Original article

Smooth muscle morphology in the nipple-areola complex

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Abstract

The Nipple is a specialized structure which can be erected by various stimulations and provides induction of milk ejection reflex and sexual arousal due to its intense sensory innervation. Smooth muscles in its structure have been found to be related with the nipple erection mechanism. However, studies aimed at explaining nipple erection mechanism are insufficient. Smooth muscle morphology were investigated by Masson's trichrome staining on sagittal sections performed in 17 different human nipple-areola complex (NAC) samples. According to the results, NAC smooth muscles that have longitudinal and horizontal course are associated with epidermis, lactiferous ducts and blood vessels. Besides, areola is richer compared to nipples in terms of horizontal muscle fibers. Despite being erectile textured, NAC are different from penis in its structure. Contrary to available data, when the NAC smooth muscle morphology evaluated together with erection dynamics, smooth muscle relaxation should also be considered to have an effect.

Keywords: nipple, morphology, female sexual response, breast-feeding.

1 Introduction

Nipples are the milk access points for infants. Due to its intensive sensory innervation, it may provide induction of milk ejection reflex and sexual arousal. Additionally, it is a specialized form that have the characteristic of being erected with cold, sexual arousal, breast-feeding or other tactile stimulations (GIACOMETTI and MONTAGNA, 1962; MONTAGNA, 1970; COWIE, 1974; MONTAGNA and MACPHERSON, 1974; ERIKSSON, LINDH, UVNÄS-MOBERG et al., 1996; MUNARRIZ, KIM, GOLDSTEIN et al., 2002; SHEPHERD, 2002; LEVIN, 2006; LEVIN and MESTON, 2006).

The most remarkable characteristic of the nipple is its erection. It enables breast-feeding with this function (MONTAGNA, 1970; MONTAGNA and MACPHERSON, 1974; ERIKSSON, LINDH, UVNÄS-MOBERG et al., 1996). Additionally, it is an incident that occurs in the arousal phase of the female sexual response cycle (MUNARRIZ, KIM, GOLDSTEIN et al., 2002; SHEPHERD, 2002; LEVIN, 2006). According to the data available, there are smooth muscles in the structure of the nipple-areola complex (NAC). Although it is stated that erection occurs with the contraction of smooth muscles, studies aimed at explaining the NAC structure and nipple erection physiology are inadequate (MONTAGNA, 1970; MONTAGNA and MACPHERSON, 1974; BIRKENFELD and KASE, 1994; ERIKSSON, LINDH, UVNÄS-MOBERG et al., 1996; UVNÄS-MOBERG and ERIKSSON, 1996; FRANKE-RADOWIECKA, KALECZYC, KLIMCZUK et al., 2002; LEVIN, 2006; GARTNER and HIATT, 2007; WALKER, 2009; JOHNSON, 2010). In the present study, smooth muscle morphology that may be related with erection in the NAC was investigated.

2 Material and methods

All phases of the study have been conducted in Istanbul Faculty of Medicine. With the purpose of including in this study, NACs of 30 female patients who had undergone mastectomy because of breast carcinoma in the Department of General Surgery were examined. Because it was found that NAC tissues from 13 patients were affected by tumor (invasion with tumor cells), they were excluded of research. Taking the consideration of the Department of Pathology, sagittal halves of the 17 NACs without cancer were used in the study by obtaining informed consent from the patients. Tissues were taken to paraffin-embedded blocks in the laboratory of the Department of Histology. In order to examine the smooth muscle morphology, three-micron-thick 3 sagittal sections with 1 mm intervals from each of the NACs were evaluated by standard Masson's trichrome staining.

2.1 Evaluation of the results of the study

All light microscopy studies were done by Leitz Wetzler model microscope. It was observed that cell nucleus was blue/black; muscle, erythrocytes and fibrins were red; and connective tissue were brown in Masson's trichrome staining.

3 Results

In the present study, the structure and progress of the muscles in the NAC were investigated with Masson's trichrome staining which was done to sections. It was observed that muscle fibers extended to the different directions in NAC sections and that though these muscle fibers were seen to be intermixed and irregular, they were

found to have different patterns and orientations in detailed examinations. The results obtained from the examination of sections.

It was observed that muscle fibers in the NAC extended vertically (longitudinal) or horizontally to the nipple base, in the form of thin, fusiform fibers or bundles (Figure 1). It was found that muscle fibers may branching or changing direction during their progress and that longitudinal and horizontal muscles may extend separately just as they may be found intermixed. While some of the muscle fibers oriented vertically to the epidermis with one of their edges, some of them extended subepidermal and parallel to the epidermis (Figure 2). Mainly, longitudinal muscles were placed in the nipple while horizontal muscles were placed in the areola. While especially in the proximal of ducts, longitudinal muscles extending parallel to them were found, in the distal, sphincter-like horizontal muscles were located (Figure 3). It was observed that smooth muscles were also closely associated with blood vessel and some of the smooth muscles extended so as to surround the blood vessels (Figure 4). Sinusoidal spaces with endothelial layers surrounded by smooth muscles similar to penile cavernosal tissue is not found.

4 Discussion

Nipple functions can be counted as the transmission of stimuli occuring with suction and induction of milk ejection reflex due to intense sensory innervation; preventing the leaking of milk by the contraction of the smooth muscles placed in the form of sphincter around the lactiferous ducts between breast-feeding episodes; erection in order to ease breast-feeding and during sexual arousal; the induction and increase of sexual arousal (GIACOMETTI and MONTAGNA, 1962; MONTAGNA, 1970; COWIE, 1974; MONTAGNA and MACPHERSON, 1974; ERIKSSON, LINDH, UVNÄS-MOBERG et al., 1996; MUNARRIZ, KIM, GOLDSTEIN et al., 2002; SHEPHERD, 2002; LEVIN, 2006; LEVIN and MESTON, 2006).

The most remarkable feature of the nipple among these functions is the nipple erection. The data about the nipple erection that are still valid nowadays date back to previous studies. In those studies, the fact that there are plenty smooth muscles in the structure of the NAC has suggested that it contributes erection by contraction which is a function of smooth muscles (MONTAGNA, 1970; MONTAGNA and MACPHERSON, 1974; BIRKENFELD and KASE, 1994; ERIKSSON, LINDH, UVNÄS-MOBERG et al., 1996; UVNÄS-MOBERG and ERIKSSON, 1996; FRANKE-

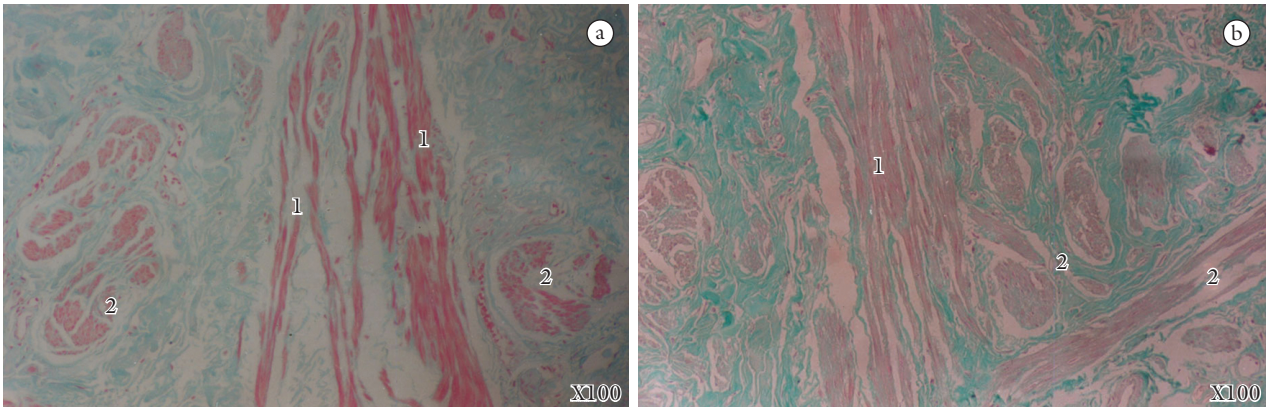

Figure 1. a,b) Longitudinal (1) or horizontally (2) extended muscles.

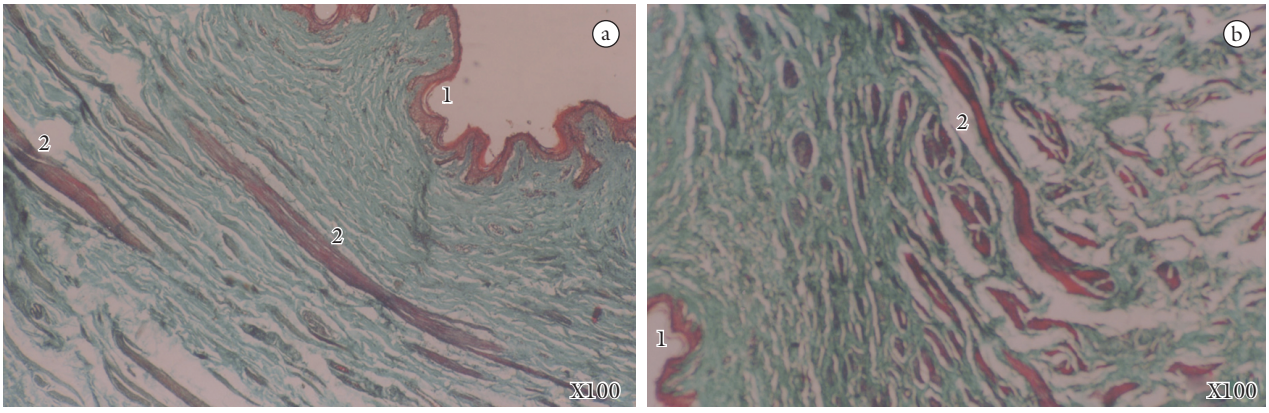

Figure 2. a,b) Parallel muscles (2) extended to the epidermis (1).

RADOWIECKA, KALECZYC, KLIMCZUK et al., 2002; LEVIN, 2006; GARTNER and HIATT, 2007; WALKER, 2009; JOHNSON, 2010). However, this interpretation should be reviewed when the nipple smooth muscle morphology and the erection dynamics are considered.

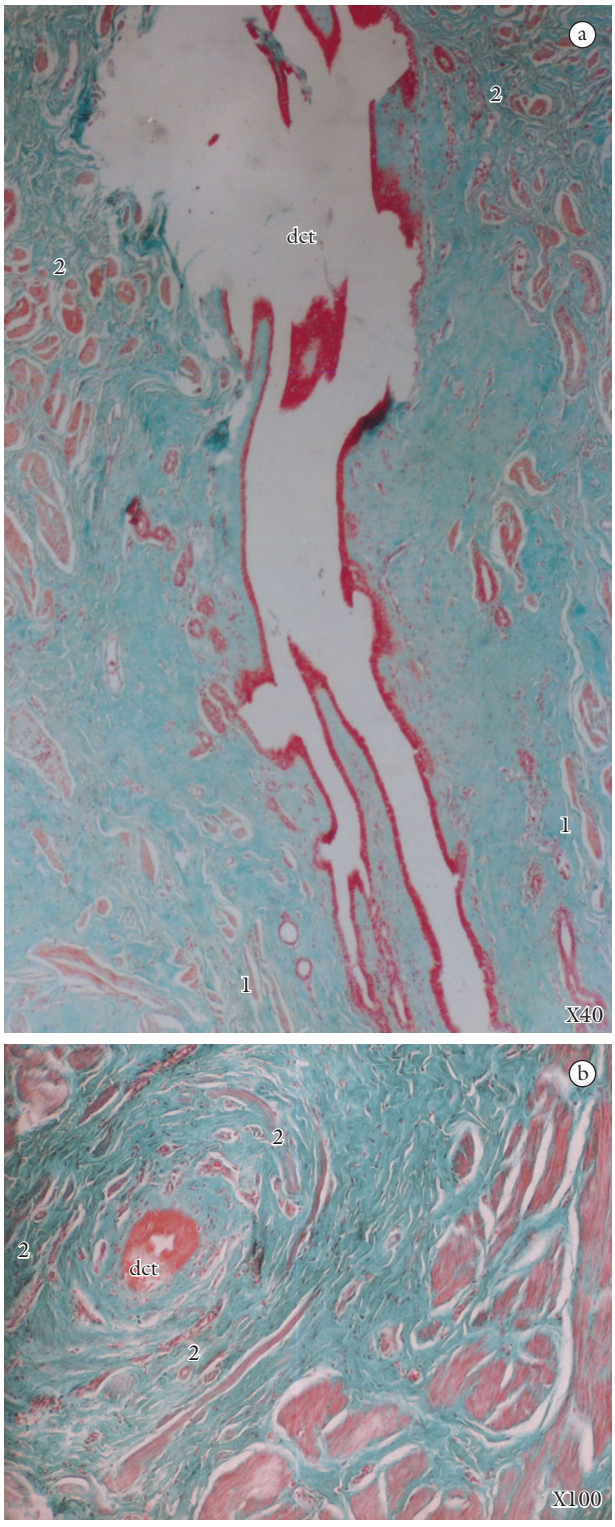

Figure 3. a,b) In the proximal of ducts (dct) longitudinal muscles extending parallel to them (1). In the distal of ducts sphincter-like horizontal muscles (2).

Morphological findings of the NAC smooth muscles which were shown in the present study, are generally similar to that of other studies (GAIRNS and GARVEN, 1949; GIACOMETTI and MONTAGNA, 1962; MONTAGNA, 1970; MONTAGNA and MACPHERSON, 1974).

Similar to the studies of Giacometti and Montagna (1962) and Montagna (1970) and Montagna and Macpherson (1974), muscle fibers investigated in the present study placed vertically (longitudinal) or horizontally in relation to NAC base direction. Similarly, it was observed that longitudinal and horizontal muscles were placed separately or intermixed during their progress and that some smooth muscles were closely associated with ducts and extended parallel to them, yet, there were sphincter-like horizontal muscles in the distal of ducts.

Similar to Gairns and Garven (1949) findings, it was observed that smooth muscles can be found in the form of thin and fusiform fibers or bundles and that some the muscle fibers branched or changed their direction during their progress.

Some of the muscle fibers, as reported by Montagna (1970), oriented vertically towards the epidermis with one of their edges while some, as shown in the current study, extended parallel to the epidermis.

Smooth muscle fibers, as stated in the current study and in others (GAIRNS and GARVEN, 1949; ERIKSSON, LINDH, UVNÄS-MOBERG et al., 1996), were closely associated with blood vessels. Gairns and Garven (1949) stated that some of the smooth muscles in the nipple appeared around the sinus-like veins. However, it was

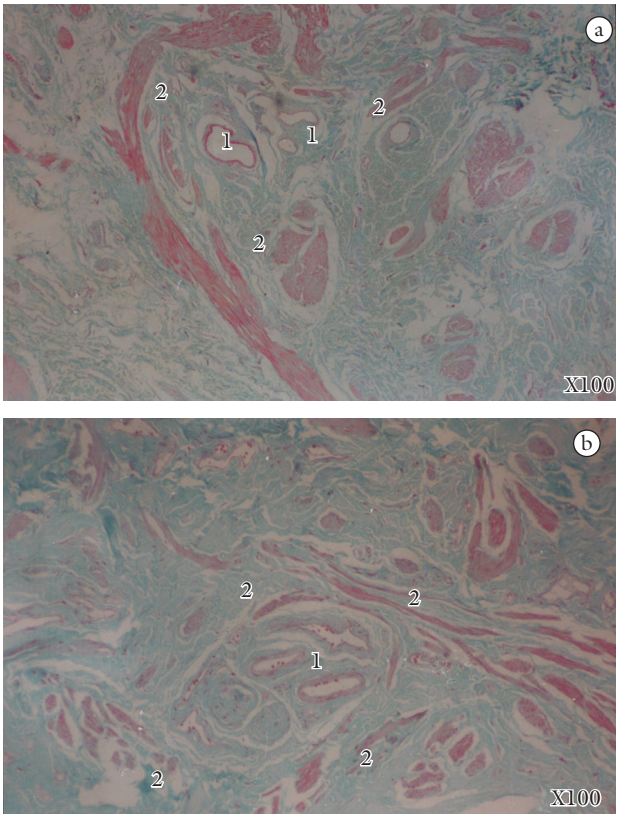

Figure 4. a,b) Smooth muscles (2) closely associated with blood vessel (1) and extended surround them.

reported that penis-like cavernosal tissues were not found in the nipple (MONTAGNA, 1970; MONTAGNA and MACPHERSON, 1974; GARTNER and HIATT, 2007; WALKER, 2009; JOHNSON, 2010). Sinusoidal spaces furnished with endothelium, which smooth muscles encompass in a similar way to that of penile cavernosal tissue, were not seen in the present study.

In the current study, sphincter-like smooth muscles were present in the distal of ducts as stated by Giacometti and Montagna (1962). These muscles prevented milk leakage between breast-feeding episodes (ERIKSSON, LINDH, UVNÄS-MOBERG et al., 1996).

In the present study, 3 sections were taken from each NAC for the histological examination. As the NAC were in circular form, it was supposed that these sections may reflect the morphology. However, as the number and form of sections were inadequate for the term "circular muscles" mentioned in other studies (MONTAGNA, 1970; MONTAGNA and MACPHERSON, 1974; ERIKSSON, LINDH, UVNÄS-MOBERG et al., 1996), the term "horizontal muscles" were used instead.

4.1 How should the function of smooth muscles be explained in the nipple-erection mechanism?

The nipple rises and becomes prominent during erection (MONTAGNA, 1970; MONTAGNA and MACPHERSON, 1974). Longitudinal muscle fiber contractions in the nipple may prevent the rise of the nipple.

Epidermis in the unerected nipple shows wrinkles that increases the surface area. This wrinkles enables the surface to expand and becomes flat during erection (MONTAGNA and MACPHERSON, 1974; GARTNER and HIATT, 2007). However, contractions of muscle fibers localized near the epidermis in the nipple may prevent the skin surface to expand and flatten during erection.

In a similar way, muscle fibers that proceed parallel to ducts and that are in close association with them shorten the ductal length with its contractions (ERIKSSON, LINDH, UVNÄS-MOBERG et al., 1996) and may prevent their rise during the erection.

Besides, during the breast-feeding of an erected nipple, relaxation of sphincter-like smooth muscles placed in distal of ducts is necessary in order not to prevent milk flow (GIACOMETTI and MONTAGNA, 1962; ERIKSSON, LINDH, UVNÄS-MOBERG et al., 1996).

It has been reported that blood flow increases in breast skin during sexual arousal and breast-feeding in which nipple erection occurs and nipple erection may have a vascular basis (PEREZ-APARICIO, DANTZER, NAVARRO et al., 1995; ERIKSSON, LUNDEBERG, UVNÄS-MOBERG, 1996; UVNÄS-MOBERG and ERIKSSON, 1996; SHEPHERD, 2002; LEVIN, 2006). However contraction of muscle fibers closely associated to blood vessels in the nipple, decrease in blood flow is expected.

According to these data and assessments, for the nipple erection, the relaxation of the smooth muscles in its structure is necessary. The case is different when nipple erection is considered in terms of areola. In contrast to the nipple, wrinkles in the areola are seen during erection and surface of the areola at this time reduces (MONTAGNA, 1970; MONTAGNA and MACPHERSON, 1974). Contraction of muscle fibers in the areola may explain the reducing of areola surface and wrinkles in the skin of areola.

For the purpose of explaining the smooth muscle base of the nipple erection better, comparative histological analyses of the erected and unerected nipples which would be done using serial sections are needed.

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