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Brief communication (Original)

Carboxymethylchitosan, alginate and tulle gauze wound dressings: a comparative study in the treatment of partial-thickness wounds

Apichai Angspatt[a], Boonchai Taweerattanasil[a], Wanida Janvikul[b], Prayuth Chokrungvaranont[a], Wimon Sirimaharaj[c]

[a]*Division of Plastic and Reconstructive Surgery, Department of_Surgery, Faculty of Medicine, Chulalongkorn University, Bangkok 10330;* [b]*National Metal and Materials Technology Center (MTEC), National Science and Development Agency, Pathumthani 12120;* [c]*Division of Plastic and Reconstructive Surgery, Department of Surgery, Faculty of Medicine, Chiangmai University, Chiangmai 50000, Thailand*

Background: Carboxymethylchitosan is a chitosan-derivative obtained from the carboxymethylation of chitin with chloroacetic acid in alkaline solution. It has shown its potential in animal model studies as an accelerator of wound healing.

Materials and methods: Prospective, comparative clinical trials of traditional tulle gauze, alginate membrane, and carboxymethylchitosan sponge were carried out in the treatment of partial- thickness skin graft donor sites. Between June 2005 and March 2006, 70 donor sites from 44 patients were randomly treated by these three different wound dressing materials. Each wound was treated until it was completely healed, and a visual analogue scale was used for the pain evaluation.

Results: The results showed that the donor sites dressed with carboxymethylchitosan or alginate healed more rapidly than those treated with tulle gauze. There was no significant difference in the healing rate between carboxymethylchitosan and alginate. The pain scores evaluated among these three dressing groups did not significantly differ.

Conclusion: Carboxymethylchitosan is as efficacious as traditional tulle gauze or alginate membrain in the treatment of partial thickness skin graft donor sites.

Keywords: Alginate, carboxymethylchitosan, partial-thickness wound, tulle gauze, wound healing

With the advances in wound healing science and biomaterials technology, there are varieties of wound dressing products available today. Among wound dressing materials, bioactive dressings that contain bioactive substances seem to draw the greatest attention. Alginate is considered a bioactive biopolymer that can facilitate the wound healing process. It has long been extensively employed as a wound dressing material in a commercial point of view.

Chitosan is a biopolymer derived from chitin, a second abundant biopolymer extracted from crustacean outer skeletons, such as shrimp and crab shells and squid pens [1]. This material has been known in the wound-dressing field for its hemostatic, bacteriostatic, and fungistatic properties [2, 3]. Recently, chitin and chitosan have been studied in wide spread in the literature for their ability to promote a wound healing process [4-12].

Carboxymethylchitosan (CMC) sponge was prepared in the laboratory of the National Metal and Materials Technology Center (MTEC), Thailand. This chitosan-derivative dressing possessed greater water-absorption ability than chitin and chitosan. It could rapidly absorb fluid from wounds, providing a moist wound environment that is essential for the wound healing process [13-15].

Correspondence to: Apichai Angspatt, MD. Plastic and Reconstructive Unit, Department of Surgery Faculty of Medicine Chulalongkorn University, Bangkok 10330, Thailand. E-mail: aangspatt@hotmail.com

In this study, the healing of partial-thickness skin graft donor sites was used as a model to comparatively evaluate the efficacy of three different wound dressing materials; tulle gauze, alginate and carboxymethylchitosan, by means of a prospective randomized controlled clinical study [16, 17].

Materials and methods

Between June 2005 and March 2006, 70 enrolled adult patients who underwent a spit-thickness skin graft procedure at either the Division of Plastic and Reconstructive Surgery, Department of Surgery, King Chulalongkorn Memorial Hospital or Department of Surgery, Chiangmai University Hospital were randomly divided into three groups. Skin graft was harvested by using Zimmer® dermatome (0.008 to 0.015 inch depth), followed by the application of epinephrine soaked gauze over the donor sites prior to the use of a selected type of dressing.

In group 1, donor sites were dressed with the tulle gauze dressings (Bactigras, Smith and Nephew, Hull, UK) then covered with gauze sheaths and elastic bandages. The outer dressings were changed on the second post- operative day. After the dressings were applied, all the patients were followed up for any complications. Epithelialization was assessed starting from the fifth post-operative day. Spontaneous lifting off of the dressing indicated a complete epithelialization. The healing time was then recorded. In group 2, donor sites were dressed with commercial alginate dressings (Algisite-M, Smith and Nephew, Hull, UK) and subsequently covered with gauzes and elastic bandages. If the dressings were still strongly attached to the wounds, no dressing change was performed. However, the dressings were replaced on the second post-operative day, if they were fully soaked with wound fluid and easily peeled off. The treated patients were followed up for any complications. The healing time was recorded when the epithelialization was complete, indicated by spontaneous lifting off of the attached dressings.

In group 3, donor sites were dressed with carboxymethylchitosan sponges (MTEC, Pathumthani, Thailand) and then covered with gauzes and bandages. The dressing protocol and criterion for a complete epithelialization were the same as those in groups 1 and 2.

The patients' pains were evaluated using a visual analog scale (0-10) on the first, second and third post-operative days.

Statistic test was performed using a Pearson Chi-Square test, one-way ANOVA computed by SPSS for Windows version 11.5.

Results

Seventy donor-sites from 44 consent patients took part in the study. The characteristics of the studied population are shown in **Table 1**. There were no differences in mean age, sex, location of donor sites, mean donor size, and mean donor thickness among each group. In addition, no wound infections or allergic reactions were observed with the uses of all the tested dressing materials.

Pain score

There were no significant differences in the mean pain score recorded on the post-operative day one, two, and three between the three different wound dressings, as shown in **Table 2**.

Table 1. Demographic characteristics

	Tulle gauze	Alginate	CMC	Significant
Total	29	19	22	
Mean age (year)	39	47	40	p >0.05
Sex				
Male	19	14	16	p >0.05
Female	10	5	6	p >0.05
Donor site				
Scalp	2	3	1	p >0.05
Thigh	26	15	21	p >0.05
Calf	1	1	0	p >0.05
Size (cm^2)	237	146	120	p >0.05
Thickness (inch)	0.0105	0.0108	0.0098	p >0.05

Table 2. Donor site pain scores

Day	Tulle gauze	Alginate	CMC	Significant
1	5.48	4.47	4.14	p >0.05
2	4.38	4.74	4.68	p >0.05
3	3.59	3.11	3.41	p >0.05

Healing time

The mean healing time (days) and standard deviation in each group were determined as follows:

Tulle gauze	15.03±2.93
Alginate	10.37±2.73
Carboxymethylchitosan	11.32±2.55

Post-hoc tests showed that there was a strongly significant difference in the mean healing time between the tulle gauze group and the other two groups, carboxymethylchitosan and alginate groups ($p < 0.001$). However, there was no significant difference in the mean healing time between the alginate and carboxymethylchitosan groups ($p > 0.05$).

Discussion

Carboxymethylchitosan sponge was a chitosan-derivative wound dressing that possessed a better ability to absorb aqueous fluid than chitosan. It had shown its potential as an accelerator of wound healing in both the animal model and pathological study [16, 17].

This clinical trial revealed that carboxymethylchitosan could as efficiently facilitate the epithelialization of the split thickness skin graft donor site wounds, as could the commercial wound dressing, i.e. Algisite-M. Moreover, it is better than the conventional tulle gauze in term of healing rate.

The mean visual analog pain scores recorded on the post-operative periods were not significantly different among each group. No wound infections were observed during the study. Concerning the allergic reaction with seafood, there was also no allergic reactions found during the study.

Conclusion

Carboxymethylchitosan sponge had shown its satisfactory clinical efficacy, comparable with that of the commercial alginate membrane, in the healing of the split thickness skin graft donor site wounds.

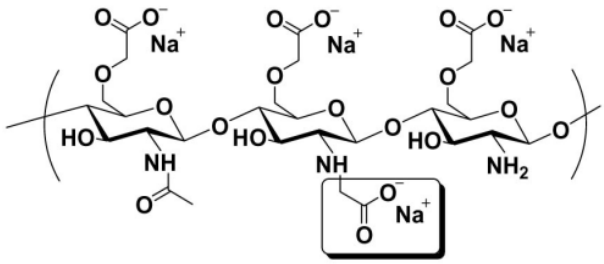
Acknowledgements

The authors have no conflicts of interest to declare.

Appendix

Carboxymethylchitosan sponge (MTEC)

Chemical structure



Preparation

Carboxymethylchitosan is a chitosan-derivative prepared by the carboxymethylation of chitin with chloroacetic acid alkaline solution. To obtain the dressing, lyophilized water soluble carboxymethylchitosan sponges were steamed at 115^{O}C for 15 min. The resultant dressings were sterilized with ethylene oxide gas before use.

Characteristic

A carboxymethylchitosan dressing is flexible, pliable and capable of imbibing water up to 20 times of its original dry weight with reasonable strength after swelling.

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