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### **Invasive techniques for the removal of necrotic tissue in chronic wounds, a systematic review**

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## SYSTEMATIC REVIEW

## INVASIVE TECHNIQUES FOR THE REMOVAL OF NECROTIC TISSUE IN CHRONIC WOUNDS: A SYSTEMATIC REVIEW

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**Abstract**

**Background:** One of the most challenging problems facing the medical community, is the treatment of chronic wounds. Wound bed debridement is a crucial factor in healing any type of wound and there are new invasive methods like low frequency ultrasound frequency debridement, hydro surgery and coblation technology that look very promising alternatives to the current "gold standard" of sharp debridement.

**Method and Material:** A search of 'PubMed', 'Cochrane database of systematic reviews' and 'Science Direct' digital databases were made for studies between the years of 2010-2019. Material was randomized controlled trials, cohort studies and prospective or retrospective studies on the subject.

**Results:** Our search revealed 1933 articles. After removing 118 duplicates 1815 articles were screened, a further 1568 were removed because of their type and of the remaining 247, 165 were removed after title reading. Finally, of the remaining 82 articles, 71 were rejected after full reading thus bringing the total number of the articles examined in this systematic review to 11.

**Conclusions:** The advanced methods of mechanical debridement seem to be less time consuming, more accurate and at the same or lower cost than sharp debridement. Additionally, they offer faster healing rate while reducing the bacterial load of the wound at a greater percentage than sharp debridement.

**Keywords:** Chronic wound debridement, versajet, ultrasound, Plasma mediated bipolar radiofrequency ablation.

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## INTRODUCTION

Chronic wounds and their care is one of the biggest current medical issues. In United States of America, alone there are over 6 million patients suffering from chronic wounds of various causes such as diabetes, vascular and venous causes as well as pressure ulcers. In another example of the high cost that the care of chronic wounds is imposing on health care systems, the Federal Republic of Germany spends between 5 to 8 billion euros annually for the care of patients with wounds of that kind.<sup>1,2</sup> Fundamental in solving the problem of a chronic wound regardless of its origin, and beside the treatment of its underlying cause, is the debridement of the wound bed from necrotic tissue and/or debris that prevents the formation of granulating tissue and its healing.<sup>1,3,4</sup>

### Wound debridement and its importance

Wound debridement is the removal of necrotic and /or infected tissue, foreign body or every kind of biological barrier that prevents the unhindered healing of the wound.<sup>3</sup> A recent research in the United States of America showed that the patients who received wound debridement had a quicker recovery than those who did not, something that proves the importance of debridement in wound care.<sup>5</sup> In another important development, the trend that wanted the chronic wounds to be treated in the same way like those of acute origin has been replaced from newer practices that treat chronic wounds as a separate entity.<sup>6</sup> Since the early 2000s the European Wound Management Association (E.W.M.A) is using the Tissue Inflammation Moisture Edge of wound (T.I.M.E) concept for the treatment of chronic wounds. Fundamental in this concept, is the management of 'Tissue' as it is now widely recognized that the debridement of necrotic tissue, bio-membrane or secretions from the wound bed is crucial in removing the factors that often prevent the rapid healing of the wound and thus promoting its closure. The main tool for a clean wound bed is the debridement, invasive or not.<sup>2,4,6,7,8</sup>

### Wound Debridement Methods

There are several methods of wound debridement, the main categories being the enzymatic, autolytic, mechanical, biological (with the use of maggots) and the sharp debridement. Sharp debridement is the oldest invasive method in use and is often used as the 'gold standard' with which every other method of

this type has to be compared.<sup>1,9</sup> The mechanical debridement is a category that previously included methods such as hydrosurgery, ultrasound and coblation technology debridement. Recent developments and the potential of those more advanced methods are merit them to be treated as a separate category and challenge the sharp debridement as the invasive method of choice for wound cleaning.<sup>1,3,4,10</sup>

### Advanced mechanical debridement methods

**Hydro-surgery:** Hydro-surgery is in use for a number of years and allows for the precise removal of the necrotic tissue and thus the reduction of the bio-burden.<sup>11-13</sup> The main instrument of the method is a high pressure beam of saline water which is administered through a single use hand held nozzle and utilizing the 'Venturi' effect it removes and simultaneously draws the necrotic tissue from the wound without damaging the neighboring areas.<sup>13</sup> The method can be used in a large variety of wounds, but its main use is in burns and fibrotic or infected wounds.<sup>12,14</sup>

**Low Frequency UltraSound Debridement:** The use of low frequency ultrasound for wound debridement is a fairly recent development<sup>15</sup>. It can be administered on the wound surface either directly through a nozzle or indirectly through a saline water mist.<sup>10,15</sup> There is a great variety of frequencies in use but for optimum results, the use of those between 20 and 34kHz has been suggested.<sup>16</sup> The method is considered relatively safe and precise and can be used in a variety of wounds with pressure, low extremity and diabetic ulcers being the focus of its scope.<sup>10,14</sup>

**Plasma Mediated Bipolar Radiofrequency Ablation (Coblation):** The use of coblation in wound debridement has began only recently, even though the method is in use for several years in fields like maxillofacial surgery.<sup>17</sup> A typical coblation device is making use of a bipolar radiofrequency wave, which is administered on the wound surface through a conductive solution, producing a focused plasma field that breaks molecular bonds and allows removal of the necrotic tissue with minimal damage to the healthy surface around it.<sup>17,18</sup> The method is optimized for use in small and deep burns, chronic, venous or infected ulcers.<sup>14,18</sup>

## AIM

The aim of the present systematic review was to describe the invasive methods of hydro surgery, low frequency ultrasound and coblation technology debridement and their comparison to sharp debridement in terms of intervention time, cost, healing capacity, patient safety and reduction of bacterial load of the wound in patients with chronic wounds of diabetic vascular and venous origin as well as pressure ulcers.

## METHODS

A search of 'PubMed', 'Cochrane database of systematic reviews' and 'Science Direct' online databases was made for articles in English or Greek language that compared hydro-surgery, low frequency ultrasound and coblation debridement to sharp debridement. The material that was included in this systematic review was studies that the population was adult patients with chronic wounds of venous, vascular, or diabetic cause and also pressure ulcers. The material that was included in the search were Randomized Controlled Trials, Cohort studies, and, in their absence, prospective or retrospective studies on the subject. Effort was made to find studies that compared the methods in question in all five variables that had been set (healing time, intervention time, cost, reduction of bacterial load, patient safety). Excluded from our search were studies that were financed exclusively from companies, animal studies or studies that their subject were children or patients with burns. Also excluded were studies that were purely technical or irrelevant to the variables that had been set. To include the latest data available on the subject, articles between only 2010-2019 were included. The result of the search was 1933 articles and after further analysis of different stages 11 of them were finally included in this systematic review (Flowchart). More specifically, after 118 duplicates were deleted, 1815 articles were screened. 1568 of the articles found were excluded because of their type (systematic reviews, technical articles, etc.) and after title reading another 165 of the remaining 247. Of the 82 articles left, 71 were removed after full reading, thus bringing the final number of studies included in this review to 11.

Search terms used were 'Hydro-surgery', 'Versa jet', 'Arthrocare', 'Plasma mediated bipolar radiofrequency ablation', 'Coblation

technology', 'Ultrasound', 'Ultrasonic', 'Electrochemical debridement'. The search made was for Abstract, Keywords or Titles that included the aforementioned words either individually or in combination.

## RESULTS

An effort was made to find studies that compared all three invasive methods of hydrosurgery, low frequency ultrasound and coblation with the sharp debridement, but with no results. What follows instead is a separate comparison of each individual method against sharp debridement in terms of healing time, intervention time, cost, patient safety and reduction of the bacterial load of the wound. The search produced eleven studies, five for the low frequency ultrasound debridement, four for the hydrosurgery and two for the coblation debridement. The total number of the patients included was 493. Starting from the oldest to the more recent method the results were as follows.

### Hydrosurgery

Our review examined four studies with a total of 247 patients with chronic wounds of various causes.<sup>12,13,19,20</sup> From the studies that were examined (Table 1 studies 1-4), the Randomized Controlled Trial of Liu et al.,<sup>12</sup> included 40 patients divided in two groups (control and intervention) that received sharp and hydrosurgery debridement respectively, its main findings were that the cost of hydrosurgery was the same as that of sharp debridement even if one is taking in consideration the cost of procurement for the hydrosurgery equipment. In addition, hydrosurgery was judged as faster and safer method than sharp debridement as the blood loss during the intervention was significantly lower in hydrosurgery than in sharp debridement. In terms of healing time and of reduction of the wound bacterial load no significant differences were noted, even though there was a slightly greater bacterial reduction in the group that received hydrosurgery debridement. The prospective ,2 leg, study of Schwartz et al.,<sup>19</sup> included 13 patients divided in two groups that received hydrosurgery and sharp debridement respectively, and the two methods are judged as equally safe while in the group that received hydrosurgery debridement a slightly greater bacterial load reduction was observed.

The prospective, one leg, study of Sola-Ferrer et al.,<sup>13</sup> included 39 patients with chronic wounds of various causes that received hydrosurgery debridement. There was no control group, but it was observed that hydrosurgery debridement was less time consuming because of the smaller number of interventions needed per wound and safer than conventional sharp debridement as no blood loss incidents were reported. Finally, because of the reduced intervention time as well as the improved safety, the method was considered less costly than the sharp debridement. The retrospective, one leg, study of Vanwicik et al.,<sup>20</sup> examined the cases of 155 patients with wounds of various causes that received hydrosurgery debridement. While there was no control group the authors judged the hydrosurgery to be of the same safety level as the sharp debridement and more precise than the later method.

#### Low Frequency UltraSound Debridement

A total of five Randomized Controlled Trials (Table 1 studies 5-9) were reviewed. They included 230 patients with venous or diabetic ulcers that received either low frequency ultrasound or sharp debridement.<sup>15,21-24</sup> The study of Murphy et al.,<sup>15</sup> compared the effects of Low Frequency UltraSound (LFUS) to those of sharp debridement in a total of 68 patients with chronic venous ulcers. The authors judged LFUS as safe as the sharp debridement and of providing faster healing than the later method. Amini et al.,<sup>21</sup> compared LFUS to sharp debridement on 40 patients with diabetic ulcers and osteomyelitis. The main conclusion of this study was that LFUS provides faster healing than sharp debridement but at a reduced rate after the first six months of use. White et al.,<sup>22</sup> examined the use of LFUS on 36 patients with chronic venous ulcers and compared it to sharp debridement. Their conclusion was that LFUS provided a faster healing rate, and it was considered safer than sharp debridement as the number of adverse incidents reported in the group that received LFUS was smaller than in the group that received sharp debridement. Michailidis et al.,<sup>23</sup> studied the effects of LFUS against sharp debridement on a total of 10 patients with diabetic ulcers. Their observation was interesting in that it showed sharp debridement providing faster healing than LFUS. Finally, Alvarez et al.,<sup>24</sup> in a study that included 76 patients with

chronic venous ulcers, compared the use of LFUS to that of sharp debridement. The conclusions of this study were that LFUS is providing a faster healing rate than sharp debridement and also that it is less time consuming. LFUS is also considered as more cost effective than sharp debridement, but this is an indirect conclusion based on the reduced intervention times and the faster healing rate provided by the method. None of the studies examined, compared the two methods in terms of bacterial load reduction.

#### Coblation Therapy

Our review examined two small descriptive studies of the coblation therapy, that compared the method against sharp debridement only indirectly (Table 1 studies 10,11). The retrospective and descriptive study of Trial et al.,<sup>18</sup> had a population of 10 patients with chronic wounds of various causes. The main conclusion of this study was that coblation is safer and more precise than sharp debridement as no adverse incidents were reported. The descriptive study of Richards et al.,<sup>25</sup> focused on the cases of 6 patients with venous or pressure ulcers. The coblation debridement is described as safe and precise and also it is judged as less time consuming than sharp debridement.

As for the variables of time to heal, bacterial load reduction and cost, they were not examined, in the studies found.

#### DISCUSSION

The studies that were examined in this systematic review were for the greater part randomized controlled trials<sup>12,15,21-24</sup> while the rest of them were either retrospective or prospective studies.<sup>13,18,19,20,25</sup> The debridement method that was more widely discussed was that of low frequency ultrasound, while the least discussed was that of coblation, because this method is relatively new and thus it remains largely undiscussed, a fact that occurs in other systematic reviews of the same subject as well. The conclusions of this study are similar to those of previous systematic reviews that have compared either coblation, or low frequency ultrasound or hydrosurgery debridement with sharp debridement. Namely similar to our review, studies by Doerler et al.,<sup>26</sup> Madhok et al.,<sup>17</sup> Bekara et al.,<sup>14</sup> as well as systematic review from N.I.C.E institute in the U.K<sup>11</sup>, show that hydrosurgery

is safer and less time consuming method, with the same or lower cost than the sharp debridement as well as achieving at least the same level of bacterial reduction.

Regarding low frequency ultrasound debridement, the results of this study are similar to those of the systematic reviews of Doerler et al.,<sup>26</sup> Madhok et al.,<sup>17</sup> Chang et al.,<sup>16</sup> and Bekara et al.,<sup>14</sup> in to judging the method as providing faster healing rate than sharp debridement and being safer for the patient. Finally, in one of the earlier studies, of Chang et al.,<sup>16</sup> low frequency ultrasound debridement appears to reduce the bacterial load at a greater rate than sharp debridement, something that was not found in our study.

The number of studies that compare coblation debridement with sharp debridement is small, but there are two systematic reviews from Madhok et al.,<sup>17</sup> and Bekara et al.,<sup>14</sup> that discuss this subject and the conclusions are similar to those of this study, namely that coblation is safer, more precise and less time consuming method than sharp debridement.

## LIMITATIONS

Despite its useful conclusions, the current review has a number of limitations. Namely a number of the studies that were included in it (especially those that dealt with the coblation debridement) had a small patient population with no control group, thus limiting their reliability. There were also a number of variables that were set but not examined due to the lack of data, or because the data presented for them was limited. Also, some of the conclusions of this study are partly indirect thus reducing its reliability.

Another limitation is the possibility of language bias since only English language studies were included in this systematic review. Practical reasons, mainly the difficulty to translate from a variety of languages led us to the decision to exclude studies published in a different language, than English. In addition, searching bibliographies only in international electronic databases may have introduced publication bias to our systematic review since its likely to have missed studies that have not been published in peer reviewed journals. Finally, potentially related data bases like EMBASE and CINAHL were not used.

## CONCLUSIONS

Even though there are some limitations in it, this systematic review proved that the invasive methods of hydrosurgery, low frequency ultrasound and coblation have a number of advantages over sharp debridement and they are valuable tools in the hands of healthcare professionals. Hydro-surgery is considered to be safer and less time consuming than sharp debridement while there are indications that is more cost effective and reduces the bacterial load of the wound at a greater level than sharp debridement.

Low frequency ultrasound debridement offers faster healing and the same or better level of safety than sharp debridement. It also appears to be less time consuming and more cost effective than sharp debridement. Coblation debridement is described as more precise and more safe than sharp debridement and appears to be less time consuming.

More detailed studies are needed in order to examine the full spectrum of those methods especially the aspects that were not fully analyzed in these systematic reviews and also those that the conclusions about them were indirect. Only further analysis will allow the health professionals to utilize them to the maximum of their effect and show their full potential.

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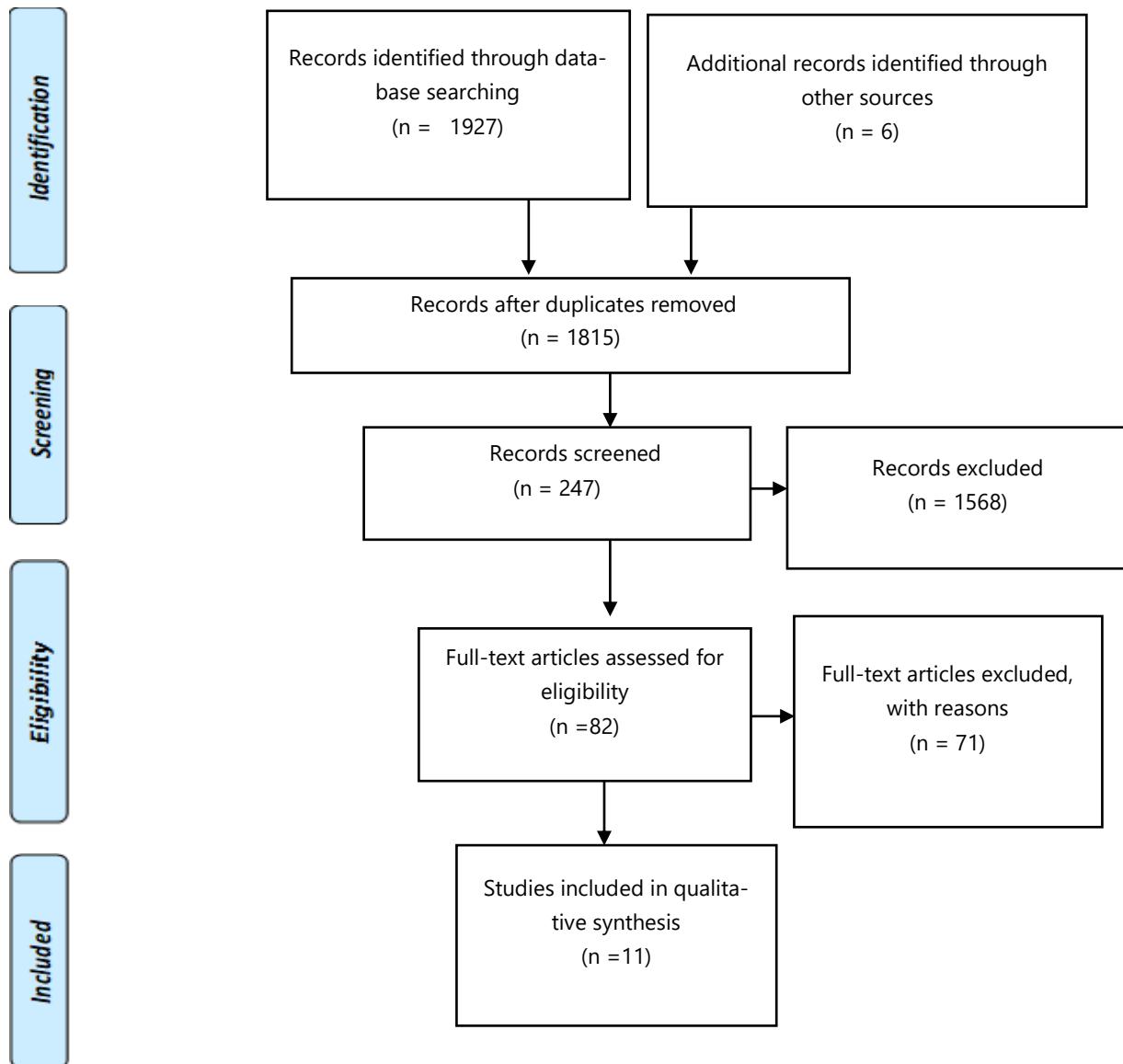
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## ANNEX

**Figure 1.** Flow diagram of search strategy.

**TABLE 1.** Results of the studies included in the systemic review.

STUDY YEAR	TECHNIQUE	METHOD & POPULATION	RESULTS
1) Liu et al U.S.A 2013	Hydrosurgery	Randomized Controlled Trial .40 Patients in two groups (21 in intervention, 19 in control group).Chronic wounds of various causes	No significant differences between the two methods in terms of healing time and cost. Hydrosurgery proved faster, safer and more efficient in reducing bacterial load than conventional debridement.
2) Schwartz JA et al. U.S.A , Italy 2010	Hydrosurgery	Prospective 2 leg study. 13 patients, 8 patients in intervention 5 in the control group. Chronic wounds of various causes.	Hydrosurgery proved as safe as conventional debridement. Greater reduction of bacterial load in hydrosurgery debridement but not significant
3)Vanwicjk et al. Belgium 2010	Hydrosurgery	Retrospective single leg study. 155 patients.Chronic wounds of various causes	Hydrosurgery proved more precise and as safe as conventional debridement
4) Solla- Ferrer et al. Spain. 2017	Hydrosurgery	Prospective single leg study. 39 patients. Chronic wounds of various causes.	Hydrosurgery proved faster, safer, providing improved healing with less cost than conventional debridement
5) Amini S.et al . Iran 2013	Low Frequency Ultra Sound Debridement (L.F.U.S)	Randomized Controlled Trial. 40 patients in 2 groups. (20, Surgical debridement / 20, LFUS). Diabetic ulcers, osteomyelitis	L.F.U.S provides faster healing than conventional debridement, but at a reduced rate after 6 months.
6) White J. et. al. U.K 2016	Low Frequency Ultra Sound Debridement (L.F.U.S)	Randomized Controlled Trial. 36 patients in 2 groups. (19 Surgical debridement / 17 LFUS). Chronic venous ulcers	L.F.U.S provides faster healing than conventional debridement and also is proved safer (3 to 4 adverse incidents reported).
7) Murphy C. et al. Canada 2017.	Low Frequency Ultra Sound Debridement (L.F.U.S)	Randomized Controlled Trial. 68 patients in 2 groups. (36 Surgical debridement / 32 LFUS). Chronic venous ulcers	L.F.U.S is proved as safe as conventional debridement and provides faster healing
8) Michailidis et al. Australia 2018	Low Frequency Ultra Sound Debridement (L.F.U.S)	Randomized Controlled Trial. 10 patients in 2 groups. (5, Surgical debridement / 5, LFUS). Diabetic ulcers	Conventional debridement is judged as providing faster healing than L.F.U.S debridement
9) Alvarez O.M et al. USA 2019.	Low Frequency Ultra Sound Debridement (L.F.U.S)	Randomized Controlled Trial. 76 patients in 2 groups. (40, Surgical debridement /36,LFUS). Chronic venous ulcers	L.F.U.S is proved safer, faster and providing faster healing than conventional debridement L.F.U.S is also judged as more cost effective than conventional sharp debridement.
10) Richards A.J et al. UK 2012	Coblation Therapy	Single arm descriptive study. 6 patients. Venous and pressure ulcers	Coblation therapy, described as safe (no adverse incident reported ) and precise. Finally, coblation therapy is judged as faster than conventional sharp debridement.
11) Trial C. et al. France 2015	Coblation Therapy	Retrospective, descriptive study. 10 patients. Chronic wounds of various causes.	Coblation therapy is described as safer (0 adverse incidents recorded) and more precise than conventional sharp debridement