644.9±5053.7	4372.4±4012	0.7
Total blue pixels	3042.9±2468	2579±1331	0.1
Blue index			0.8



**Figure 3: (a) The region of interest selected by the radiologist and (b) Cb component in YCbCr color model**

in the field of elastography. So, proper evaluation of dermis in this field will be confusing due to bone interference.<sup>[1]</sup> This may present elastography as not suitable method for elasticity evaluation of finger dermis as there is no much soft tissue in fingers than arms or forearms. SS is characterized by reduced elasticity of the skin as the result of changes in collagen deposition and connective tissues.<sup>[1]</sup> Skin involvement in SS is disabling and predictor of visceral involvement and mortality.<sup>[12-14]</sup> Although mRSS is used for skin involvement in SS, it has some limitations such as operator dependence and changing over time.<sup>[11]</sup> So, modalities such as ultrasound and durometry (using digital hand-held, spring-loaded devices) could provide objective measurements.<sup>[15-17]</sup>

This study had some limitations. First, it conducted in a tertiary center. Second, the number of patients was limited. Further, larger multi-centric studies are recommended. Also, further studies could apply shearwave elastography which is more convenient and user friendly for evaluation.

## Conclusions

Sonoelastography could be used for evaluating skin of forearm in sclerodermic cases which will be helpful for disease evaluation in clinical course.

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## Conflicts of interest

There are no conflicts of interest.

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