Original Article

Histological and Morphometric Analysis of the Effects of Methyl Methacrylate compounds on the Skin of Adult Male Albino Rats: a model for Reflection on Occupational Hazards

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ABSTRACT

Introduction: The skin is the largest organ in body subjected to external and internal stressors. Methyl methacrylate compounds have proven to be hazardous in many professionals dealing with them. These compounds are mainly used by dentists, nail salon technicians and some orthopedic surgeons.

Aim of Work: to explore the cellular alterations occurring in the skin at the histological and ultrastructural levels due to usage of methyl methacrylate compounds.

Material and Methods: Twenty mature male albino rats weighing 200 grammes were used for 2 weeks. The skin on the abdominal region of each rat was shaved. Rats were divided into 2 groups: Control (without intervention) and experimental (topically administered a 2 ml of methyl acrylate).

Results: Sections of the experimental group displayed thinning of the epidermis with relatively increased thickness of keratin layer. The dermis showed wide spacing of collagen fibres. Increased hair follicles and sebaceous glands was noted. Collagen bundles appeared loosely arranged in Masson's trichrome sections. Experimental group displayed marked loss of elastic fibres in sections stained with Orcein. Strong immunostaining to iNOS in epidermal melanocytes was also seen. Ultrastructural study showed keratinocytes with multiple cytoplasmic vacuoles. Melanocytes also revealed cytoplasmic extensions containing melanin granules. Dermis of skin displayed a degenerating fibroblast. Morphometric analysis confirmed the microscopic findings.

Conclusion: Several cellular effects of methyl methacrylate compounds on adult male albino rats' skin was demonstrated in the current work. It is highly advised that further research be done on the many methods that may be utilized to safeguard employees from such threats.

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Key Words: Dentists, methyl methacrylate, nail salon, orthopedics, skin.

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INTRODUCTION

Being the largest organ of human body, the skin has attracted lots of scientific attention since it is the first line of the body defense against many stressors either internal or external[1]. Many hazards have been detected due to the usage of volatile organic compounds as acetone, methyl methacrylate and Toluene. These compounds have been proved to cause irritation in the eyes, nose, throat and skin. Application of these compounds within nail salons include some cosmetics, nail polishes, nail polish removers as well as artificial nails care[2].

Methacrylate components can also be found in paint and facial creams[3]. In the sixties, by the beginning of acrylic nails application services, usage of methyl methacrylate liquid monomers was widely utilized since they were cheaper than many safer alternatives. These monomers are only hazardous in the liquid form and have a strong fruity odor. Some salons were able to minimize the contact adverse effects by the use of personal protective equipments (PPE) as masks and gloves[4].

Since the seventies, the compound methyl methacrylate was recognized among the poisonous substances by the FDA. However, its usage in cosmetic products was not sufficiently regulated and the continuous usage has been correlated with allergic reactions especially nail deformities[5].

Due to its excellent transparency, chemical stability, and electrical insulation, high molecular weight methyl methacrylate is used extensively in a variety of industries, including aviation, architecture, medicine, and optical equipment[6]. Furthermore; it has been also recognized that some of the tapes used in medical procedures for adhesive purposes possess some residuals of acrylic acid that might account for some skin irritation recognized by medical professionals[7].

Methyl methacrylate has been widely used also in bone cementing with fractures or joint replacements especially hip and knee. Authors recorded many allergic reactions occurring years after the intervention which appeared in the form of pain during rest, decreased range of movements, skin dermatitis as well as joint effusion. Allergy to

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such component has been reported in dentistry as well, sometimes even systemic reactions were seen[8]. Thus, leaving orthopedics as well as dentists susceptible to the contact hazards of using this cement in their occupational demands.

Ninety-five percent of all cases of occupational skin disorders that have been documented include contact dermatitis[9]. Methacrylate sensitivity and allergies, according to an assessment published in 2020 on the impact of contact allergens on public health, are on the verge of epidemic proportions[10]. Many literature focused on the clinical presentation of these hazards over humans subjected to the methyl methacrylate compounds, however, very few literature pointed out the changes occurring on the cells of skin of affected personnel. So, it is the aim of the present work to investigate these cellular changes on histological and ultrastructural levels to correlate with these clinical findings. Such correlation is important in skin lesions in order to prescribe the proper therapy and avoid any predisposing factors[11].

MATERIAL AND METHODS

Experimental animals

In the current investigation, twenty adult male albino rats weighing 200 g. were employed. Animals were obtained from the Medical Research Center's animal house at Ain Shams University's Faculty of Medicine (MASRI). Two rats were kept in each cage, with free access to food and water, a 12-hour light cycle, excellent ventilation, and sanitary living circumstances. Before the trial began, animals were given a week to acclimate.

Ethical considerations

The entire experimental protocol was carried out in accordance with the regulations approved by the Committee of Animal Research Ethics (CARE), Faculty of Medicine-Ain Shams University, which complied with Polish legal requirements and EU Directive 2010/63/EU of the European Parliament and the Council of September 22, 2010, as well as the National Research Council 2011 requirements. Ethical committee approval number FMASU R 165 2022.

Chemicals

Methyl methacrylate; also known as acrylic acid methyl ester; is present in the form of Methyl methacrylate 99%, (Methyl methacrylate contains ≤30 ppm MEHQ as inhibitor) from Sigma-Aldrich (product number M55909) 500 ml bottle. It is a colorless fluid that has a distinctive fruity smell. Methyl methacrylate concentration was used as supplied without dilution since this is the way it is used in industry[12], (Commercial name: Acrostone®).

Experimental design

Rats were divided randomly into two equal groups (ten rats each). The skin on the same abdominal region of each rat was shaved using a shaving cream to remove the hair and reveal an area approximately 4 cm^2[13].

Group I (control group): rats were left exposed to normal environmental condition without any intervention for 2 weeks.

Group II (Experimental group): rats were topically administered a 2 ml of methyl acrylate on a sponge to the shaved area of skin (2 ml/4 cm^2) and tapped to this area with surgical tape for 5 minutes once daily over a period of 14 consecutive days[14]. Rats were continuously observed for skin manifestations to avoid ulcerations and burns.

At the end of the experiment, rats were sacrificed by ether inhalation. Experimental skin areas were surgically excised then processed for staining and microscopic examination.

Light microscopic study

The excised skin Samples were inserted into 10% formalin. After being dehydrated with ethanol at varying concentrations, they were briefly cleared in Xylol, then the samples were fixed in paraffin wax for an hour to create paraffin blocks. The blocks were thinned out and serially cut into 5-µm thick sections then were stained with the following:

- Hematoxylin–Eosin (H&E)[15].
- Masson Trichrome: for detecting collagen fibers[16].
- Orcein: for detecting elastic fibers[17].

Immunohistochemical study

For detection of inducible nitric oxide synthase (iNOS), using Rabbit anti-rat, Monoclonal anti iNOS primary antibody. The reaction appeared as brownish cytoplasmic granules. Avidine–biotin peroxidase technique was performed[18]. Negative control specimens were done after omitting the primary antibody.

All sections were examined with the light microscope and photographed with the Lecia ICC50 W camera at Anatomy Department; faculty of Medicine; Ain Shams University.

Ultrastructural study

Other dissected samples were divided into tiny pieces, each 1 mm3 thick, and promptly fixed in 2.5 percent glutaraldehyde before being chilled for 24 hours at 4 °C. Semithin sections (1 µm thick) were prepared. Following that, staining for about 30 seconds with 1 percent toluidine blue solution in 1 percent borax was done then the field was determined using a light microscope. From the chosen locations, using uranyl acetate and lead citrate, ultrathin sections (60 nm) were stained[19]. The grids were inspected and captured using a Philips 201-transmission electron microscope at the University of Ain Shams' Faculty of Science.

Quantitative Image Analysis

The studied groups were assessed for the following parameters

In H&E-stained sections at (X100) magnification; they were examined to evaluate the epidermal thickness (um).

In Masson's trichrome-stained sections at (X100) magnification; the collagen fibres surface area (%) was measured[20].

In orcein-stained sections at (X100) magnification; the elastic fibres surface area (%) was evaluated.

The quantification of the iNOS immunoreactivity mean area percentage in skin sections of both groups.

In morphometry, for each parameter, ten non-overlapping fields were examined using Image J software version 1.50i. For measurement of the surface area (%) for collagen fibres, elastic fibres and iNOS immunoreactivity, the area of each one was measured and expressed in relation to the area of the measuring frame of a known area (estimate area %/135.84 μm2 frame)[21].

Statistical analysis

Utilizing GraphPad Prism version 6.03, the gathered data were assessed, and statistical analyses were carried out (San Diego, CA, U.S.A). The observed histo-morphometric and quantitative immunohistochemistry data in the two study groups were compared using the unpaired t-test. The results were presented as means ± standard deviations (SD), and differences were considered statistically significant when $P < 0.05$[22].

RESULTS

Light Microscopic Results

H&E staining

Examination of rat's thin skin in the control group revealed its layers, epidermis and dermis. The epidermis consisted of stratified keratinized squamous epithelium (keratinocytes) with its layers, stratum basal consisted of one basal layer of basophilic columnar cells, containing less prevalent rounded melanocytes. The stratum spinosum consisted of several layers of basophilic polygonal cells with Langerhans cells inbetween. Then the stratum granulosum viewed as nearly flat basophilic cells with granular cytoplasm. The most superficial layer was the stratum corneum that displayed a squamous cornified (keratinized) non nucleated cells. The dermis consisted of an outer papillary layer and an inner reticular layer with well-organized, densely arranged and closely packed collagen fibres associated with many fibroblasts, multiple hair follicles and sebaceous glands (Figures 1 a,b). The mean epidermal thickness was measured as (5.57+1.22) (Histogram 1).

Sections of the experimental group displayed thinning of the epidermis with noticed relatively increased thickness of keratin layer (Figures 2 a,b). This was statistically documented by a highly significant reduction in epidermal thickness detected in this group as compared to the control group, measuring (2.013+0.51) (Histogram 1). The epidermal cells appeared disorganized with no apparent distinction between the layers. Some epidermal cells appeared vacuolated, with deeply stained eccentric nuclei, while others displayed deeply stained, flattened, pyknotic nuclei (Figure 2c). The dermis showed wide spacing of collagen fibres with relatively fewer fibroblasts. Increased hair follicles and sebaceous glands was noted (Figures 2 a,b,c).

Masson-trichrome staining

Sections of the control group dermis displayed finely arranged collagen bundles in papillary layer underlying the epidermis & deeper course wavy densely packed collagen bundles with different directions in reticular layer (Figure 3a). The collagen mean area percentage was measured as (65.75+13.44) (Histogram 2).

Experimental group showed marked decrease in collagen bundles that appeared loosely arranged with marked spacing in-between them (Figure 3b). Collagen mean area percentage was highly significantly decreased as compared to group I, measuring (24.87+6.99) (Histogram 2).

Orcein staining

Control group thin skin displayed a network of fine thin short, branched elastic fibres in the papillary layer of the dermis & coarse long thick elastic fibres in the reticular layer surrounding hair follicles & sebaceous glands (Figure 4a). The mean area percentage of elastic fibers was measured as (63.94+14.12) (Histogram 3).

Experimental group displayed marked loss of elastic fibres which appeared short and fragmented with wide empty spaces between them (Figure 4b). A highly significant decrease in the mean area percentage of elastic fibers was detected as compared to the control group, measuring (23.197+20.57) (Histogram 3).

iNOS staining

Control group displayed minimal immunostaining to iNOS in epidermal melanocytes and in few dermal cells (Figure 5a). The mean area percentage of iNOS was measured as (7.11+6.23) (Histogram 4).

Experimental group displayed strong immunostaining to iNOS in epidermal melanocytes and surrounding hair follicles (Figure 5b). A highly significant increase in the mean area percentage of iNOS was detected as compared to the control group, measuring (39.88+18.01) (Histogram 4).

Ultrastructural Results

Ultrastructural study of control group skin revealed that epidermis consisted of multiple arranged layers of keratinocytes with euchromatic nucleus and prominent nucleolus. Melanocytes appeared with a pale nucleus, rough endoplasmic reticulum, mitochondria and melanin granules (Figure 6a). Melanocytes also revealed cytoplasmic extensions containing melanin granules. Desmosomes obviously appeared between adjacent keratinocytes. (Figure 6b).

Experimental group skin ultrastructural study showed keratinocytes with multiple cytoplasmic vacuoles, electron dense nucleus in the epidermis (Figures 7 a,b). Dermis of skin displayed a degenerating fibroblast with a folded irregular heterochromatic nucleus surrounded by disintegrating cytoplasm. Widely-spaced collagen fibres were prominent with characteristic axial periodicity (Figure 7c).

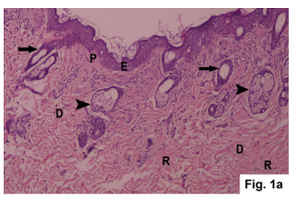


Fig. 1a

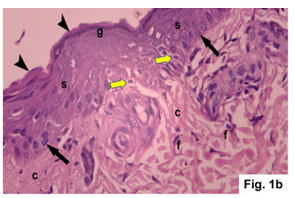


Fig. 1b

Fig. 1: A photomicrograph of a section of rat's thin skin (control group) showing: **(a)** layers of the thin skin; epidermis (E) & dermis (D). The dermis consists of outer papillary layer (P) & inner reticular layer (R) with multiple hair follicles (arrow) & sebaceous glands (arrowhead); (H&E X 100) **(b)** epidermis consisting of stratum basale (arrow) with melanocytes (yellow arrow), stratum spinosum (s) with Langerhans cells & stratum granulosum (g). Superficially, stratum corneum displays a layer of Keratinized acidophilic squamous cells (arrowhead). The papillary layer of dermis displays many fibroblasts (f) with densely arranged collagen fibres (c) in-between. (H&E X 400)

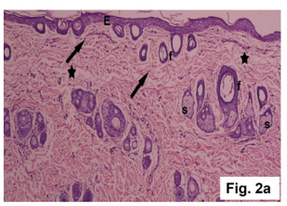


Fig. 2a

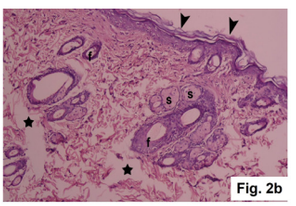


Fig. 2b

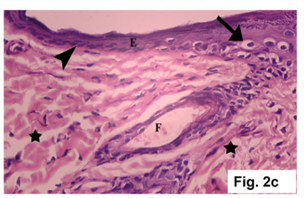


Fig. 2c

Fig. 2: A photomicrograph of a section of rat's thin skin (experimental group) showing: **(a)** thinning of epidermis (E) & widely spaced (star) collagen bundles in dermis with relatively few fibroblasts (arrow). The dermis displayed relatively increased number and size of hair follicles (f) & sebaceous glands (s); **(b)** relatively increased keratin layer (arrowhead), marked spacing (star) of collagenous fibres in the dermis with markedly increased sebaceous glands (s) & hair follicles (f). (H&E X 100) **(c)** markedly thin epidermis (E) with disorganization of the epidermal cells; some appeared vacuolated with deeply stained eccentric nuclei (arrow) & others showed deeply stained flattened pyknotic nuclei (arrow head). An obliquely cut hair follicle is noted (F) & widely spaced (star) collagen bundles in dermis. (H&E X 400)

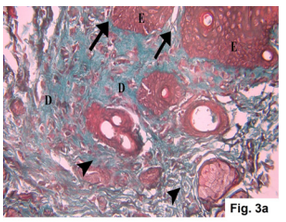


Fig. 3a

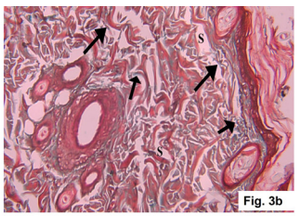


Fig. 3b

Fig. 3: A photomicrograph of a section of rat's thin skin showing: (a) layers of the skin in the Control group; epidermis (E) & dermis (D). The dermis displayed finely arranged collagen bundles in papillary layer (arrows) & course wavy collagen bundles with different directions in reticular layer (arrowheads); (b) marked decrease in collagen bundles (arrows) in the Experimental group that appeared loosely arranged with marked spacing (S) in-between. (Masson trichrome X 100)

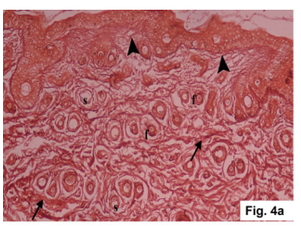


Fig. 4a

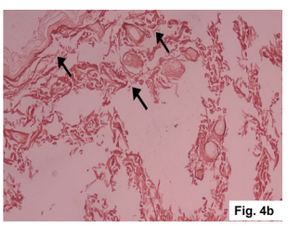


Fig. 4b

Fig. 4: A photomicrograph of a section of rat's thin skin showing: (a) a network of fine thin elastic fibres (arrowhead) of the Control group in the papillary layer of the dermis & coarse thick elastic fibres (arrow) in the reticular layer surrounding hair follicles (f) & sebaceous glands (s); (b) the Experimental group with marked loss of elastic fibres which appeared short and fragmented (arrow). (Orcein stain X 100)

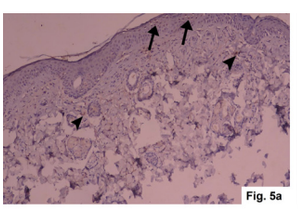


Fig. 5a

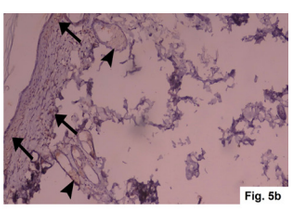


Fig. 5b

Fig. 5: A photomicrograph of a section of rat's thin skin displaying: (a) the control group with minimal immunostaining to iNOS in epidermal keratinocytes (arrow) and in few dermal cells (arrowhead) and (b) the Experimental group with strong immunostaining to iNOS in epidermal keratinocytes (arrow) and surrounding hair follicles (arrowhead). (iNOS immunostaining X100)

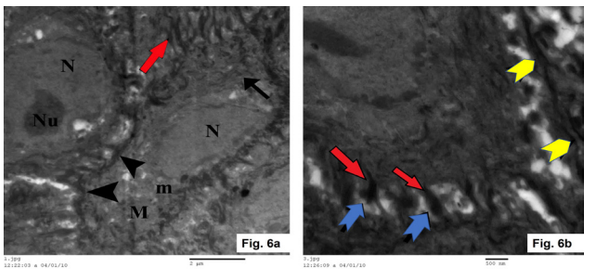


Fig. 6: A transmission electron micrograph of epidermis of rat's thin skin from the control group showing: **(a)** multiple arranged keratinocytes with euchromatic nucleus (N) and prominent nucleolus (Nu). A melanocyte (M) is noted with a pale nucleus (N), rough endoplasmic reticulum (arrow), mitochondria (m) and melanin granules (red arrow). Note desmosomes (arrowhead) between adjacent keratinocytes. (TEM X3000) **(b)** cytoplasmic extensions (blue arrow) of melanocyte containing melanin granules (red arrow). Note desmosomes (yellow arrowhead) connecting adjacent keratinocytes. (TEM X5000)

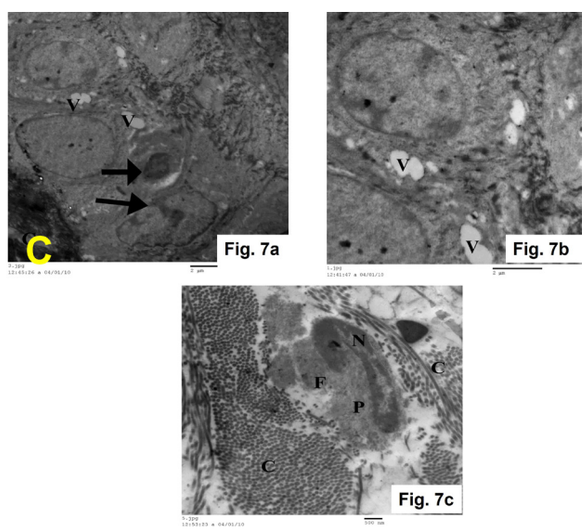
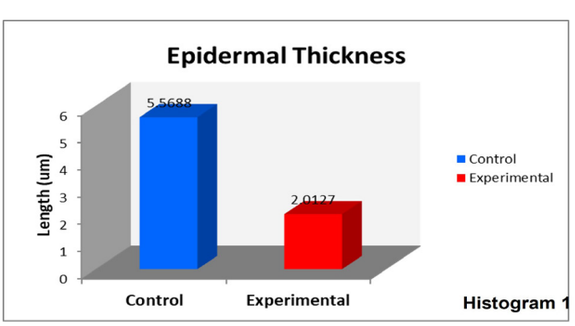
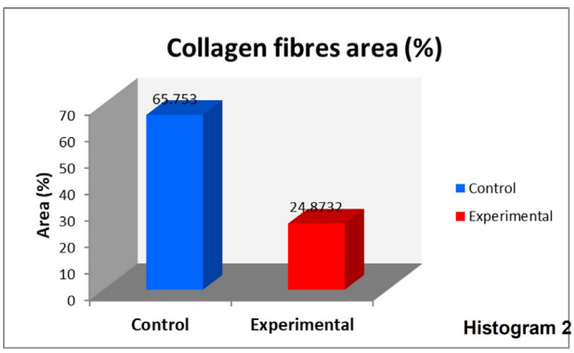


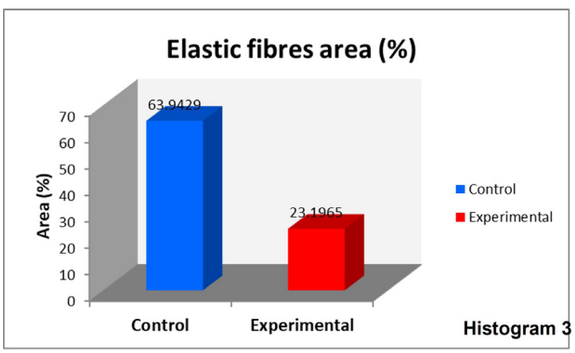
Fig. 7: A transmission electron micrograph of rat's thin skin from the experimental group showing: **(a)** keratinocytes with multiple cytoplasmic vacuoles (V), apoptotic cells with small electron dense nuclei (arrow) and collagen fibers (C) can be seen in the dermis. (TEM X1500) **(b)** multiple vacuoles (V) of the cytoplasm in keratinocytes. (TEM X3000) **(c)** a degenerating fibroblast (F) in the dermis with a folded irregular heterochromatic nucleus and accumulation of chromatin under the nuclear envelop (N) surrounded by disintegrating cytoplasm (P). Notice widely-spaced collagen fibers (C) with characteristic axial periodicity. (TEM X4000)



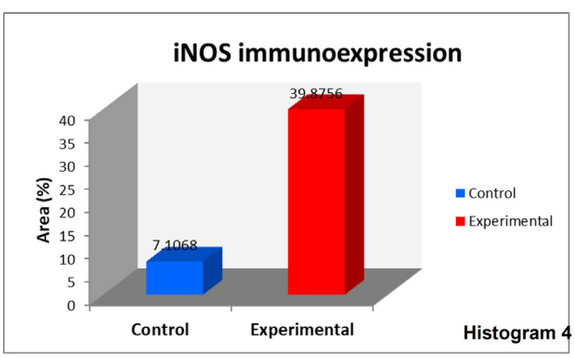
Histogram 1: showing mean epidermal thickness between the control and experimental groups.



Histogram 2: showing collagen fibers area percentage between the control and experimental groups.



Histogram 3: showing elastic fibers area percentage between the control and experimental groups.



Histogram 4: showing iNOS immune-expression between the control and experimental groups.

DISCUSSION

In almost all species, the skin and all of its constituent parts act as a sturdy shield to support and shelter all internal organs, preventing potentially dangerous external structures from impinging on the integrity of these organs[23].

The epidermis continually experiences cell renewal while being exposed to environmental hazards. For the skin's homeostasis, the epidermal balance between proliferation and differentiation must be preserved[24]. The current study investigated how the use of methyl methacrylate chemicals affected the skin cells of adult male albino rats. Authors found thinning of the epidermal layers. The epidermal cells

appeared vacuolated with deeply stained nuclei, and some appeared also pyknotic. In comparison to group (I), there was a highly statistically significant reduction in epidermal thickness in group (II). On the ultrastructural level, Keratinocytes appeared vacuolated with disintegrated nucleus. This goes with the results of previous studies showing that various forms of systemic sclerosis were associated with altered basal keratinocyte proliferation and changed epidermal keratinocyte differentiation[25].

The experimental group in our present work revealed increased thickness of keratin in the epidermal layer compared to the control group. However, fibroblasts were scanty in the dermis and the collagen fibers appeared to be widely spaced. These findings were confirmed in skin sections examined with the electron microscope. Previously, researchers have demonstrated the important link between the keratinocytes and fibroblasts activities to promote the healing of skin wounds in a double way action[26]. The disturbance in the continuous evolution of the keratin layer might lead to serious skin diseases which finally might develop cancer. Such process is highly regulated by serum levels of calcium and vitamin D in the body[23]

The protein keratin is a widely used diagnostic element in the discovery of numerous genetically determined; benign and malignant skin diseases[27]. Skin cancer is a highly predominant type according to the world health organization which announced that one in every three cases of cancer is diagnosed to be of skin origin[28], with the melanoma as the highest in mortality among white population[29].

In the current study, there was increased number and size of hair follicles and sebaceous glands in the dermis of experimental group of rats when compared to the control group. It is known that stem cell niche of the skin lies in the hair follicular bulge, so, increased number and size of hair follicles might be for the repair process by stem cell differentiation[30].

In the Masson's trichrome stained sections collagen bundles showed diverse difference between both the control and experimental groups. These bundles, in the control rats, were finely arranged in the papillary layer of dermis and densely packed in the reticular layer. However, the experimental group showed loosely arranged bundles with marked spacing in between. Axial periodicity of these widely spaced collagen fibers was apparent in ultrathin sections. Comparing group (II) to group (I), there was a highly statistically significant decline in the mean area percentage of collagen fibers. Collagen is the main protein enhancing wound healing in animal experimental models that have been used recently to manufacture bioactive wound dressings[31]. Estimating the amount of collagen in skin after irradiation using confocal microscopy have been used as a powerful tool to detect skin healing[32].

Orcein staining; in the current work; revealed marked loss of elastic fibers. These fibers appeared short, fragmented and separated by wide spaces. When compared to group (I), group (II) showed a highly statistically significant decline in the mean area percentage of elastic fibers. Fragmentation and sparse arrangement of elastic fibers in skin sections have been demonstrated before in the aging process in response to increased cellular oxidative stress that in turn causes wrinkles and diminished elasticity[33]. As a result of numerous factors affecting tissue homeostasis, loss of elastic fibers' function is linked to severe diseases[34]. All proteins, including the most prevalent fibrous proteins in the skin like keratins, collagen, and elastin, are made up of amino acids. Amino acids are crucial nutrients needed for wound healing and skin restoration[35].

Immunostaining with anti – iNOS antibody was used in the current work to reflect the amount of reactive oxygen species produced in melanocytes of skin. Melanocyte usually appear in ultrathin sections of control rats as cells with cytoplasmic extensions exhibiting pale nucleus with rER and mitochondria together with melanin granules. We found that strong immunostaining appeared in the epidermal cells of the experimental group as compared to the control. A highly statistically significant increase in iNOS immuno-expression was noted in group (II) as compared to group (I). Nitric oxide (NO) production is enhanced as a result of increased iNOS expression, which causes specific amino acid substitutions in particular chromosomes. Increased oxidative stress and an unbalanced antioxidant system in melanocytes may result from excessive NO production[36]. When melanocytes are exposed to hydrogen peroxide (H_2O_2), which is produced in excess as a result of increased iNOS activity, they are destroyed and become depigmented[37]. It has been previously documented that NO plays a role in the inhibition of cell proliferation, differentiation, and death, and that this may have a role in the etiology of autoimmune diseases[38].

Several techniques have been described to protect health professionals, dentists and nail salon technicians from the hazardous usage of methyl methacrylate compounds in their occupation. For orthopedic surgeons and support staff who want to reduce their exposure to MMA fumes because of health concerns, an activated carbon impregnated face mask was described to be an option[39].

Even while total eradication of all methacrylate is now not feasible, it is perhaps the most efficient preventive health measure. Research on methacrylate materials has shown that medical-grade dental gloves provide very little protection[40]. To reduce methacrylate exposures for both dental staff and patients, dental professionals need to be more aware of methacrylate sources and utilize workplace controls[41].

CONCLUSION

In conclusion, the present study demonstrated several cellular effects of the usage of methyl methacrylate compounds on the skin of adult male albino rats. Further studies on various tools to be used for protecting personnel against such hazards are highly recommended.

Also; awareness campaigns should be directed to staff continuously in contact with these compounds for proper self-safety as much as possible.

REDUNDANT OR DUPLICATE PUBLICATION

This manuscript has not yet been published in print or electronically, including on a website, in its current form or a form that is substantially similar to it. It is also not currently under consideration by another publication.

AUTHORSHIP

The authors all admit to having read and approved the manuscript. Additionally, they declare that they have cooperated with the ICMJE's authorship requirements, that the paper is a true reflection of their efforts, and that they are able to independently verify the veracity of the published results.

CONFLICT OF INTERESTS

There no conflicts of interest.

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الملخص العربى

التحليل النسيجي والمورفومتري لآثار مركبات ميثيل ميتاكريليت على جلد ذكور الفئران البيضاء البالغة: نموذج للتفكير في المخاطر المهنية

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الخلفية: الجلد هو أكبر عضو في الجسم يتعرض للضغوطات الخارجية والداخلية. أثبتت مركبات ميثيل ميتاكريليت أنها خطر علي العديد من المهنيين الذين يتعاملون معها. تستخدم هذه المركبات بشكل رئيسي من قبل أطباء الأسنان وفنيي صالون الأظافر وبعض جراحي العظام.

الهدف من العمل: استكشاف التغيرات الخلوية التي تحدث في الجلد على المستويات النسيجية وفوق الهيكلية بسبب استخدام مركبات ميثيل ميتاكريليت.

المواد والأساليب: تم استخدام عشرين من ذكور الفئران البيضاء البالغه التي تزن ٢٠٠ جرام لمدة أسبوعين. تم حلق الجلد على نفس منطقة البطن لكل فأر. تم تقسيم الفئران إلى مجموعتين: الضابطه (دون تدخل) والاختباريه (تدار موضعيا ٢ مل من ميثيل ميتاكريليت).

النتائج: أظهرت أقسام المجموعة الاختباريه ترقق الجلد مع زيادة نسبية في سمك طبقة الكيراتين. أظهرت الأدمة تباعدا واسعا بين ألياف الكولاجين. ظهرت حزم الكولاجين مرتبة بشكل فضفاض في صبغة ماسون الثلاثية. أظهرت المجموعة الاختبارية فقدانا ملحوظا للألياف المرنة في المقاطع المصبوغة بصبغة الأورسين. كما شوهد تلطيخ مناعي قوي ل iNOS في الخلايا الصباغية للبشرة. أظهرت دراسة فوق هيكلية خلايا كيراتينية ذات فجوات سيتوبلازمية متعددة. أظهرت أدمة الجلد تورما ليفيا متدهورا. أكد التحليل المورفومتري النتائج المجهرية.

الاستنتاج: تم إثبات العديد من التأثيرات الخلوية لمركبات ميثيل ميتاكريليت على جلد ذكور الفئران البيضاء البالغة في العمل الحالي. وينصح بشدة بإجراء مزيد من البحوث حول العديد من الأساليب التي يمكن استخدامها لحماية الموظفين من مثل هذه التهديدات.