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Artificial nail modelling systems in healthcare workers: An emerging risk of contact sensitization to a well-known occupational allergen in an alternative way

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Abstract

Background: Artificial nail modelling systems (ANMS) pose a significant risk for nail stylists and their clients regarding acrylate sensitization, which might jeopardize the use of acrylate-containing medical devices.

Objectives: To evaluate the frequency of artificial nail practices among female healthcare workers (HCWs) compared with controls and assess ANMS-related side effects.

Methods: In this comparative, cross-sectional, single-centre study, a face-to-face interview with 200 female HCWs and 200 age-matched female dermatology patients (controls) was conducted regarding the use of ANMS between March and November 2023.

Results: Among 400 participants (median age: 25), 85 (21.3%) have applied ANMS at least once. The prevalence of ANMS application was significantly higher in HCWs ($n = 54/200$, 27%) compared with controls ($n = 31/200$, 15.5%) ($p < 0.05$). Long-lasting nail polish was the most commonly preferred technique ($n = 82/85$, 96.5%). ANMS were mainly performed in nail studios by nail stylists ($n = 79/85$, 92.9%), while three participants were using home kits. Nail brittleness was the most frequently reported side effect ($n = 19/85$, 22.4%). No case of allergic contact dermatitis (ACD) was detected.

Conclusions: The popularity of ANMS among young female HCWs is growing. This striking trend might further put these individuals not only at risk of medical device-related adverse events but also occupational ACD.

KEYWORDS

2-hydroxyethyl methacrylate, acrylates, allergic contact dermatitis, artificial nail modelling systems, healthcare worker, long-lasting nail polish, occupational

1 | INTRODUCTION

Artificial nail practices have become tremendously popular due to their fancy appearance and long-lasting properties compared with traditional nail varnish.^{1,2} Although various techniques (including acrylic nails, gel nails,

long-lasting nail polish, press-on artificial nails, and dipped powder nails) are used under the umbrella term artificial nail modelling systems (ANMS), they all involve acrylates which are well-known contact sensitizers.^{3–5}

Acrylates are monomers that polymerize into plastics and plastic resins through a curing process, occurring spontaneously or by several

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catlysing factors such as ultraviolet light.^{5,6} These monomers have a high sensitizing potential,⁷ whereas the final products are inert substances if adequately cured.^{4,6} However, residual monomers remaining uncured in these products might cause contact sensitization in exposed individuals.^{3,6}

Both acrylic and gel nails are reconstructive techniques used to correct a damaged nail or to extend its length.³ Acrylic nails are formed by a mixture of acrylates sculpted over the nail plate without the need for photocuring.^{3,5,8} Gel nail is a more recent method based on applying acrylic gel cured either by ultraviolet A (UVA) or light-emitting diode (LED) lamps.^{3,5} Long-lasting nail polish, also interchangeably referred to as 'semi-permanent nail polish' or 'gel nail polish', is a type of manicure applied on the natural nail plate or artificial nails constructed by acrylic or gel nail technique.³ It consists of multiple coloured layers including acrylates polymerized by UVA or LED.³ Press-on artificial nails or dipped powder nails fixed on the nail plate by cyanoacrylate-based glue or polish, respectively, are quite different methods.^{1,3} Depending on the technique, ANMS are removed mechanically or by soaking the nails in acetone.³

ANMS-related adverse events are classified as mechanical (due to trauma during the application and/or removal), ultraviolet-related (comprising solar urticaria and squamous cell carcinoma), and allergic (mainly allergic contact dermatitis [ACD]).^{3,9,10}

ACD from acrylates in ANMS has been increasingly reported in professional nail stylists and their customers over the last few decades.^{2,6,11} The most common clinical scenario is periungual eczema and pulpitis.^{3,9,12–14} Ectopic eczema involving the face, due to allergen transfer by hands, contaminated tools, or airborne particles, was also reported.^{3,9} Acrylates are ubiquitous allergens found in a broad spectrum of products such as insulators, varnishes, sealants, paints, glues, and printing inks.^{5,6,8} Various medical devices (contact lenses, dental fillings and prostheses, orthodontic adhesives, wound dressings, orthopaedic prostheses, bone cement, electrocardiogram electrodes, glucose sensors, hearing aids, surgical glues) also include acrylates.^{3,6} Thus, contact sensitization with these allergens through ANMS in younger age groups could jeopardize these individuals' future occupational careers and medical interventions.^{3,4}

This study aimed to investigate the frequency of the use of ANMS among female healthcare workers (HCWs) compared with the general population and assess the side effects related to ANMS.

2 | MATERIALS AND METHODS

This comparative cross-sectional study was conducted between March and November 2023 in our tertiary referral centre at Çanakkale Onsekiz Mart University Faculty of Medicine. Two hundred female HCWs and 200 age-matched female controls were interviewed by a face-to-face questionnaire regarding their knowledge of ANMS and their possible side effects, participants' attitudes toward ANMS, and their applications. Responders who confirmed applying ANMS at

least once were further questioned about the techniques performed, the aim for application, the duration and frequency of application, and any occurrence of side effects related to ANMS (Table 1). The use of acrylate-containing medical devices (including those with no currently published evidence of complication in previously sensitized individuals, such as contact lenses) and any reactions following exposure were also evaluated.

HCWs comprised medical doctors, intern doctors, dentists, dental medicine students, dental technicians, nurses, midwives, healthcare technicians, physiotherapists, and patient caregivers who actively work in a hospital setting and have possible contact with medical devices. The control group was selected from patients admitted to the dermatology outpatient clinic in a randomized fashion.

The demographic features (age, educational background, occupation), presence of atopy (atopic dermatitis,¹⁵ atopic skin,¹⁶ bronchial asthma, and allergic rhinoconjunctivitis), and past medical history (including previous nail disorders) were recorded. The participants currently performing ANMS were examined clinically and by onychoscopy when possible.

IBM SPSS® Statistics Version 26 was used to store and analyse the data. Shapiro–Wilk test was used to evaluate the normality of variable distribution. Descriptive statistics were calculated as median [minimum–maximum] values for continuous variables, and as frequency and percentage for categorical variables. The chi-squared test or Fisher's exact test was used to assess the differences in the distribution of categorical variables between two independent groups. The Mann–Whitney *U* test was used to compare two non-normally distributed groups. A two-tailed *p*-value <0.05 was considered statistically significant.

The study was approved by the Ethical Committee of Çanakkale Onsekiz Mart University Faculty of Medicine (approval number: 2023/03-13) and conducted in accordance with the Declaration of Helsinki.

3 | RESULTS

A total of 400 female participants with a median age of 25 (range: 18–50) were included. The demographic and clinical characteristics of HCWs and controls are summarized in Table 2. Three hundred and sixty-four (91%) responders had heard about ANMS, particularly about gel nails/long-lasting nail polish (*n* = 342/400, 85.5%), followed by press-on artificial nails (*n* = 143/400, 35.8%), acrylic nails (*n* = 80/400, 20%) and dipped powder nails (*n* = 2/400, 0.5%). In total, 39.8% (*n* = 159/400) declared that they were aware of ANMS-related side effects (Table 2).

Eighty-five participants (21.3%) have applied ANMS at least once. The prevalence of ANMS application was significantly higher in HCWs (*n* = 54/200, 27%) than in controls (*n* = 31/200, 15.5%) (*p* < 0.05) (Table 2). One hundred and nineteen (29.8%) were planning to continue (*n* = 68) or initiate ANMS (*n* = 51) in the future. Apart from 36 individuals who had never heard of these applications, those who claimed to be aware of the side effects were keener to perform

TABLE 1 Answers of participants who applied artificial nail modelling systems ($n = 85$) to questions regarding application details.

Questions	Response ($n = 85$)
Which technique(s) have you applied? ^a	Long-lasting nail polish ($n = 82$), gel nails ($n = 17$), acrylic nails ($n = 5$), press-on artificial nails ($n = 4$), dipped powder nails ($n = 0$)
Why do you prefer artificial nails? ^a	Long-lasting manicure ($n = 75$), nail extension ($n = 16$), hiding nail dystrophy ($n = 5$)
Who applies your artificial nails?	Nail stylist ($n = 79$), self-application as a nail stylist ($n = 3$), self-application with ultraviolet-curing home kit ($n = 3$)
How are your artificial nails removed?	Mechanical removal ($n = 82$), by soaking in acetone ($n = 3$)
Did you have nail dystrophy before artificial nail application?	Yes ($n = 9$, 10.6%)
What type of nail dystrophy did you have?	Nail brittleness ($n = 8$), onychophagia ($n = 4$), nail loss ($n = 1$)
When did you have your first artificial nail application?	During the last year ($n = 32$, 37.6%) During the last 1–3 years ($n = 41$, 48.2%) During the last 3–5 years ($n = 12$, 14.1%) More than 5 years ago ($n = 0$)
At what age was your first artificial nail applied?	Median: 25 years (range: 16–49)
How frequently do you apply artificial nails?	Biweekly ($n = 2$), once a month ($n = 49$), once in 2 months ($n = 7$), once in 3 months ($n = 9$), once in 6 months ($n = 2$), once a year ($n = 10$), only once ($n = 6$)
How long do you wear artificial nails?	1–2 weeks ($n = 3$), 2–4 weeks ($n = 67$), 4–8 weeks ($n = 13$), more than 8 weeks ($n = 2$)
Do you give any break between each application?	Yes ($n = 46$) No ($n = 33$) Applied only once ($n = 6$)
If yes, how long do you wait for the next application?	Less than 1 week ($n = 2$), 1–2 weeks ($n = 3$), 2–3 weeks ($n = 3$), 3–4 weeks ($n = 7$), 4–8 weeks ($n = 9$), more than 8 weeks ($n = 22$)
Have you ever experienced pain or numbness following application or removal?	No ($n = 85$)
Have you experienced any side effects following the application? ^b	Yes ($n = 21$, 24.7%)
Mechanical side effects	Nail brittleness ($n = 19$), onycholysis ($n = 5$), nail discoloration ($n = 2$), splinter haemorrhagia ($n = 1$), nail loss ($n = 1$), lamellar splitting ($n = 1$)
Eczema (hand or ectopic)	None
Respiratory symptoms	Rhinoconjunctivitis ($n = 1$)
If yes, do you still plan to continue the application?	Yes ($n = 16$, 76.2%)
Are you using a medical device?	Yes ($n = 40$, 47.1%) (Dental filling [$n = 32$], contact lenses [$n = 15$])
If yes, when did you start using the medical device?	Before the artificial nail application ($n = 35$) After the artificial nail application ($n = 5$)
Have you experienced any problems confined to areas in contact with the medical device?	No ($n = 40$, 100%)

^aThe total number of responders is >85, as some of them selected more than one option.

^bRecorded based on clinical examination or anamnesis of the responders.

ANMS than those unaware of the adverse reactions (39.6% [$n = 63/159$] vs. 27.3% [$n = 56/205$]; $p < 0.05$).

Participants applied ANMS mainly once a month ($n = 49/85$, 57.6%) and for cosmetic purposes ($n = 80/85$, 94.1%), whereas only 5.9% ($n = 5/85$) were using these techniques primarily to cover their dystrophic nails. Long-lasting nail polish was the most commonly preferred technique ($n = 82/85$, 96.5%), performed together with gel nail method in 17 participants (Table 1). ANMS were generally performed in nail studios by professionals ($n = 79/85$, 92.9%), while three nail stylists and three ultraviolet-curing home kit users were applying ANMS themselves for the last 1–5 and 1–3 years, respectively. One of the home kit users was a nurse, while two were from the control

group. All of them declared that they had heard about ANMS-related side effects, while only one of the controls was aware of the allergy risk. This consumer also described nail brittleness, whereas the other two did not have onychodystrophy.

Any dermatologic and onychoscopic findings regarding side effects were documented along with those described by the subjects without current symptoms. Twenty-one participants described side effects, most commonly nail brittleness ($n = 19$). However, the mechanical changes (nail brittleness [$n = 4$], onycholysis [$n = 2$], splinter haemorrhagia [$n = 1$], lamellar splitting [$n = 1$]; Figure 1A,B) could only be examined in four (three HCWs and one control) during the interview. None of the participants showed signs of ACD. However,

TABLE 2 The comparison of healthcare workers and age-matched controls (patients from dermatology outpatient clinic) regarding demographic features, clinical characteristics, and attitudes toward ANMS.

	Healthcare workers (n = 200)	Controls (n = 200)	p-Value
Age, years, median (range)	25 (19–49)	25 (18–50)	0.263 ^a
Educational background (n)	Postgraduate (12) College (178) High School (10) Middle School (0)	Postgraduate (5) College (163) High School (26) Middle School (6)	N/A
Atopy, n (%)	22 (11)	27 (13.5)	0.446 ^b
Previous nail disorder, n (%)	12 (6)	5 (2.5)	0.083 ^b
Heard about ANMS before, n (%)	192 (96)	172 (86)	0.001^b
Source of information, n (%)			
Friend	139 (69.5)	117 (58.5)	0.022^b
Social media	157 (78.5)	145 (72.5)	0.163 ^b
Nail stylist	11 (5.5)	10 (5)	0.823 ^b
Information on ANMS-related side effects, n (%)	95 (47.5)	64 (32)	0.002^b
Mechanical	95 (47.5)	61 (30.5)	0.001^b
Allergy	50 (25)	22 (11)	0.001^b
Others ^c	6 (3)	2 (1)	0.284 ^d
Information on the presence of acrylates in medical devices, n (%)	21 (10.5)	3 (1.5)	0.001^b
Application of ANMS, n (%)	54 (27)	31 (15.5)	0.005^b
Occupations of participants applying ANMS (n)	Medical doctor (27) Nurse (9) Intern doctor (9) Healthcare technician (4) Dental medicine student (2) Patient caregiver (2) Physiotherapist (1)	Student (13) Company employee (6) Teacher (2) Engineer (2) Sports trainer (2) Nail stylist (2) Nail stylist and hairdresser (1) Housewife (1) Architect (1) Chemist (1)	N/A
Planning to apply/continue ANMS in the future, n (%)	72 (36)	47 (23.5)	0.006^b

Note: Statistically significant results are highlighted in bold.

Abbreviations: ANMS, artificial nail modelling systems; N/A, not applicable.

^aMann–Whitney *U* test.

^bChi-squared test.

^cInfection (n = 4), skin cancer (n = 2), ultraviolet damage (n = 2).

^dFisher's exact test.

the acrylate sensitization could not be ruled out in those showing mechanical damage, as they were not patch-tested. A nail stylist complained about rhinoconjunctivitis-like symptoms, mainly during gel nail/long-lasting nail polish removal (Table 1). Neither paraesthesia/hyperaesthesia nor any lesions suspected of malignancy were detected in any participant.

4 | DISCUSSION

ANMS may be used to hide nail disorders or rebuild a damaged nail.^{9,17} However, currently, there is an increased demand solely for cosmetic purposes.⁹ In accordance with this, in our subjects the primary aim of application was to have a long-lasting manicure or

cosmetically acceptable long nails. In contrast, a limited number of participants preferred ANMS to cover dystrophic nails.

ANMS-related mechanical side effects were rarely reported by our participants and occasionally observed during the examination, since most of them were either on a long break or wearing ANMS at the time of the interview, which hindered the evaluation of the actual traumatic injury (Figure 1C,D). Thus, the low rate of mechanical side effects would possibly result from a response bias of the participants. In a recent study from Poland conducted as an online self-administered questionnaire among females interested in long-lasting nail polish, nearly 85% of participants reported side effects, mainly nail plate changes following removal.¹⁸ However, most responders (76.3%) in the study above declared that they performed long-lasting nail polish themselves. Moreover, the rate of nail plate changes

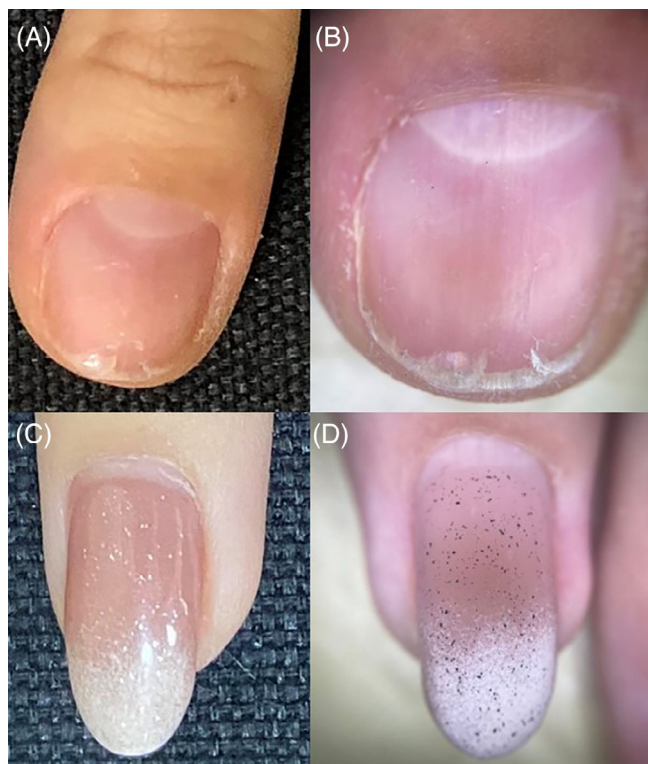


FIGURE 1 (A,B) Lamellar splitting of the thumb nail following removal of long-lasting nail polish observed in clinical and onychoscopic examination, respectively; (C,D) clinical and onychoscopic images of a totally normal-looking nail covered by long-lasting nail polish.

following long-lasting nail polish removal was reported to be higher in individuals applying the polish themselves compared with those having performed by nail stylists.¹⁸ The majority of the participants in our study, on the other hand, had ANMS done in professional studios.

Individuals might experience paraesthesia/hyperaesthesia of the fingernails following the application or removal of ANMS due to damage of free nerve endings by acrylic monomers or direct mechanical trauma.^{17,19,20} Fortunately, none of our participants complained about this phenomenon that has recently been termed onychodynia.²⁰

Squamous cell carcinoma was reported to develop occasionally more than a decade following ultraviolet exposure.⁹ In our series, no cases of malignancy were detected, possibly due to the low carcinogenic risk of ultraviolet nail lamps²¹ and the short duration of application in our participants (maximum for 5 years).

ACD in the setting of ANMS-related acrylate sensitization causes a wide range of clinical findings. The changes in nail plate, nail bed, and nail folds might mimic skin disorders such as psoriasis and lichen planus.^{22,23} There are ACD cases presenting with isolated subungual hyperkeratosis and onycholysis without skin involvement who were unnecessarily treated with systemic agents reported in the literature.²⁴ It would therefore be reasonable to perform patch tests in participants showing traumatic nail changes in our study. Rhinoconjunctivitis and respiratory symptoms following exposure to acrylates, also described by one of the nail stylists in our study, are not uncommon.^{4,7,12,19}

The increasing prevalence of acrylate allergy from ANMS has been named an epidemic by some authors.^{7,19} Traditionally, some particular professions, such as dental professionals, industry workers, and printers, were reported to have a higher incidence of contact sensitization with acrylates, as they come across related products/uncured plastics in their occupational environment.^{4,6,8,25} Following increasing awareness regarding acrylate allergy, the advent of non-touch techniques and adequate protective measures, the prevalence of occupational ACD from acrylates has declined in these occupational groups.^{4,13} Instead, a shift has been observed toward nail stylists, accounting for the majority of acrylate-related occupational ACD cases in the current literature.⁶ However, ACD affects more than just professional nail stylists; it also affects consumers.^{4,6,7,12,13,26} Thus, implementation of ANMS in the early years, as in young HCWs in our series, especially in the dental medicine students ($n = 2$), could have a negative impact on the course of their professional lives in the long run.

ANMS are mainly applied in nail studios by professionals. In some European countries, ANMS are indicated as a part of the training curriculum of hairdresser apprentices²⁷ and hairdressers also perform ANMS to their customers in hairdresser salons^{28,29} similar to the hairdresser applying ANMS in our series (Table 2). Indeed, in a recent systematic review, the risk of sensitization to 2-hydroxyethyl methacrylate (HEMA) was found to be increased ninefold in hairdressers and beauticians who were in charge of ANMS compared with controls.²⁷

The ultraviolet-curing nail polish kits are also available online for domestic use.^{17,30} These kits used by non-professionals, even children and adolescents,^{30–32} further increase the risk of sensitization, as these individuals might apply artificial nails very frequently without taking protective measures.^{4,17,31} The curing might be incomplete due to non-calibrated ultraviolet devices in these kits or inadequate time spent on curing by untrained users.^{4,32} In Sweden, one of these kits was banned by regulatory authorities³⁰ and recently, the use of HEMA for ANMS was limited to professional use in Europe.⁶ The number of responders using ultraviolet-curing nail polish kits in our study was also limited.

Although not very common, individuals formerly sensitized to acrylates through ANMS could experience severe reactions such as allergic contact stomatitis or prosthesis failure following exposure to acrylates in medical devices.^{12,33–35} A recent study from Spain conducted as a telephone survey on patients previously diagnosed with ANMS-related ACD revealed that 15.5% of those requiring acrylate-containing dental materials experienced temporary reactions to these products.³⁶ The acrylate allergy might also compromise future occupational preferences.^{4,30} In line with this, dental professionals suffering from acrylate-related occupational ACD following sensitization through ANMS were reported in the literature.^{37,38} The higher rate of female HCWs preferring ANMS compared with controls of similar age and educational background in our study is somehow frustrating, when the potential occupational ACD burden that could occur following ANMS-related acrylate sensitization of these individuals in the healthcare sector due to widespread use of acrylates is considered. Indeed, a significantly higher rate of HCWs declared being aware of

the side effects and the presence of acrylates in medical devices. Moreover, HCWs reported their friends as a source of information regarding ANMS more frequently compared with controls. This means a higher probability of ANMS being popular among HCWs. The reason for this popularity is unknown. Since traditional nail varnish is more prone to chipping by antiseptics and frequent hand washing, HCWs who use nail varnish in daily life might prefer ANMS to avoid this damage that inevitably occurs due to their profession.

The use of ANMS in HCWs is a controversial issue. Several healthcare authorities recommend that HCWs do not wear artificial nail products.³⁹ On the other hand, in a recent randomized controlled trial, the antibacterial effect of surgical hand scrub with chlorhexidine gluconate was not impaired in HCWs wearing long-lasting nail polish.⁴⁰ As expected, as a part of general safety measures, no HCW currently in contact with high-risk patients regarding infection, particularly in intensive care units, operating rooms or oncology units, was wearing ANMS in our study.

In the online questionnaire study from Poland, nearly 78% of subjects reporting side effects related to long-lasting nail polish would like to continue performing this manicure technique.¹⁸ Similarly, a high share of our participants who were aware of the side effects or reported these adverse reactions in their practice stated that they would perform ANMS.

HEMA is the leading allergen reported in the majority of the patients patch-tested with the suspicion of acrylate allergy.^{6,7,13,14,26} Due to a marked increase in ACD cases from ANMS, it was included in the European baseline series as a screening marker for acrylate allergy.⁴¹ Ethyl cyanoacrylate, another acrylate that does not cross-react with HEMA,⁸ was also proposed to be tested in patients with suspected acrylate allergy from ANMS.^{7,12} On the other hand, the lack of signs of ACD in any individual in our series was surprising. The time interval between the first application and the onset of ACD ranges from 7 days to 19 years in the literature, depending on the technique used.^{9,14} In contrast, it is quite shorter for domestic ultraviolet-curing nail polish kit users (~5.5 months)³⁰ and nail professionals (mainly within the first year of occupation).^{7,42} The limited number of participants using domestic ultraviolet-curing kits ($n = 3$) or working as nail stylists ($n = 3$) could explain the lack of acrylate allergy in this study. Moreover, as the maximum duration of application was 5 years in our series, it might be possible to detect ACD in these participants if a follow-up visit is scheduled after 3–5 years.

The face-to-face questionnaire conducted along with dermatological examination was the main strength of our study providing a more detailed evaluation. However, response bias is possible, as responders might have denied ANMS-related side effects. The cross-sectional design of the study is another limitation. It would provide more insight to conduct a prospective cohort study in a similar format.

5 | CONCLUSION

The popularity of ANMS among the young female population is increasing. Our study highlights the growing trend of ANMS among

female HCWs. This might increase the risk of contact sensitization in these individuals already exposed to acrylates within their work, consequently leading to occupational ACD. The number of participants planning to perform/continue ANMS was also relatively high despite the knowledge and/or experience about side effects. Thus, it is crucial to inform nail stylists and their clients, especially HCWs, regarding the sensitizing potential of ANMS and the risk of domestic ultraviolet-curing nail polish kits.

AUTHOR CONTRIBUTIONS

Zeynep Keskinaya: Investigation; writing—original draft; methodology; validation; visualization; writing—review and editing; software; formal analysis; project administration; data curation; supervision; resources; conceptualization. **Selda Işık Mermutlu:** Writing—original draft; methodology; writing—review and editing; formal analysis; investigation. **Özge Kaya:** Writing—original draft; methodology; writing—review and editing; formal analysis; investigation. **Haile Çakır:** Investigation; writing—original draft; methodology; visualization; validation; writing—review and editing; software; formal analysis; data curation.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Research data are not shared.

ETHICS STATEMENT

The study was approved by the Ethical Committee of Çanakkale Onsekiz Mart University Faculty of Medicine (approval number: 2023/03-13).

INFORMED CONSENT STATEMENT

Informed written consents were obtained from patients for their images to be included.

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