



Morphological characteristics of pressure ulcers due to elastic compression stockings and factors associated with their occurrence

Sachiko Kinoshita, MHS, RN, WOCN^{1) 2)}; Rie Ishikawa, RN, WOCN³⁾; Mariko Seishima, PhD⁴⁾; Chizuko Konya, PhD, RN, WOCN⁵⁾; Yuko Matsui, PhD, RN⁶⁾; Mayumi Okuwa, PhD, RN^{2) 7)}; Hiromi Sanada, PhD, RN, WOCN^{8) 9)} and Junko Sugama, PhD, RN¹⁰⁾

School of Nursing, Kanazawa Medical University¹⁾
Department of Clinical Nursing, Faculty of Health Sciences, Institute of Medical,
Pharmaceutical and Health Sciences, Kanazawa University²⁾
Nursing Department, Gifu University Hospital³⁾
Department of Dermatology, Gifu University Graduate School of Medicine⁴⁾
School of Nursing, Ishikawa Prefectural Nursing University⁵⁾
Department of Nursing, Faculty of Health Sciences, Komatsu University⁶⁾
Department of Clinical Nursing, Institute of Medical, Pharmaceutical
and Health Sciences, Kanazawa University⁷⁾
Department of Gerontological Nursing/ Wound Care Management,
Graduate School of Medicine, The University of Tokyo⁸⁾
Global Nursing Research Center, Graduate School of Medicine, The University of Tokyo⁹⁾
Research Center for Implementation Nursing Science Initiative, School of
Health Sciences, Fujita Health University¹⁰⁾

Abstract

Background: Elastic stockings (ESs) are used for compression therapy, but medical device-related pressure ulcers (MDRPUs) due to ESs (ESRPUs) have been reported. Objective: To clarify the morphological characteristics and factors related to the occurrence of ESRPUs. Method: A qualitative descriptive study was implemented. The setting was a 606-bed university hospital in Japan from 2006 to 2012. The morphological characteristics were analyzed by qualitative descriptions from photographs of hospital-acquired ESRPUs. Factors associated with the occurrence of ESRPUs were analyzed using the medical records. Results: Twenty-four ESRPUs in nine patients were analyzed. The ESRPUs were divided three variables: location, shape, and distribution. Locations were divided into protruding regions (Protrusion) such as bones and tendons, movable regions (Joint) such as joints, and soft regions (Soft). The shapes were irregular, linear, and round. All ESRPUs in the Soft were linear (n=5), and ESRPUs in the Protrusion and the Joint were found irregular (n=12). BMI was higher than the median in 75% of those with soft region ESRPUs, and thigh-length stocking type was found the only in this region.

Corresponding author : Sachiko Kinoshita
School of Nursing, Kanazawa Medical University
1-1 Daigaku, Uchinada-Machi, Kahoku-Gun, Ishikawa, 920-0293, Japan

Sachiko Kinoshita (096-94) Manuscript received : 18 January 2021
Manuscript accepted : 23 April 2021

Patients in the Protrusion exhibited peripheral circulatory insufficiency. Discussion: The region of the Soft and the Joint were a characteristic of ESRPU that was not found in pressure ulcers of its own weight. Linear ESRPUs were considered to be related to BMI and ES length. Conclusion: Location, shape, and distribution were morphological characteristics, and linear shapes were feature in soft regions. ESRPU-related factors were considered BMI, ES length, and peripheral circulatory insufficiency.

Key Words: elastic compression stocking, medical device-related pressure ulcer, qualitative sketch technique, morphological characteristic, occurrence factor

Introduction

In Japan, Guidelines for the Diagnosis, Treatment, and Prevention of Pulmonary Thromboembolism and Deep Vein Thrombosis (DVT) were established in 2004¹⁾, after which the use of elastic compression stockings (ESs) and intermittent pneumatic compression (IPC) became common. Although the use of anticoagulant therapies for prevention DVT is becoming more common, some patients need ESs, depending on their general condition.

ESs are used for compression therapy for DVT, and they are designed such that stepwise pressure is applied²⁾. However, ESs have been reported to be associated with medical device-related pressure ulcers (MDRPUs)³⁾. The Japanese Society of Pressure Ulcers (JSPU) reported that 14.3% of pressure ulcers occurred on the lower limbs and that ESs are among the factors causing them⁴⁾. Moreover, in 2016, the JSPU Academic Committee published best practice medical device-related pressure ulcer prevention and management, and presented a conceptual diagram of MDRPU, preventive care, and risk assessment⁴⁾. Outside of Japan, the incidence of pressure ulcers from ESs and other medical devices has been reported to be 34.5%⁵⁾, 65.6%⁶⁾, and 23.8%⁷⁾, which is worryingly high. A set of collaborative guidelines (NPUAP/EPUAP/PPPIA)⁸⁾ indicated the importance of measures for preventing MDRPUs and other related injuries. However, assessments of the risk of MDRPUs and the appropriate care to prevent them differ depending on the particular expert being consulted⁴⁾. Therefore, to prevent MDRPUs, there is a need to clarify the factors associated with their occurrence.

In previous studies, by using qualitative descriptions, the morphological characteristics of pressure ulcers

were used to clarify their causative factors, leading to the development of effective preventive care^{9) - 14)}. Regarding the morphological characteristics of MDRPU, the morphology of non-invasive positive pressure ventilation masks has been analyzed¹⁴⁾, but ES has not been clarified, and the factors related to them have not been analyzed. As such, the aim of this study is to clarify the morphological characteristics and factors related to the occurrence of ESRPUs.

Methods

This work involved a retrospective mixed methods design using qualitative and quantitative methods. In Study 1, we used qualitative descriptive analysis to evaluate the morphological characteristics of ESRPUs in patients in whom pressure ulcers had appeared during a hospital stay. In Study 2, we collected quantitative data from medical records and analyzed the relationship between the morphological characteristics and factors associated with the occurrence of ESRPUs.

1. Setting and participants

The setting and participants were as follows. This study was conducted between 2006 and 2012 at all wards (n=12) of a 606-bed university hospital in Japan. Patients who developed ESRPUs at the hospital were investigated. The eligibility criteria were as follows: patients identified as ESRPU, matching the ES wearing area. Patients for whom photographs of ESRPU were available within 24 hours of wound development. Patients for which information on the use of ES was available from medical records. And patients over 20 years old.

Exclusion criteria were as follows: patients who presented with a skin disorder such as eczema throughout the entire area where ESs had been

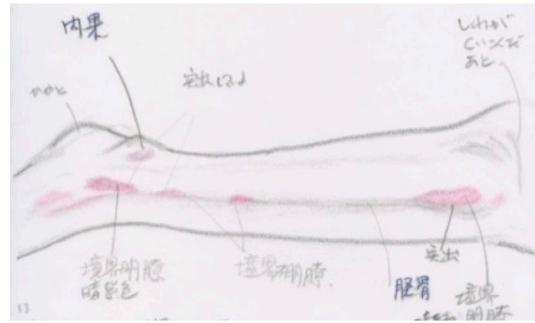


Fig. 1 Analysis the morphological characteristics of pressure ulcers by qualitative description for using qualitative sketch technique

Summary

Plural pressure ulcers located on protrusion of bone (tibia and inner ankle) and tendon (Tibialis anterior tendon, Extensor digitorum longus, and Achilles tendon etc.). Plural ulcers appeared like a stepping-stone pattern on the protrusion of the tibia. Every pressure ulcer is irregular shape, clear and unclear of edge and superficial wounds d2 (DESIGN-R®). Colors are dark red and purple. Under the knee inside appeared plural wrinkles due to upper edge of stocking.

worn based on photographs and medical records; and patients with wounds that developed at the heel (because of difficulties in distinguishing them from pressure ulcers caused by the patient's own weight). Arterial ulcers, venous ulcers, and diabetic ulcers were differentiated from ESRPUs and excluded from the study.

2. ESRPU definition

ESRPUs were defined as wounds that developed at a site that comes into contact with ESs. Wounds that developed at the medial and lateral malleolus were not included as ESRPUs because it is difficult to distinguish them from pressure ulcers caused by the patient's own weight. When rash developed throughout the entire area where ESs were worn, this was not defined as a pressure ulcer. Pressure ulcers caused by the patient's own weight were also excluded. At our hospital, the occurrence of pressure ulcers is reported through an intra-hospital system by the ward nurse who discovers them. This report includes the patient's name, age, and sex, first and last dates of using the device and date of ESRPU development. Reports are submitted through this system to the Center for Nutrition Support and Infection Control, where the pressure ulcer treatment team is stationed, and to wound ostomy and continence nurses (WOCNs). WOCNs visit the department at which the ulcer occurred on the day or day after its occurrence, examine the skin together with the attending nurse, and observe the skin disorder and the

site where the ESs have been worn to determine the presence of ESRPUs. When it is difficult to determine whether the wound is a pressure ulcer or a different skin disorder, staff from the dermatology department or WOCNs and a physician from the pressure ulcer treatment team are consulted. When an ESRPU is confirmed, DESIGN-R®¹⁵⁾ is used to record the findings and images, after which a report is submitted. Typically, the patient's skin is assessed once or twice daily depending on the shift (two to three shifts per day). Redness that persists for at least half a day, including redness that disappears with pressure, is reported.

3. Study 1

For Study 1, the survey method used qualitative description of ESRPUs. For this qualitative description analysis, data were collected using a descriptive method⁹⁾. Details of individual wounds were recorded with sketches (Fig. 1). The sketches were drawn by a trained researcher. Morphological characteristics were obtained from photographs of each ESRPU taken from the front. The ESRPUs' shapes, such as round or linear, were categorized based on the descriptions for each patient. These characteristics were compared with the descriptions in previous studies on pressure ulcers^{10) 14)}, and new subcategories were designated as a feature of the present study. For subcategories such as "shape of pressure ulcer," the general findings across the whole period of development of the

pressure ulcers were used. Wounds were evaluated for depth (severity) by DESIGN-R^{®15)} by staff nurses and WOCNs.

4. Study 2

In Study 2, a survey was conducted to examine the association between the occurrence of ESRPUs and general/local conditions. Information on general conditions and events related to ESRPUs was obtained based on medical records and analyzed. Detailed data that were considered to be related to the occurrence of pressure ulcers, such as changes in general conditions, were evaluated. The researchers created and conducted a survey from the perspectives of individual, device-related, and care-related factors based on items that are considered to cause pressure ulcers or to increase the risk of lower limb ulcers, in addition to the patient's underlying disease, based on a conceptual diagram on the development of pressure ulcers. The following information was obtained from the medical records, in terms of the patient status at admission: age, sex, BMI, cognitive state evaluated by sensory perception on the Braden Scale, primary disease, complications, and medications, duration of ES use before ESRPU occurrence, as well as the presence/absence of pressure ulcers at another sites. Regarding the ESs used, information obtained at the time of wearing them was extracted, such as the type of ESs (below-knee (HS) or thigh-length stockings (S)), use of elastic bandages, and intraoperative/postoperative use of IPC. The blood examination data obtained at the date closest to that of the report of ESRPU occurrence were used. Nutritional state was evaluated using serum albumin and hemoglobin, inflammation/infection state was evaluated using CRP, hemodynamics was evaluated using mean blood pressure, and data were also obtained on respiratory condition/oxygenation, oxygen saturation (SpO₂), oxygen inhalation, and respiratory management with a ventilator. Regarding the local conditions of the lower limbs, data were obtained on the presence/absence of edema in the lower limbs, presence/absence of dorsalis pedis artery palpation, and presence/absence of coldness of both feet. Regarding the care-related factors, information was obtained on ankle branchial index (ABI), which was measured prior to wearing ES.

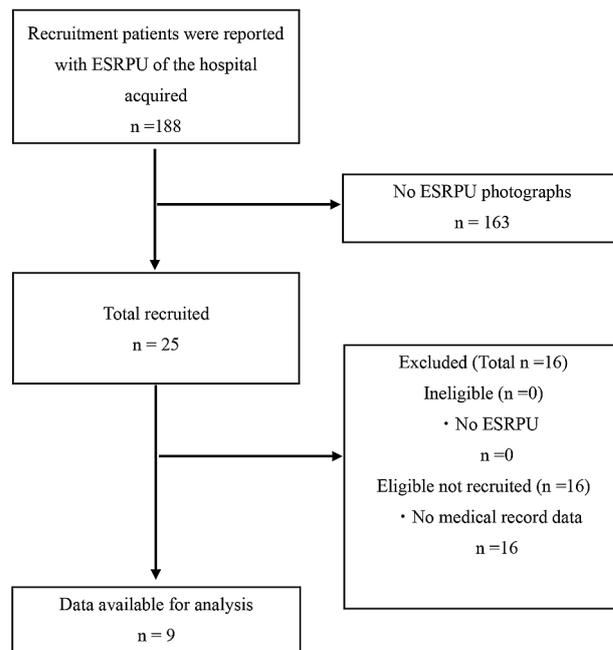


Fig. 2 Elastic stocking related pressure ulcer recruitment flow diagram

The presence of MDRPUs was determined by WOCNs and staff nurses. The qualitative description of PU was appropriately supervised by researchers with specialized knowledge in this field. The photographs of ESRPUs were taken by a single researcher. The method for analyzing the qualitative descriptions of ESRPUs was as follows. All data from the medical records were extracted by a researcher who was a WOCN and knowledgeable in research settings. By matching the characteristic morphological patterns of ESRPUs, individual patients were grouped together. ESRPUs with similar morphological characteristics were categorized together. The associations between the characteristics of the categorized wounds and these factors were then analyzed.

This study was approved by the ethics committees of Kanazawa Medical University (approval number: 199) and Gifu University (approval number: 25-348).

Results

Twenty-four MDRPUs in nine patients were analyzed in this study. A flow chart of patient selection is shown in Fig. 2.

1. Patients' backgrounds

The mean age of the nine patients was 76 years (six men, three women; age range 63-93 years).

| Location: Anatomical sites | | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Protrusion on the bone/tendon: protrusion on the bone/tendon, such as tibia, lateral malleolus, long elongated toes extender, Achilles tendon etc. | Joint: The movable or fixed place or part where two bones or elements of a skeleton join | Soft region: soft tissue between skin and bone |
| Shape: Visible shape of pressure ulcers | | |
| Irregular: Unclear wound edge like a map | Liner: Linear shape, A long, narrow mark or band | Round: A round plane figure whose boundary |
|  |  |  |
| Number and Distribution | | |
| Single: Number of the shape is only one on the place | Plural: Number of the shape are more than two on the place | |
| | Stepping stone pattern  | Plural forming outward arch  |

Fig. 3 The definition of categories for morphological characteristics of pressure ulcers

Table 1 Morphological characteristics of pressure ulcers^a

| Wound characteristics | Total | Protrusion on the bone/tendon | Joint | Soft region |
|-----------------------|------------|-------------------------------|-----------|-------------|
| Depth ^b | | | | |
| d1 | 20 (83.3) | 14 (93.3) | 3 (75.0) | 3 (60.0) |
| d2 | 2 (8.3) | 1 (6.7) | 1 (25.0) | 0 (0.0) |
| D3 | 1 (4.2) | 0 (0.0) | 0 (0.0) | 1 (20.0) |
| DU | 1 (4.2) | 0 (0.0) | 0 (0.0) | 1 (20.0) |
| Shape | | | | |
| Irregular | 12 (50.0) | 9 (60.0) | 3 (75.0) | 0 (0.0) |
| Liner | 9 (37.5) | 3 (20.0) | 1 (25.0) | 5 (100.0) |
| Round | 3 (12.5) | 3 (20.0) | 0 (0.0) | 0 (0.0) |
| Distribution | | | | |
| Single | 20 (83.3) | 13 (86.7) | 4 (100.0) | 3 (60.0) |
| Pulral | 4 (16.7) | 2 (13.3) | 0 (0.0) | 2 (40.0) |

^a n=24. Values represent N (%)

^b based on DESIGN-R[®] 15)

Underlying conditions included gastrointestinal cancer (n=3), total knee arthroplasty (TKA) (n=1), cerebrovascular disease (n=2), heart disease (n=2), and kidney disease (n=1).

2. Morphological characteristics

In total, 24 wounds were analyzed. There were six wounds in one individual (B), five wounds in two individuals (D, E), two wounds in two individuals (A, G), and one wound in four individuals (C, F, H, I). Their morphological characteristics were defined in terms of three variables: location, shape, and distribution. The definitions are listed in Fig. 3. The location could be

divided into protruding regions (Protrusion) such as bones and tendons, movable regions of joints (Joint), and soft regions of skin other than bones and joints (Soft). The shapes were divided into irregular, linear, and round. The distribution was divided into single and plural. Table 1 shows the wound characteristics by location. Fifteen wounds were observed in the Protrusion region, all with a depth of d1 or d2 (DESIGN: PU Status Tool). The most common ulcer shape was irregular (9/15, 60.0%), and most ulcers were present as a single ulcer (13/15, 86.7%). There were two cases (13.3%) of plural ulcers that appeared in a stepping

Table 2 Individual, Device, and Care Factors related to ESRPU*1 occurrence

| Patient | ESRPU Location | Age | Sex | Disease | BMI | sensory perception of the BS*2 | PAD | DM | Use of anticoagulants | Long-term use of steroids | Preexisting pressure ulcer | Alb (g/dL) | Hb (g/dL) | CRP (mg/dL) | Mean blood pressure*3 (mmHg) |
|---------|-----------------------------------------|-----|-----|-----------------------------|--------------|--------------------------------|-----|----|-----------------------|---------------------------|----------------------------|------------|-----------|--------------|------------------------------|
| A | | 76 | M | Coronary atherosclerosis | Last hp 20.8 | 3 | + | + | + | - | + | 3.1 | 9.5 | 17.97 | 64 |
| B | Protrusion on the bone/tendon | 80 | M | Post gastric cancer surgery | 19.7 | 4 | + | - | - | - | - | 2.2 | 8.8 | 9.45 | 75 |
| C | | 81 | M | Post AMI resuscitation | Unknown | 3 | - | - | - | - | + | 2.9 | 9.1 | 13.07 | 53 |
| D | Protrusion on the bone/tendon and joint | 71 | M | HCC treatment | 18.7 | 4 | - | - | + | - | - | 1.9 | 7.2 | 13.34 | 69 |
| E | | 63 | F | Pyelonephritis | 19.6 | 3 | - | - | - | - | - | 2.6 | 11.9 | 25.86 | 65 |
| F | | 93 | F | Post TKA | 29.4 | 4 | - | - | - | - | - | 2.6 | 6.9 | Not measured | 63 |
| G | | 75 | M | Acute cerebral infarction | 20.8 | 1 | - | - | + | - | - | 2.3 | 9.1 | 10.36 | 79 |
| H | Soft region | 90 | M | Squamous cancer | 18.6 | 4 | - | - | - | - | - | 2.5 | 7.2 | 7.03 | 76 |
| I | | 76 | F | Left thalamus hemorrhage | 24.2 | 2 | - | - | + | - | - | 4.5 | 11.8 | 0.26 | 95 |

Table 2 Individual, Device, and Care Factors related to ESRPU occurrence (continue)

| Patient | ESRPU Location | SpO ₂ | Oxygen inhalation | Use of ventilator | Skin perfusion/dorsalis pedis artery state | Coldness of limbs | Lower limb edema | Intraoperative/postoperative IPC*4 | Stockings type*5 | ABI*6 measurement | Durations*7 |
|---------|-----------------------------------------|------------------|-------------------|-------------------|--------------------------------------------|-------------------|------------------|---------------------------------------|------------------|-------------------|-------------|
| A | | 95 | + | - | Weak | - | - | - | HS | - | 1 |
| B | Protrusion on the bone/tendon | 90 | + | + | Weak | - | + | Intraoperative/postoperative IPC | HS | - | 7 |
| C | | 96 | + | + | Weak | + | - | - | HS | - | 5 |
| D | Protrusion on the bone/tendon and joint | 95 | + | - | Not measured | - | - | - | HS | - | 11 |
| E | | Not measured | + | - | Not described | + | + | - | HS | - | 4 |
| F | | Not measured | - | - | Good | - | - | Intraoperative/postoperative IPC (AV) | S | - | 1 |
| G | Soft region | 99 | + | + | Not described | + | - | - | HS | - | 6 |
| H | | 94 | - | - | Not described | - | - | - | S | - | 2 |
| I | | Not measured | + | - | Not described | - | - | - | HS | - | 10 |

*1 ESRPU: ES related pressure ulcer, *2 BS: Braden Scale, *3 Mean blood pressure: diastolic blood pressure + (maximum blood pressure-minimum blood pressure) ÷ 3, *4 IPC: Intermittent pneumatic compression, *5 Stocking type: HS:below-knee stocking S: thigh-length stockings, *6 ABI: Ankle Branchal Pressure Index, *7 Duration: Duration of ES use before ESRPU occurrence

stone pattern on the protrusion of the tibia. Four wounds were observed in the Joint region, all with a depth of d1 or d2, three (75.0%) of these ulcers were irregularly shaped and all four were single ulcers. Five wounds were observed in the Soft region. Three wounds were with depth of d1, one wound was D3 and one wound was DU. All linearly shaped ESRPUs were

found in soft region, with perpendicular and oblique on the trunk. Three were single (60.0%) and two were plural ulcers (40.0%).

3. Relationship between wound characteristics and patient/care-related characteristics

Table 2 shows the characteristics of the nine patients and the wound site. Among them, the median

BMI was 19.65 (18.6-29.4) and the median number of days wearing ESs was 4.5 days (1-11 days). Regarding the ESs, the number with below knee stocking (HS) was 7 (77.8%), while that with thigh-length stocking type (S) was 2 (22.2%). In terms of the cognitive state, sensory perception scores of 1 to 3 on the Braden scale were observed in 5 patients (55.5%) in the every location.

Patients in the Soft region had a median BMI of 22.5, which was higher than that in the others. Both patients with peripheral circulatory disorder (PAD) were in the Protrusion (A, B), as were two patients who had already suffered pressure ulcers before wearing ESs (A, C). Diabetes mellitus was seen in only a single case (A). Oral administration of anticoagulants was observed in four patients (A, D, G, I) (44.4%). In terms of nutritional status, serum Alb and Hb levels were below the standard values in all patients. In terms of the inflammatory/infected marker CRP was higher than the standard value in all patients. In terms of hemodynamics, mean blood pressure was lower than the standard, with one exception (I). Oxygen saturation (SpO₂) was 90.0%-99.0% and seven individuals (77.8%) were receiving oxygen inhalation therapy as respiratory management in any location (A, B, C, D, E, G, I), three of whom were under ventilatory management by mechanical ventilation (B, C, G). Regarding the skin perfusion/dorsalis pedis artery state, three patients of the protrusion dorsalis pedis artery state were weak only in the Protrusion (A, B, C). Three patients had a cold sensation on bilateral feet (C, E, G). Lower limb edema was present in two patients (B, Protrusion group; E, Joint group) (22.2%). IPC was used postoperatively in patients B and F during and after surgery. Thigh-length stocking type of ESRPUs were found only in the Soft region (F, H). Ankle Branchal Pressure Index (ABI) was not measured before wearing ESs in any of the patients.

Discussion

Previous studies have reported that ESRPUs were located on the posterior surface of the foot, upper leg, below the knee, medial knee, toe³⁾, and ankle joint¹⁶⁾. In addition, for pressure ulcers due to the patient's own weight, they were considered to most frequently

occur on bony protrusions.

Novel features of this study include that it involved descriptive analyses and revealed the morphological characteristics of ESRPUs. In terms of the morphological features of the ESRPUs, they could be differentiated based on location, shape, and distribution. The locations could be classified as protrusion, joint, and soft regions. The Joint and Soft regions have not been described for pressure ulcers due to the patient's own weight, so it can be considered that these locations were specific to ESRPUs. The shapes could be classified into linear, irregular, and circular. In this study, linearity was found only for wounds in the Soft group, which was not reported for pressure ulcers due to the patient's own weight. Therefore, it can be asserted that the linear shape is specific to ESRPUs. Previous studies presented linear ESRPUs¹⁷⁾, but a description from the perspective of morphological features is new. However, irregularly shaped and round wounds have been reported for pressure ulcers due to the patient's own weight^{10) - 13)}. Therefore, these shapes cannot be said to be specific to wounds due to ESs. However, no descriptions of ESRPU with irregular, stepping stone-like pattern have been reported. This was considered to be due to an anatomical feature of the tibia.

Regarding the depth, 22 of the wounds in this study (91.6% of the total) had a depth of d1 or d2. Previous studies reported as Stage 1 and Stage 2^{7) 17) 18)} with similar result. In this study, ESRPUs with a depth of D3 (3.8%) and one with DU (3.8%) were found, both of which involved wounds in a soft region. In previous reports of necrotic ulcers, these affected the heel and ankle¹⁷⁾. Therefore, deep wounds in soft regions are new findings. The results show that ESRPUs can occur as deep wounds at any locations, so it is important to carefully observe the ES sites.

Another new finding of this study is the clarification of the relationship between morphological characteristics and factors associated with the occurrence of ESRPUs. BMI was high in 75% of these individuals in the soft region. Thigh-length stocking type were found only in the soft region. There was a previous study⁷⁾ that identified BMI >30 kg/m² as a factor associated with patients who developed ESRPUs in intensive care units, which supports the findings of

this study. For ESRPUs in the soft region, high BMI may be related to subcutaneous fat tissue or edema presence in the calf. Although, edema could not be clarified as a related factor in this study, patients with wounds in the soft regions were in a postoperative or acute status in this study, which is considered to be related to edema.

It is also considered that the curls at the upper edge of ESs and their wrinkles can exert extra pressure on the soft regions. Linear shaped wounds were found only in the Soft regions at the proximal region of the lower leg (calf), which was considered to be related to the thigh-length stocking type of ESs. From this, we considered the relationship among the curls of the top edge of ESs, their wrinkles, and their length. A previous study^{19) 20)} found that the skin disorders that arose in patients depended on the stocking length. Therefore, wearing ESs that are too long could lead to problems at the top edge of ESs and wrinkles in the ESs. Therefore, it is suggested that the length of ESs is related to the occurrence of ESRPUs as a device related factor.

Tendons such as the Achilles tendon had not been described in previous studies so far. Also, stepping stone pattern on the protrusion of the tibia had not been described, these might be anatomical features of the tibia and lower limbs. It is a location that needs to be observed.

In this study, there were cases that were insufficient to assess the importance of peripheral circulatory insufficiency. This study did not characterize cold feet and palpation of the arteries. In addition, ABI was not measured in any of the risky cases in this study. Therefore, it is important to assess hemodynamics. Regarding peripheral circulatory insufficiency, in a case report¹⁷⁾ of ESRPU, ABI was low and it was reported that it was arteriosclerosis obliterans. Wearing ES requires caution in peripheral circulatory insufficiency, as described in the guidelines for the diagnosis, treatment, and prevention of pulmonary thromboembolism and deep vein thrombosis¹⁾. Therefore, to prevent ESRPU, it is important to measure ABI or other methods and carefully evaluate peripheral circulation.

All patients in a postoperative or acute status in

this study, had poor general condition. Rathore et al.²¹⁾ reported from a case report of ESRPU that paralysis, deterioration of respiratory status, and cognitive decline due to brain trauma. Decreased cognitive function is also a risk factor for pressure ulcers due to the patient's own weight, and prior assessment is important not only for ESRPU. Precautions for the use of ES need to be explained in advance, and caution is required for the use of patients with cognitive decline. Continuous observation of patients wearing ESs is necessary because discomfort can occur regardless of the number of days that they have been worn. No differences were identified regarding the number of days of wearing ESs between the above-mentioned previous study and this study. The frequency of observation of patient status was once or twice a day, but the frequency may differ depending on the individual. The use of anticoagulants was in every patient. In addition, one individual had experienced the long-term use of steroids. It is currently unclear whether these medicines are ES-specific risk factors or wound-related characteristics.

The above findings show that individual factors related to ESRPUs include obesity and edema, while care-related factors include the observation of wrinkle-prone sites and careful removal of wrinkles in ESs. The length of ESs may also be related to wrinkles developing within them, which is a device related factor. The method of putting on ESs and the technique by which they are fitted to minimize the likelihood of wrinkles are important.

This study revealed that ESRPUs can occur at locations such as soft and joint regions, along with bony prominences as previously reported for pressure ulcers. This revealed specific regions where nurses need to assess the skin observation points, individual conditions and device factors to prevent ESRPUs.

One of the limitations of this study was that it only focused on one type of ES from a single company. To generalize our results, it will be necessary to increase the sample size in future work. In addition, the details of the actual care provided were unclear because this study was retrospective in nature. This potentially limits the validity of the extracted care-related factors.

Conclusion

This study clarified the morphological characteristics of ESRPUs in terms of three variables. ESRPUs were classified as those occurring at a protrusion (bone/tendon), a joint, or a soft region. The occurrence at soft regions and joints is a characteristic feature specific to ESRPUs, which is not observed in pressure ulcers due to the patient's own weight. In addition, linear shape of ESRPUs were specific in soft regions. Such linear wounds in soft regions were oriented either perpendicularly or obliquely to the body trunk. Factors related to the morphological characteristics of the wounds included length of ESs, BMI, and peripheral circulatory failure. This study suggests the selection and fitting of ESs of an appropriate length are important as care-related factors for preventing ESRPUs. And suggests the importance of specifically assessing BMI and peripheral circulatory failure as individual factors.

Acknowledgment

We thank Prof. Nobuo Murakami and the medical staff at the Center for Nutrition Support and Infection Control at Gifu University Hospital for their cooperation, support, and advice on this study. We also thank Edanz Group (<https://en-author-services.edanz.com/ac>) for editing the English text of a draft of this manuscript.

References

- 1) The Japanese Circulation Society. (2018, March) . GUIDELINE LIST: Guidelines for Diagnosis, Treatment and Prevention of Pulmonary Thromboembolism and Deep Vein Thrombosis (JCS 2017) . 2021/1/4, https://www.j-circ.or.jp/cms/wp-content/uploads/2017/09/JCS2017_ito_h.pdf [in Japanese]
- 2) Sigel B, Edelstein AL, Savitch L, et al. Type of compression for reducing venous stasis. A study of lower extremities during reactive recumbency. *Arch Surg* 110: 171-175, 1975.
- 3) Nomura Y, Murakami M, Wakashiro Y, et al. Current status of pressure ulcer by medical equipment and countermeasures by classification of medical devices. *Jpn JPU* 14: 553-557, 2012. [in Japanese]
- 4) Japanese Society of Pressure Ulcers ed. Over View of Medical Device Related Pressure Ulcer. Best Practice Prevention and Management for Medical Device Related Pressure Ulcer, 5-22, Shorinsha Inc, Tokyo, 2015. [in Japanese]
- 5) Black JM, Cuddigan JE, Walko MA, et al. Medical device related pressure ulcers in hospitalized patients. *Int Wound J* 7: 358-365, 2010.
- 6) Coyer FM, Stotts NA, Blackman VS. A prospective window into medical device-related pressure ulcers in intensive care. *Int Wound J* 11: 656-664, 2014.
- 7) Hobson DB, Chang TY, Aboagye JK, et al. Prevalence of graduated compression stocking-associated pressure injuries in surgical intensive care. *J Crit Care* 40: 1-6, 2017.
- 8) National Pressure Ulcer Advisory Panel, European Pressure Ulcer Advisory Panel and Pan Pacific Pressure Injury Alliance. Medical Device Related Pressure Ulcers, Intervention for Prevention & Treatment of Pressure Ulcers. Prevention and Treatment of Pressure Ulcers: Clinical Practice Guideline, 119-125, Cambridge Media, Perth, Western Australia, 2014.
- 9) Sanada H, Mori T. Qualitative sketch technique. *Bioengineering Nursing*, 174-181, University of Tokyo Press, Tokyo, 2015. [in Japanese]
- 10) Fujimoto Y, Sanada H, Sugama J, et al. The relationship between pressure ulcer development and wheelchair position in elderly. *J Jpn Acad Nurs Sci* 24: 36-45, 2004. [in Japanese]
- 11) Kinoshita S, Sugai A, Konya C, et al. Pressure ulcer status and relevant factors in person who are seating posture by wheelchair with spinal cord injuries. *J So Nurs Pract* 21: 36-43, 2009. [in Japanese]
- 12) Nanjo Y, Nakagami G, Kaitani T, et al. Relationship between morphological characteristics and etiology of pressure ulcers in intensive care unit patients. *J Wound, Ostomy and Continence Nurs* 38: 404-412, 2011.
- 13) Nozawa K, Tamai N, Minematsu T, et al. Situation of occurrence and morphological characteristics

- of pressure ulcers among inpatients with mental illness. *J Jpn WOCM* 21: 10-24, 2017.
- 14) Fujimoto Y, Okuwa M, Takei N, et al. Risk Factors of pressure ulcer development due to non-invasive positive pressure ventilation mask use. *J Jpn WOCM* 22: 297-302, 2018. [in Japanese]
 - 15) Sanada H, Iizaka S, Matsui Y, et al. Clinical wound assessment using DESIGN-R total score can predict pressure ulcer healing: pooled analysis from two multicenter cohort studies. Scientific Education Committee of the Japanese Society of Pressure Ulcers. *Wound Repair Regen* 19: 559-567, 2011.
 - 16) Sugiyama S, Azuma N, Mo M, et al. The Japanese Vein Study: Survey of Adverse Events of the Elastic Stockings. *Jpn J Phlebol* 25: 403-409, 2014. [in Japanese]
 - 17) Minakata T, Kakudo N, Suzuki K, et al. Pressure ulcers of the legs due to elastic stockings. *Jpn J PU* 11: 502-509, 2009. [in Japanese]
 - 18) Michelle BJ, Catharine B, Timothy W, et al. Medical device-related pressure injuries: An exploratory descriptive study in an acute tertiary hospital in Australia. *Journal of Tissue Viability* 26: 246-253, 2017.
 - 19) The CLOTS Trials Collaboration ed. Effectiveness of thigh-length graduated compression stockings to reduce the risk of deep vein thrombosis after stroke (CLOTS trial 1) : a multicentre, randomized controlled trial. *Lancet* 373: 1958-1965, 2009.
 - 20) Winslow EH, Brosz DL. Graduated Compression Stockings in Hospitalized Postoperative Patients: Correctness of Usage and Size. *Am J Nurs* 108: 40-50, 2008.
 - 21) Rathore FA, Ahmad F, Khan OJ. Compression Stockings and Pressure ulcers: Case Series of a Neglected Issue. *Cureus* 9: e 1763, 2017.

深部静脈血栓症予防用弾性ストッキングによる 圧迫創傷の形態的特徴と発生要因

木下 幸子^{1) 2)} 石川 りえ³⁾ 清島真理子⁴⁾ 紺家千津子⁵⁾
松井 優子⁶⁾ 大桑麻由美^{2) 7)} 真田 弘美^{8) 9)} 須釜 淳子¹⁰⁾

金沢医科大学看護学部¹⁾

金沢大学大学院医学系研究科²⁾

岐阜大学医学部附属病院看護部³⁾

岐阜大学医学部皮膚病態学⁴⁾

石川県立看護大学看護学部⁵⁾

公立小松大学保健医療学部看護学科⁶⁾

金沢大学大学院医薬保健学総合研究科臨床看護学⁷⁾

東京大学大学院医学系研究科老年看護学/創傷看護学⁸⁾

東京大学大学院医学系研究科グローバル・ナーシング・リサーチセンター⁹⁾

藤田医科大学保健衛生学部社会実装看護創成研究センター¹⁰⁾

要 旨

背景：深部静脈血栓症予防用弾性ストッキング（ES）は圧迫療法の1つであるが、一方でESによる医療関連機器圧迫創傷（ESRPU）の報告がある。本研究の目的はESRPUの形態的特徴と発生要因を明らかにすることである。方法：研究デザインは質的記述研究である。2006年から2012年までの606床の大学病院で、院内発生したESRPUの写真から質的記述法により特徴を抽出し診療記録から発生要因の関連を分析した。結果：9名24個は部位、形状、分布の特徴に分類できた。部位は骨や腱などの突出部（突出部）15個、関節の可動部（関節部）4個、骨・関節以外の軟らかい部位（軟部）5個に分けられた。形状は線状、不正形、円形、分布は単数、複数であった。軟部はすべて線状（5個）であり、突出部や関節部にのみ不正形（12個）があった。軟部ではBMIは75%が平均より高値で、ストッキングタイプはこの部位にのみ見られた。突出部は褥瘡の保有や末梢循環不全の既往があった。考察：軟部や関節部はESRPUに特有で、軟部の線状はBMI、ESの長さの関連が示唆された。突出部は従来の褥瘡ケアに加え、末梢循環のアセスメントの重要性が再認識された。結論：ESRPUの形態的特徴は部位、形状、分布に分けられた。軟部における線状はESRPUに特徴的であった。BMI、ESの長さが機器やケアに関連する発生要因として明らかになった。

キーワード：深部静脈血栓症予防用弾性ストッキング、医療関連機器圧迫創傷、質的スケッチ法、形態的特徴、発生要因