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## Identifying, managing and preventing skin maceration: A rapid review of the clinical empirical evidence.

*Journal: Journal of Wound Care*

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### **Abstract:**

#### Research Question

What is the clinical empirical evidence for identifying, managing and preventing skin maceration?

#### Objective

To identify clinical empirical evidence based on human subjects that can inform healthcare professionals and patients on how maceration may be identified and how to prevent and manage maceration and promote skin health.

#### Method

A rapid review of the current literature using the key words: *skin macerat\**, *wound macerat\**, *moisture associated skin damage*, *wound exudate* and *hyper-hydration of skin*.

#### Results

A total of 526 papers were found using an electronic database search. Four were identified as fitting the search parameters, and a further two papers were retrieved from a manual search of reference lists. Three themes emerged from the six papers; how to identify and measure maceration, how to manage and reduce maceration once it has already occurred, and how to prevent skin maceration. The depth of hyper-hydration is deeper than previously thought, which has implications for treatment and healing time. Furthermore, the problem is compounded if hyper-hydration is due to incontinence and skin is also exposed to urine and/or faeces. In relation to wound management, the authors advocate the removal of moisture away from the wound or skin either through superabsorbent dressings, or allowing the excess moisture to evaporate through semi-permeable dressings to reduce maceration, enhance patient comfort and encourage healing. However, we found no evidence regarding the limits of hydration of the dermis and epidermis and thereby the optimal conditions for managing exuding wounds and promoting skin health. The majority of the research for skin maceration is either based on animal subjects or focussed on the biomechanics of

the skin. It is therefore very difficult to apply to clinical practice effectively. Each of the six papers in this review call for further research to help identify treat and prevent maceration.

#### Conclusion

Maceration causes patients' discomfort and pain as well as prolonging healing time and deserves more focused research. This rapid review highlights how limited the clinical empirical research is on identifying and managing skin maceration from an early stage so that healthcare professional may be better equipped on how to prevent it. Moisture wicking fabric, superabsorbent dressings and semi-permeable rather than occlusive materials are shown to improve patient comfort and reduce pain and further damage in relation to exuding wounds. Trans-epidermal water loss rates and colorimetric measurements, such as an erythema index were noted as useful tools to identify and track maceration but there needs to be a clinically appropriate and objective maceration index. Further clinical research is also needed on when levels of hydration in the skin become damaging. The small number of studies within this review show that skin maceration can be avoided, but clearer guidance is needed.

#### **Declaration of interest:**

The authors have nothing to declare.

#### **Key Words:**

Skin maceration; moisture associated skin damage; skin moisture management; rapid review

## **Introduction:**

The skin is a very complex organ with a variety of functions including, but not limited to, temperature and fluid homeostasis, mechanical protection of underlying tissues and organs, as well as defence from infectious agents.

When the skin becomes too moist it undergoes a process of *maceration*; this is the result of prolonged exposure to moisture and causes the skin to soften and breakdown<sup>1</sup> so that the connective fibres can be teased apart and the skin often exhibits a white appearance. Moisture that macerates the skin takes various forms including perspiration, wound exudate, urine, faeces, mucus and saliva, which has implications for clinical management. Continence-related skin maceration for example involves the management of fluids and moisture but also the excoriating effects of urine and or faeces and skin damage arising from washing and drying practices on the skin barrier.<sup>2</sup>

Skin compromised by wounds or burns, results in impairment of these functions; thus speedy and effective restoration of skin integrity is a key goal of wound care. Much effort has thus gone into ascertaining the best possible clinical practice to support wound treatment and in past decades moist wound healing has become the accepted practice for treating acute wounds and has been extended to treating chronic wounds.<sup>3</sup> However, first advanced in Winter's 1962 seminal paper on porcine skin,<sup>4</sup> this theory suggests that in moist, occlusive environments, epithelisation occurs at a faster rate than in dry environments<sup>5</sup> but mentions little regarding granulation of the management of exuding wounds.

In relation to exuding wounds, Haryanto et al<sup>6</sup> demonstrated that if maceration levels were high then wound healing time also increased. However, Koh et al's<sup>7</sup> earlier study found no significant association between wound duration and hydration scores. Cutting and White<sup>7</sup> suggest it is preferable to avoid maceration completely rather than treat it once it has already appeared.

There are a high number of reviews within the existing body of knowledge that discuss maceration of the skin and wound,<sup>8-10</sup> but they are based on laboratory studies and not on human subjects<sup>4 11 12</sup> and while the biomedical research is invaluable in terms of how moisture effects the epidermis for example, it is important to look at the clinical research about how maceration effects the patient. National Institute of Health and Care Excellence (NICE) guidelines on chronic wounds<sup>13</sup> highlight the lack of good quality research that is able to inform clinical practice. This paper will critically examine the existing empirical research that can inform healthcare workers and patients on what factors contribute to maceration to determine the optimal conditions for managing and promoting skin health.

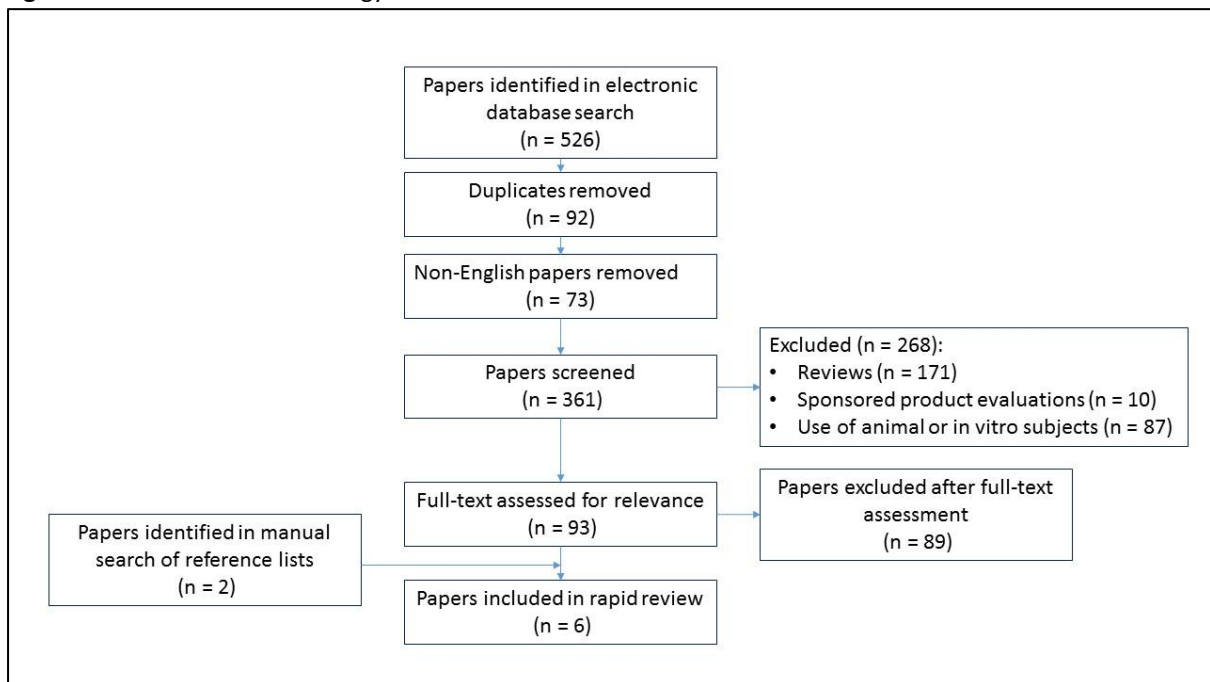
Maceration is often referred to in the literature as *moisture-associated skin damage* (MASD), the terms appear to be used interchangeably,<sup>14</sup> but maceration is a component of MASD, along with erythema and others.<sup>15</sup> This review will refer solely to the term *maceration* in order to avoid confusion.

## **Method**

The methodology applied to this research is that of a rapid review, which uses simplified components of the systematic review to produce synthesized evidence in a timely manner.<sup>16</sup> According to O'Leary et al<sup>17</sup> there is no single approach for rapid reviews, as there is for a systematic review. This increases the risk of bias and can limit the quality of the research.<sup>18</sup> However, close collaboration between researchers, transparency in reporting and a systematic and structured search strategy can ensure robust research that is useful, replicable and relevant to clinical

practice.<sup>17</sup> Between 5<sup>th</sup> September and 19<sup>th</sup> September 2016, a literature search was conducted using electronic databases CINAHL, MEDLINE, PUBMED and Cochrane with the following search terms; *skin macerat\**, *wound macerat\**, *moisture associated skin damage*, *wound exudate* and *hyper-hydration of skin*. In order to reduce the risk of missing relevant papers, there were no limits set for any participant characteristics (age, gender, medical history etc) other than human. The dates of publication for inclusion were broad and included all papers published before 19<sup>th</sup> September 2016 when the search was concluded. 536 titles and abstracts were examined (see Fig 1).

**Fig 1.** Flowchart for search strategy



Papers were excluded if they were not written in English, if they were review papers, if the research was conducted on animals or *in vitro*, or if they were wound dressing evaluations funded by the manufacturer. Papers that did not consider maceration as a main aim of the research were deemed non-relevant. A manual search was conducted through the reference lists of retrieved articles. In total six articles were found that matched all relevant search parameters<sup>14 19-23</sup> (see Table 1); one cross-sectional comparative study, three randomised controlled trials, one non-comparative observational study and one case study. The paper by Ichikawa-Shigeta et al<sup>19</sup> investigated maceration from urinary and faecal incontinence in elderly women and Mayrovitz & Sims paper addresses maceration from synthetic urine in young women. They have been included because of the focus on skin hydration in both papers, which informs the effects of moisture on the skin.

**Table 1.** Final paper characteristics

Article reference	Study type	Population size (Test vs control)	Population Characteristics	Main results
Ichikawa-Shigeta, Y., Sugama, J., Sanada, H., et al. Physiological and appearance characteristics of skin maceration in elderly women with incontinence. <i>Journal of Wound Care</i> . 2014; 23: 1, 18-30.	cross-sectional comparative study	69	Elderly females (median age 90) with urinary and/ or faecal incontinence	44 patients exhibited skin maceration. TEWL and skin pH Erythema and white index lower and higher, respectively in maceration group compared to non-maceration group.
Mayrovitz, H.N., Sims, N. Biophysical effects of water and synthetic urine on skin. <i>Advances in Skin &amp; Wound Care</i> . 2001; 14: 6, 302-08.	Randomised control trial	10 (one control arm, one test arm on each participant)	Young females (median age 28.8) with no previous relevant medical history	Erythema and skin temperature were lower on wet sites compared to dry sites.
Singh, C.D. Use of a Moisture Wicking Fabric for Prevention of Skin Damage Around Drains and Parenteral Access Lines. <i>Journal of Wound, Ostomy &amp; Continence Nursing</i> . 2016; 43: 5, 551-53.	Case study	8	Children with challenging skin integrity issues around tubes and drains and underneath medical devices. Median age unable to ascertain due to lack of data. Youngest patient 3 months old, eldest 9 years old.	In all 8 cases the moisture wicking fabric maintained skin integrity.
Faucher, N., Safar, H., Baret, M.N., et al. Superabsorbent dressings for copiously exuding wounds. <i>British Journal of Nursing</i> . 2012; 21: 12, 22-8.	Non-comparative observational study	15	9 females, 6 males (median age 71) with copiously exuding wounds	46.7% of participants experienced maceration at the start of the study. This was reduced to 6.7% after 7 days of using the superabsorbent dressings. Dressing change frequency was also reduced in 80% of participants.
Terrill, P.J., Kedwards, S.M., Lawrence J.C. The use of Gore-Tex bags for hand burns. <i>Burns</i> . 1991; 17: 2,161-65.	Randomised control trial	14 participants; 10 test hand burns, 10 control hand burns (Bilateral hand burns were randomized for the left hand, the right hand was then allocated to other treatment group).	5 females, 9 males (median age 34 for the test group and 36 for the control group) with hand burns covering more than 20% of the hand surface area.	Maceration developed in all hands in the control group using standard polythene bags. Only 1 hand developed maceration in the group testing the GORE-TEX bags.
Wulfhorst, B., Schwanitz, H.J., Bock, M. Optimizing skin protection with semipermeable gloves. <i>Dermatitis</i> . 2004; 15: 4, 184-91.	Randomised control trial	20 participants; all in control or test environments over 5 sessions.	18 females, 2 males (median age 33) with no previous medical history.	TEWL rates after 20minutes of occlusion: Powdered latex 18.6, Powder-free latex 19.75, Polyvinyl chloride 18.7, Nitrile 17.45, Semipermeable membrane 10.25.

## **Results**

Three themes emerged from this rapid review; how to identify and measure maceration,<sup>19 20</sup> how to manage and reduce maceration once it has already occurred,<sup>14 21</sup> and how to prevent skin maceration.<sup>22 23</sup> These different approaches to maceration shed light on the clinical factors that contribute to skin and wound maceration. The papers are from a wide range of countries including Japan, France, Germany and the United Kingdom, and study paediatric patients and elderly patients, indicating that maceration is a global issue in healthcare.

### **Maceration identification and measurement**

Ichikawa-Shigeta et al<sup>19</sup> measured the amount of water on the surface layer of skin (the stratum corneum) in order to assess the ability of the skin to maintain moisture levels. They were additionally able to evaluate the effect of water on the connective tissues by measuring the level of water in the dermis layer of the skin. Furthermore, to assess the barrier function of the macerated skin, the pH and trans-epidermal water loss (TEWL) were measured. They found that both epidermal and dermal hydration is increased when skin is macerated, suggesting that hyper hydration of the skin is much deeper than previously thought – earlier studies have only focused on the epidermal layer. Ichikawa-Shigeta et al's findings also indicated that the pH of macerated skin is more alkaline than healthy skin and TEWL rates were also greater in skin that showed maceration.

Ichikawa-Shigeta et al also compared different outcome measures/indexes to suggest a clinical tool for identifying skin maceration. They advocate the use of the Erythema Index, which provided greater agreement among clinicians than other physiological or appearance characteristics.

Where Ichikawa-Shigeta et al studied the skin of elderly patients (median 90 years old), Mayrovitz & Sims<sup>20</sup> studied the effects of water and synthetic urine on healthy, young skin (median 28.8 years old). They applied pads soaked in water or synthetic urine covered with a water-impermeable dressing to the forearm of healthy volunteers, and after five hours they compared the blood perfusion, tissue hardness, tissue loading, erythema and temperature of the wet skin, to dry skin.

The findings indicate that wet skin provides less support for pressure compared to dry skin, the temperature of wet skin is lower, perfusion caused by pressure was greater in wet skin (and is therefore more vulnerable to pressure), and erythema (skin redness) was reduced after the five hours. Tissue hardness was significantly lower in sites exposed to either fluid when compared to dry pad exposure; exposure to the synthetic urine reduced tissue hardness to a greater extent than exposure to water alone. The effect on blood flow was not sustained in either situation possibly due to the recovery systems of the young healthy subjects and possibly the short duration of the experiment (five hours).

### **Maceration management**

Singh<sup>14</sup> reported difficulties associated with current practices in preventing moisture-associated skin damage and particularly maceration, amongst her paediatric patients with peritubular drainage. Where previously gauze and foam had held moisture close to the skin surface, compromising its integrity, Singh and her team found that moisture wicking fabric was useful around gastrostomy tubes, Penrose drains, under tracheostomy ties and around central line insertion sites. By 'wicking' the moisture up and away from the skin, often by wrapping the fabric around the tubing drawing the fluid up, the skin had less contact with the moisture and was able to heal, and increase the patients' comfort. This was the only paper that directly referred to the well-being of the patient.

Faucher et al<sup>21</sup> evaluated superabsorbent dressings that are used to treat copiously exuding wounds in an effort to successfully reduce the effects of wound exudate on peri-wound skin. The specific dressing in question was able to absorb large amounts of exudate and keep it within its core, thereby ensuring the excess moisture did not touch the wound or healing skin. After seven days of applying the dressing, maceration rates in the participant group reduced from 46.7% (7 out of 15) to 6.7% (1 out of 15). This was the biggest change in skin condition noted. Faucher et al referred to the need for a 'controlled moist environment', acknowledging the usefulness of moist wound healing but highlighting the risks of over-hydration. The authors also measured healing time but perhaps due to the short length of the study, they were unable to demonstrate statistical significance. However, it could be surmised that the excess moisture may cause patients' pain and discomfort, which is clinically significant and just as important as reducing the healing time.

### Maceration prevention

Terrill et al<sup>22</sup> compared Gore-Tex bags to polythene bags in the treatment of hand burns. Polythene bags isolate the damaged skin from the environment but due to the full occlusion of the hand, are associated with maceration of the burned and non-burned skin held within the bag. Gore-Tex has a semi-permeable membrane which allows some water vapour to escape while remaining impermeable to bacteria. The results showed that hand maceration occurred for all ten patients who were given polythene bags. Only one out of ten patients in the Gore-Tex group developed maceration.

The conclusion that semi-permeable membranes can prevent skin maceration occurring is supported by Wulfhorst et al.<sup>23</sup> They asked hairdressers to wear semi-permeable gloves or occlusive gloves made of neoprene, latex or nitrile and compared TEWL values as an indication of skin barrier function. Those wearing occlusive gloves showed much higher values of TEWL even after only 20 minutes.

### Discussion

Searching for primary research articles that investigate factors contributing to maceration and discuss how to identify and measure it resulted in surprising challenges. Maceration itself appears to be ill-defined and a consensual definition of what constitutes skin maceration and how to measure it in clinical settings is lacking, which may impact on patient care. Maceration is a condition severe and important enough to merit its own research focus, however it is commonly referenced only briefly as part of more general research.

Many of the research papers retrieved in the key word search were secondary reviews,<sup>10 24</sup> or reviews of previous reviews,<sup>25</sup> but very few were classed as primary clinical empirical evidence. Four papers were found to be relevant primary research articles (0.9% of original search total. See Fig 1 for a breakdown) whilst another two papers were found through manual searches of reference lists. This result is supported by Grey and Weir's<sup>26</sup> review which noted a complete lack of clinical evidence relating to peri-wound skin maceration. There were a high number of bio-medical papers that studied maceration from a structural, microscopic view point<sup>12 27 28</sup> or used animal models of skin;<sup>11 29 30</sup> while this forms a useful basis for further clinical research on the application of that knowledge, it may be difficult to translate these findings in clinical practice. The relevance of animal and experimental models to clinical outcomes therefore certainly merits further discussion elsewhere. Scientific papers are aimed at a specific audience and there needs to be a bridge from these into clinical practice.

Before maceration can be managed or prevented effectively, it is important to be able to identify and measure it, as well as recognising the warning signs that are the pre-cursors to maceration.

The papers discussed here use a variety of tools to identify and measure maceration. Ichikawa-shigeta et al<sup>19</sup> suggest that the erythema index is the most accurate tool compared to other physiological and appearance characteristics. While in this instance it was based on subjective observation of photographs of maceration, looking at colorimetric changes to measure peri-wound erythema-like changes has been used with good effect in previous studies that measure maceration.<sup>31</sup> Measuring trans-epidermal water loss (TEWL) was frequently used in papers and appears to accurately record skin hydration, but usually only as a research tool which may be difficult to use in every-day clinically settings. Perhaps a new objective, maceration index is required, which, ideally, may blend information regarding wound appearance and objective measurements of moisture. The important point is that there is no guidance on the critical time between a healthy moisture level and maceration. Guidance on this would be useful in clinical practice to be able to prevent maceration rather than managing it once it has already occurred.

Maceration affects the skin at a greater depth than previously thought,<sup>19</sup> which may have implications in terms of treatment and healing times. This research was conducted primarily with elderly incontinent patients and results might differ for young skin, as maceration is thought to be enhanced in elderly skin<sup>11</sup>. The inflammation oedema present in macerated skin is caused by prolonged contact with urine and/or faeces, demonstrating that the barrier function of skin is further weakened where maceration appears in incontinence settings. This is partly supported by Mayrovitz and Sims<sup>20</sup> who were able to show that skin exposed to synthetic urine is more at risk than skin exposed to water. Of note, however, was the finding that in young health volunteers even exposure to water impaired the skin barrier. This emphasises the importance of reducing patients' skin contact with body fluids associated with incontinence, especially if patients whose skin health is already weakened. These findings, while valuable, may be difficult to generalise outside of incontinence research and further, specific research is needed on the weakening effects of other contributing moisture types such as perspiration, saliva and wound exudate.

In Singh's<sup>14</sup> case study, the author was unable to cite any research on the moisture wicking fabric she used to reduce maceration in her patients. Although the fabric was only tested on eight paediatric patients with peritubular drains in situ, the results were promising, showing a vast reduction in skin maceration and damage, and less pain and discomfort for the patient. Singh demonstrated that once the excess moisture was removed from the skin, patients were able to mobilise without discomfort. While more robust research into this fabric would be needed, it is remarkable that despite varying ages (new-born to nine years old) and varying parenteral access lines or drainage tubes in different locations, this technique was effective in all cases. Singh's findings are supported by previous research which argues that wounds are better able to heal once the water content has been drawn out and away from the wound bed and surrounding tissues.<sup>31</sup> Faucher et al<sup>21</sup> used a different approach evaluating a superabsorbent dressing, however there was no control group or comparison with other treatments. It may be interesting to compare superabsorbent dressings with those that are semi-permeable, which allow moisture to escape, rather than containing it.

The two papers that focused on prevention both explored the use of semi-permeable gloves – for healthy hands and burnt hands. Terrill et al<sup>22</sup> demonstrated that by allowing excess wound exudate to escape, the tissues were better able to heal. Wulforth et al<sup>23</sup> demonstrated that by allowing excess fluid to escape, skin remained healthier and less likely to become macerated. The participants in Wulforth et al's study were wearing the gloves for only 20 minutes and already the TEWL measurement had increased, suggesting that patients wearing occluding wound dressings, or any

type of occlusive skin covering such as a plaster cast for fractures, stoma care,<sup>32</sup> or prosthetic sockets for amputee patients<sup>33</sup> may experience moisture damage over a longer period. It would be interesting to see if semi-permeable garments capable of high moisture transfer and loss, or the moisture-wicking fabric used by Singh,<sup>14</sup> could be placed under plaster casts, medical devices or prosthetic sockets to pull moisture away from these occluded areas, thereby preventing maceration and improving patient comfort and wellbeing. However both these papers<sup>22 23</sup> only focused on preventing maceration on hands, not other areas of the skin. The epidermis is thicker in the palms of the hands and contains a greater number of sweat glands so these results may not be applicable to other areas.

It is difficult to compare six papers that all use different methodologies to study different fluid types that contribute to maceration and different ways of measuring maceration, and this highlights gaps in the current literature base that are specifically trying to tackle the condition. What is consistent across all six papers is that maceration is a severe condition that merits the need for more focused research and exploration in drawing water content out of wounds and away from the skin in order to maintain a healthy, balanced environment.

### **Conclusion:**

When searching for papers regarding maceration, the term appears to be ill-defined and usually mentioned only as part of a wider study. However it is clear that maceration is a severe condition that has been shown to cause patients discomfort and pain,<sup>14</sup> as well as prolonging healing time<sup>6</sup> and therefore merits more focused research. There is limited empirical research that is able to inform clinical practice on how to prevent maceration rather than managing the condition once it has already occurred. The six papers discussed here advocate the removal of moisture away from the wound or skin either through superabsorbent dressings, or allowing the excess moisture to evaporate and the skin to 'breathe' through semi-permeable dressings or moisture wicking fabric, depending on the type of fluid contributing to maceration. However we found no evidence regarding the limits of the hydration of the dermis and epidermis. Trans-epidermal water loss rates and the erythema index were noted as useful tools to accurately identify and track maceration but there needs to be further clinical research on when levels of hydration of the skin or wound start to become too high, and when efforts to reduce moisture levels before maceration occurs need to begin. Without full and clear guidance the skin and health of patients are at risk of damage that, as demonstrated above, can be avoided.

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