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Aging effect on tactile perception: Experimental and modelling studies

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ABSTRACT

We investigated the effects of aging on tactile perception. Ageing reduces the elasticity and extensibility of the skin throughout the epidermis, dermis and subcutaneous tissues, which greatly affects their mechanical properties as well as the layer thickness. These changes lead to a decrease in the overall Young modulus of the skin and the skin ability to detect different textures. The effects of ageing on touch perception are studied by means of experimental work and finite element simulations. Ageing behaviors are studied through the investigation of the skin geometrical and mechanical properties. As an experimental approach, we have developed two different systems: the air flow system to identify the rheological properties of the skin and the tribo-haptic system which allows the quantification of the vibrations transmitted to the finger in a tactile perception test. To better understand the mechanics of touch and the effect of ageing, new 2D finite element models of a viscoelastic multilayer finger are developed under ABAQUS environment. These models simulate the friction (finger/surface) of two groups of healthy young and old men in order to understand the effect of ageing on tactile perception and calculate the vibrations transmitted through the human finger tissue during a touch test under the same experimental conditions. The decline in tactile sensory capacity in older subjects has been highlighted. Results proved that the sense of touch decreases with age.

1. Introduction

Touch provides essential information about our surroundings [11]. As we age, our sense of touch diminishes. Some older persons find it difficult to distinguish textures and objects on the basis of touch alone. The sense of touch may become less sensitive [3,6,15,17] There are a number of reasons why this occurs. The skin of older adults may be 20% thinner than that of younger adults. There are a number of reasons why this occurs. The skin of older adults may be 20% thinner than that of younger adults. There are several factors that contribute to this thinner skin phenomenon: less collagen: collagen is a protein that makes up 80% of our skin. It provides both structure and strength. We lose the firmness of our skin as we lose collagen. Loss of elastin: elastin is another type of protein that is found in our skin [2] as shown in Fig. 1.

Regardless of the cause, many people experience changes in the touch-related sensations as they age. In this paper, we investigated the effects of aging on tactile perception. The sense of touch involves the ability to feel shape, vibration and pressure. Many studies report a decreased sense of touch with ageing. Although scientists have documented many age related changes, little has been done to examine how ageing affects a person's sense of touch. In this paper experimental and numerical studies are carried out to investigate the effects of aging on tactile perception. More specifically on the way in which vibrations propagate through the skin thus activating the mechanoreceptors embedded at various depths when a finger slides on an object.

Some of these mechanoreceptors are sensitive to deformation ("slow adapting receptors" for static touch SA) shown in Fig. 2 and others are sensitive to vibrations arising from movement ("fast adapting receptors" for dynamic touch RA) shown in Fig. 3. Slow Adapting receptors fire continuously as long as pressure is applied. Their primary functions are detection and perception of fine detail and texture, as well as finger positioning and stable grasping. Rapidly adapting receptors fire at the onset and offset of pressure. Their primary functions are the detection of low frequency and high frequency vibrations [11].

Fig. 4 shows schematically a skin section with the four types of mechanoreceptors embedded at various depths [5]. At the tip of the intermediate epidermal ridge, which projects down into the dermis, is the Merkel receptor which is in all likelihood the ending of the SA1 units. In contrast to these two endings close to the epidermal-dermal border, the Ruffini ending is located more deeply within the dermis [5]. Available evidence indicates that the Ruffini ending is the terminal of the SA2 units. The Meissner corpuscles which are located high up in the dermal papillae are the end organ RA1 units. Finally the large Pacinian corpuscles represent the endings of the RA2 units. These endings are found in

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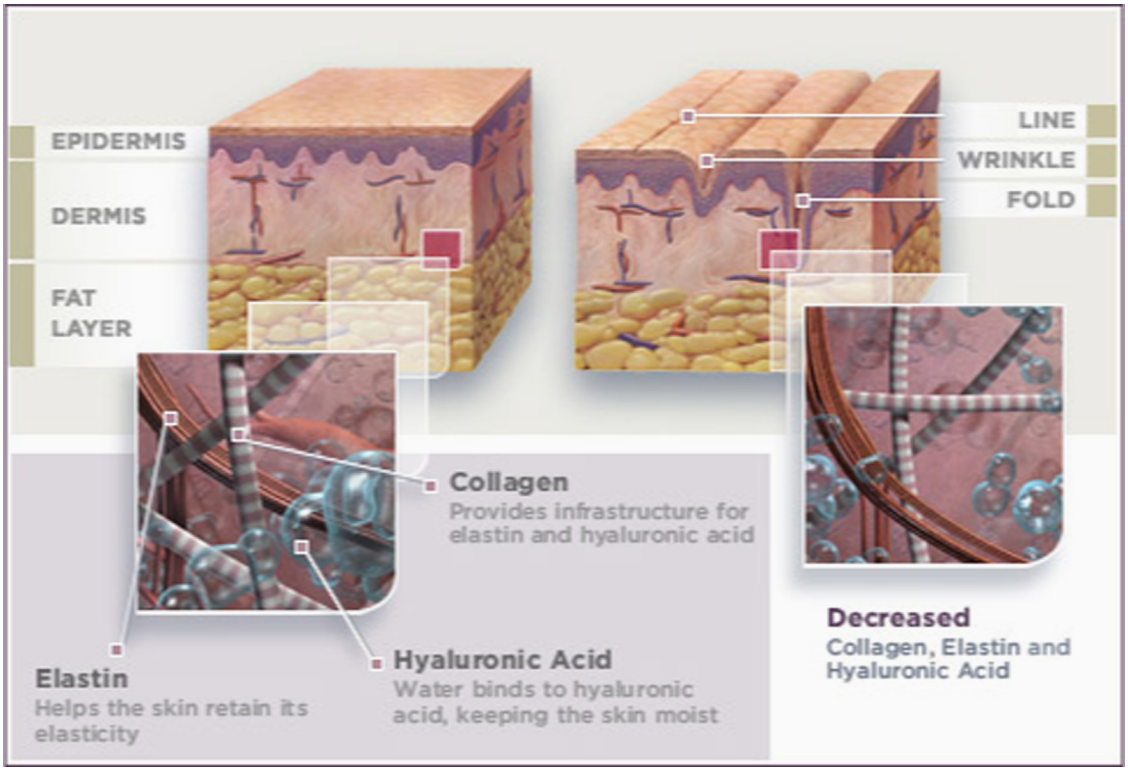

Fig. 1. Young and old skin [2].

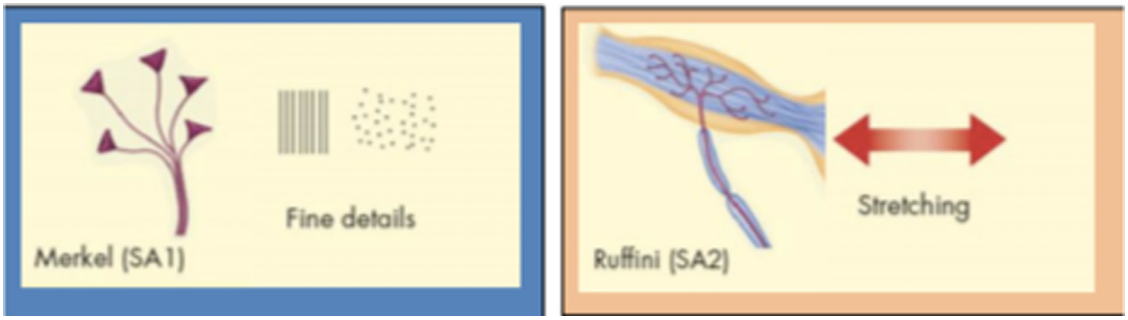

Fig. 2. Slow adapting receptors: Merkel receptor SA1 and Ruffini cylinder SA2 [1].

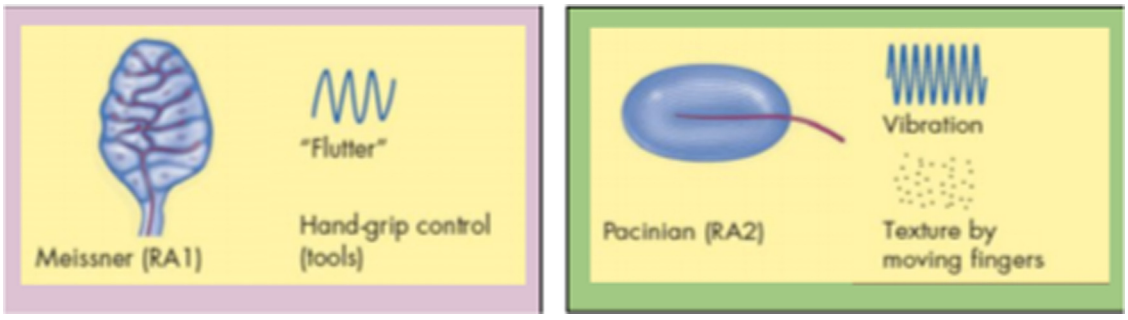

Fig. 3. Rapidly adapting receptors: Meissner corpuscle RA1 and Pacinian corpuscle RA2 [1].

the subcutaneous tissues. Most of them are located more deeply below the skin surface.

With age, the changes in the skin and the loss of elasticity reduce our touch sensitivity. It was shown that the density of mechanoreceptors declines as we get older [6]. The remaining receptors are not as precise in their response to stimulation. We cannot detect light touches as we used to do.

While the correlation between surface roughness and tactile sensation has already been reported in literature [7], the vibration spectra induced by the finger-surface scanning and the consequent activation of the mechanoreceptors on the skin and the effect of ageing on the tactile perception have received less attention.

In this paper we focus our attention on the effect of ageing on tactile perception. We identify the rheological properties of the