

A new concept: ‘Relative position between the external force and the bony prominence’ explains location-specific occurrence of superficial injury over an undermining lesion



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ABSTRACT

Aim: A pressure ulcer is localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear. Although the external forces and bony prominences differ depending on ulcer location, the way in which these anatomical differences affect pressure ulcer development is not well studied.

Methods: To clarify the location-dependent factors for pressure ulcer development, we focused on superficial injuries that develop over an undermining lesion, which we have termed them bilayer pressure ulcers. Because it is thought that a deep pressure ulcer is caused by ischemia at the deep lesion and a shallow pressure ulcer is caused by shear force to the superficial skin, a bilayer pressure ulcer can be considered a mixed phenotype, induced by both pressure and shear force. We retrospectively examined the frequency of bilayer pressure ulcers by location in a total of 568 pressure ulcers.

Results: The ratio of bilayer pressure ulcers to deep pressure ulcers staged III or more was significantly larger for pressure ulcers over the sacrum.

Conclusion: A new concept, the relative position between the external force and bony prominence, could explain the frequency and developmental mechanism of bilayer pressure ulcers. The external forces, shape of the bony prominence, and mobility of the soft tissue may be responsible for this concept.

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1. Introduction

A pressure ulcer is localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear [1]. Therefore, the location-dependent characteristics of the individual external forces and the bony prominence are important factors in the development of pressure ulcers. One study has shown that stage II pressure ulcers are associated with shear force, while deep pressure ulcers correlate with pressure force [2]. This correlation between the type of force and the depth of the pressure ulcer has not been precisely

demonstrated, but it appears to be widely accepted in practice.

Considering the definition of a pressure ulcer described above, the positioning of the action point of the force relative to the bony prominence is critical for the development of a pressure ulcer. Because the skin and subcutaneous tissue are soft, internal forces within these tissues are also dependent on the underlying hard tissues such as bone. Although we have shown that ‘wound mobility’ is an important concept for existing pressure ulcers [3], we did not consider the displacement of the action point of the force against the bony prominence in terms of the development of pressure ulcers. Theoretically, displacement of the action point can affect the internal forces within the skin and subcutaneous tissue.

To clarify this issue, we focused on a unique morphological phenomenon of pressure ulcers, in which a superficial injury

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develops over an undermining lesion (termed a bilayer pressure ulcer). This pressure ulcer phenotype can be considered a mixed phenotype induced by both pressure and shear force. We demonstrate the location-dependent occurrence of this unique phenotype, which can be explained by a new concept: the 'relative position between the external force and the bony prominence'.

2. Methods

2.1. Definition of a bilayer pressure ulcer

We defined a superficial injury that develops over an undermining lesion (bilayer pressure ulcer) according to the National Pressure Ulcer Advisory Panel (NPUAP) criteria [1]. For this definition, a superficial injury is present over the undermining lesion (Fig. 1A and B). The diagnosis of a bilayer pressure ulcer was performed when the necrotic tissues were mostly removed. Considerable exudates were observed in deep pressure ulcers in all locations.

2.2. Retrospective survey

We conducted a retrospective observational study using databases of pressure ulcers collected in a 300-bed hospital from January 2011 to June 2014. From the medical records of hospitalized patients, all pressure ulcers were examined according to their depth, location, situation over bony prominences, and undermining formation. Ulcer location was determined with respect to the position of the underlying bony prominence as reported previously [4]. Superficial injuries over undermining lesions (bilayer pressure ulcer) were specifically extracted from the database and classified according to their locations. This study complied with the ethical tenets for human experimentation outlined in the 1975 Declaration of Helsinki, and it was approved by the Ethical committee of the

National Center for Geriatrics and Gerontology. No interventions for research purposes were made in the diagnosis and treatment of pressure ulcers in these patients.

2.3. Statistical analysis

The Chi-squared test was used to compare categorical variables. The data were analyzed using a statistical software program (SPSS, version 22.0; SPSS, Inc.; Chicago, IL, USA). The statistical significance value was set at $P < 0.05$.

3. Results

A bilayer pressure ulcer was diagnosed based on its clinical features when the necrotic tissues were mostly removed (representative images are presented in Fig. 1A, B). Notably, the superficial injuries were located over the bony prominence of the sacrum. Undermining pressure ulcers without superficial injuries are also shown (Fig. 1C, D). The two pressure ulcers developed over greater trochanter and ilium.

In our retrospective survey, a total of 568 pressure ulcers in 355 patients were analyzed from the database. Bilayer pressure ulcers were detected in 24 patients (24 wounds, 4.2%). The patients with bilayer pressure ulcers were aged 48–94 years (mean 81.1 ± 10.2 years), and 11 (45.8%) were men.

Of the 568 wounds, 247 were deep pressure ulcers of stage III or more. Of the 247 deep pressure ulcers, 74 developed undermining formations. The ratio of bilayer pressure ulcers to deep pressure ulcers was examined according to location (Table 1). Bilayer pressure ulcers were most frequently observed over the sacrum (27.9%), but were rare in other locations, including the greater trochanter (3.4%), coccyx (12.5%), ilium (7.7%), and ischium (14.3%). The frequency of bilayer pressure ulcers over the sacrum compared to the other 4 locations was statistically significant ($\chi^2 = 8.17$, d.f. = 1, $P = 0.004$).

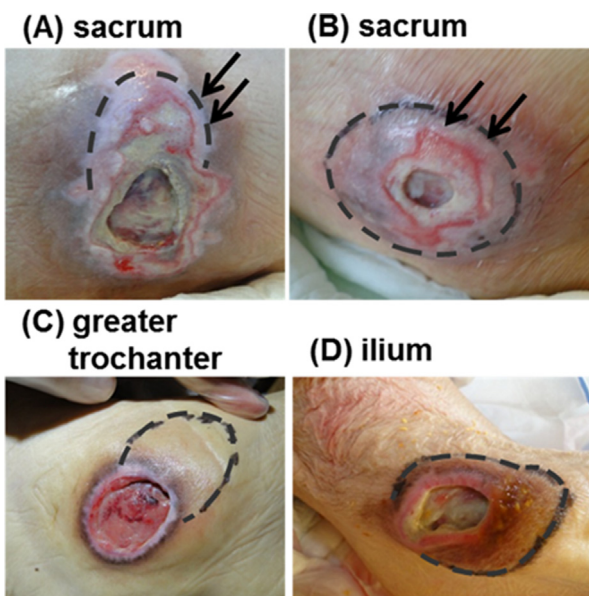


Fig. 1. Representative features of superficial injury over undermining lesions ("bilayer pressure ulcers") are shown. A–B, Bilayer pressure ulcers developed over the sacrum. The superficial injuries and undermining lesions are indicated by arrows and broken lines, respectively. It is noteworthy that superficial injuries are located over the undermining lesions. C–D, Pressure ulcers with undermining lesions over the greater trochanter (C) and ilium (D). Superficial injuries are absent over the undermining lesion where indicated by oil pen markings.

Table 1

Location-dependent frequency of bilayer pressure ulcers (superficial injury over undermining lesions) is shown. Total numbers of deep pressure ulcers (Deep PU) and bilayer pressure ulcers (Bilayer PU) are indicated according to the locations.

Location	Deep PU	Bilayer PU	
	No.	No.	(%)
Sacrum	68	19	(27.9)
Heel	34	0	(0)
Greater trochanter	29	1	(3.4)
Crus	21	0	(0)
Coccyx	16	2	(12.5)
Back	15	0	(0)
Ilium	13	1	(7.7)
Ankle	13	0	(0)
Foot	13	0	(0)
Ischium	7	1	(14.3)
Knee	5	0	(0)
Shoulder	3	0	(0)
Finger	3	0	(0)
Medial malleolus	2	0	(0)
Elbow	2	0	(0)
Scapula	1	0	(0)
Carpal bone	1	0	(0)
Arm	1	0	(0)
Total	247	24	(9.7)

PU: pressure ulcer.

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