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## Effect of silver nanoparticle membrane on wound healing and patient satisfaction following flap surgery

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### Abstract

**Aim:** To compare gingival tissue response, patient compliance following placement of (Coe-Pak™) alone and AgNP membrane (ACTICOAT®) with (Coe-Pak™), following Periodontal Flap Surgery.

**Methodology:** This Split-mouth, comparative study included 11 Chronic periodontitis patients, requiring periodontal flap surgery on contralateral sides of the arch, were selected and divided in 2 arches. Group I: Non-Eugenol periodontal dressing (Coe pack) alone after periodontal flap surgery. Group II: AgNP membrane (ACTICOAT) with Non-Eugenol periodontal dressing (coe-pak) placed after periodontal flap surgery. Clinical parameters included plaque index; bleeding scores recorded on 7<sup>th</sup> day after flap surgery.

**Results:** AgNP membrane (ACTICOAT®) with (Coe-Pak™) showed comparatively better results than (Coe-Pak™) alone when plaque scores, bleeding scores, pain and discomfort scores were compared though the differences were statistically significant, subjects found no unpleasant taste/smell and observed the silver nanoparticles membrane to be better.

**Conclusion:** AgNP membrane (ACTICOAT®) along with (Coe-Pak™) showed better patient acceptability, gingival tissue response along with swift healing.

**Keywords:** Periodontal dressing, Silver nanoparticles nanoparticle dressing (ACTICOAT®), non-eugenol periodontal dressing (Coe-Pak™), periodontitis, surgical flaps, wound healing

### Introduction

Periodontists advocate that some form of protection should be applied over the surgically traumatized tissue so that it is shielded from further insult <sup>[1]</sup>. Such protection is offered by periodontal dressings or packs that cover and protect wounds from post-operative irritation, trauma, salivary contamination, and food stagnation. Simultaneously, they have been claimed to alleviate pain, reduce hemorrhage and facilitate recovery <sup>[2]</sup>.

In 1923, with presenting periodontal dressing, Ward supported the practice of a packing material, Wondrpak, around teeth after periodontal flap surgery. Conventionally, periodontal dressings were zinc oxide eugenol based. Owing to several side-effects of eugenol, modern periodontal dressings are typically deprived by the same. An extensively used periodontal dressing is the non-eugenol dressing "Coe-pak" (GC AMERICA, INC. ALSIP, IL 60803 U.S.A.), which proposes typical, to which supplemental periodontal dressings can be compared. Though broadly accepted, Coe-pak have numeral shortcomings, e.g., poor appearance, ill-defined setting time, and poor flow properties throughout manipulation.

Silver nanoparticles (AgNPs) are nanometer-sized particles of silver that are less than 100nm in size. They possess antimicrobial properties, anti-inflammatory effects and wound healing properties, which can be used with Ag NP-impregnated dressings. ACTICOAT (Smith and Nephew medical limited, US5681575, Reg US Pat and TM) is a dressing that utilize the antimicrobial properties of silver to deliver a well-organized and effective barricade to bacterial penetration. Flexible, porous and conformable, each ACTICOAT variant is established with properties explicit to its obligatory practice.

Literature review by Karla Chaloupka *et al.*, <sup>[3]</sup> concluded practice of silver nanoparticles limited only to partial and full thickness wounds such as diabetic and venous ulcers. To the best of our knowledge, there are no studies which have evaluated the wound healing, gingival tissue response and patient satisfaction after placement of AgNPs membrane ACTICOAT and

a non-eugenol periodontal dressing Coe-pak post flap surgery. Hence, aim of the study was to compare gingival tissue response, healing, patient compliance following placement of (Coe-Pak™) alone and AgNP membrane (ACTICOAT®) with (Coe-Pak™), following Periodontal Flap Surgery.

11 Chronic generalized periodontitis patients, requiring periodontal flap surgery on the contralateral sides of the arch, were selected and divided randomly into 2 groups.

**Group I** – Non-Eugenol periodontal dressing (Coe pack) alone after periodontal flap surgery.

**Group II** – Silver nanoparticles membrane (ACTICOAT) with Non-Eugenol periodontal dressing (coe-pak) placed after periodontal flap surgery.

The study was approved by institutional ethics committee and was conducted in accordance with Helsinki Declaration of 1975, as revised in 2013. Patients' informed consent was obtained prior to the procedure.

Inclusion criteria selected for the study were patients between 30-55 years, chronic periodontitis subjects (with pocket depth  $\geq 5$ mm), requiring periodontal flap surgery in at least 2 different quadrants. Presenting almost similar periodontal involvement bilaterally as determined by clinical and radiographical assessment. Whereas, Exclusion criteria were subjects with systemic conditions. Former/ current smokers, History of periodontal intervention within the last 6 months, antibiotic treatment within the last 3 months, pregnant and lactating subjects.

## Materials and Methods

This was a split mouth, comparative study where selected sites in each patient were randomly divided into two groups; Group I and Group II. In Group I, Coe-pak was used as a periodontal dressing, and in Group II, silver nanoparticles membrane (Acticoat) [figure 1, 2] was used post-operatively. At day 0 (baseline), both groups were subjected to the recording of plaque index (Sillness and Loe), gingival index (Loe and Sillness, 1963) and bleeding index (Muehleman and Mazor 1977). Pain and discomfort (Visual Analog Scale) were recorded. All the evaluations were made by the same examiner who was blinded for the surgical procedures and pack placement.

In Group I, following sulcular incisions, a full thickness mucoperiosteal flap was reflected both facially and lingually. After thorough debridement and root planing of exposed root surface, the flap was placed in its original position and sutured using non-resorbable silk sutures. The surgical site was dried using gauze, and Coe-pak was then applied [Figure 3a, 3b]. Parallel surgical procedure was implemented on the contralateral side, and AgNP dressing (ACTICOAT) was applied thereafter in Group II. All the surgical procedures were done by the same operator. The third operator applied the dressings according to the randomizing sequence. Inter examiner disparity was compacted to an acceptable level.

In group I, Coe-pak was removed following 7 days and was checked for gingival tissue response, plaque deposition beneath the dressing and patient compliance regarding the dressings received whereas for group II, AgNP membrane along with coe-pak was removed after 7 days for inspection of the gingival tissue [Figure 4a, 4b], plaque deposition [Figure 5] and patient compliance concerning the dressing for which a questionnaire was provided to the patients and were requested to fill them out according to their perception. Since AgNP membrane (ACTICOAT) is not mucoadhesive it was decided to placed along with Coe-pak.

The third operator who had applied the dressings removed them on the fourth and seventh day. Pain and discomfort scores for the 1st, 2nd, and 3rd postoperative day were documented for each patient by means of the visual analog scale (VAS) and findings organized by the first operator who had examined at baseline and was oblivious of the type of dressing applied. Then, the subjects were examined and plaque index, bleeding index, and gingival index were scored. Patients were also given a post-operative assessment questionnaire (Table 8), in which they were questioned about taste, appearance, and retention of both the dressings and following the second procedure, they were requested to state their preference, if any, for a specific dressing.

Independent Student t Test was used to compare the mean PI and MSBI values between 2 groups at Pre and Post treatment Periods. Student Paired t Test was used to compare the mean Plaque & Modified Sulcular Bleeding Index scores b/w Pre and Post treatment time intervals in each study group. Chi Square Test was used to compare the presence of Plaque under Dressing, Wound Healing Index Scores and Patient perception about the periodontal dressings between 2 groups. The level of significance was set at  $P < 0.05$ .

## Results

The present study involved 11 Chronic periodontitis patients, requiring periodontal flap surgery on the contralateral sides of the arch, which were selected and divided in to 2 arches [Table 1]. All data obtained was put to statistical analysis. Student paired t-test and Chi square test was utilized for assessment of significance.

On comparing the mean plaque index and mSBI, the mean PI & MSBI values do not significantly differ between 2 groups during Pre-treatment groups [Table 2]. However, when there was comparison of mean PI and MSBI values between 2 groups at Post Intervention period, the results were statistically significant where the Acticoat + Coe Pack group shows significantly lesser mean PI & MSBI scores compared to Coe Pack alone group at  $P=0.003$  and  $P=0.007$  respectively. [Table 3]

On comparing, the Acticoat + Coe Pack group shows significant reduction in mean PI & MSBI scores in the Post treatment period as compared to Pre-treatment period at  $P < 0.001$ . [Table 4] Whereas, the Coe Pack group shows significant reduction in mean PI & MSBI scores in the Post treatment period as compared to Pre-treatment period at  $P < 0.001$  and  $P=0.004$  respectively. [Table 5]

The Coe Pack alone group showed more plaque [81.8%] compared to Acticoat + Coe Pack group which showed significantly lesser plaque under dressing [18.2%] in the post treatment period at  $P=0.003$ . [Table 6]

On comparison, Coe-Pak alone group showed 36.4% wound healing having no suppuration, gingival Edema, erythema and discomfort and 63.6% having uneventful healing, slight gingival Edema and slight discomfort, whereas, the Acticoat + Coe-Pak group showed 100% wound healing with no suppuration, gingival Edema, erythema and discomfort as compared to This difference in wound healing between 2 groups was statistically significant at  $P=0.001$ . [Table 7]

The Coe-Pak alone group showed 9.1% of Atypical sensation and Taste Disapproval as compared to no such reporting in the Acticoat + Coe Pack group. However, the difference was not statistically significant for patient perception regarding the periodontal dressing between 2 groups. [Table 8]

## Discussion

The justification for the use of periodontal dressings has always been debatable as their effects on periodontal wound healing have been probed over the years, and they are allied with more plaque accumulation when compared to no dressing [4], which is significant with our study where Coe Pak alone accumulated 81.8% plaque post dressing placement whereas when compared with AgNP, only 18.2% patients exhibited plaque under their dressing. Study performed on AgNPs containing dressings by Velázquez-Velázquez *et al.* demonstrated anti-biofilm activity against *P. aeruginosa*. The authors associated the anti-biofilm capability of AgNP (metallic and ions) to a potential interference, inhibition, and/or regulation of the exopolysaccharides (EPS) produced by bacteria [5] which had positive co-relation with our study where 81.8% of patients having AgNP membrane had no plaque deposition under the dressing and the majority of patients (81%) who received Coe-Pack exhibited plaque deposition. Rath *et al.* described the use of a collagen Nano matrix incorporating a reservoir of AgNPs for accelerated wound healing. In vivo studies demonstrated good wound-healing properties due to intrinsic antibacterial, anti-inflammatory, and hemostatic properties. [6] Metcalf *et al.* investigated the application of silver-based antimicrobial dressings on 112 difficult-to-heal wounds and, in 83% cases, a progression in management of exudate, biofilm, and wound healing was observed, [7] which was similarly associated with our results as AgNP membrane showed 100% good wound healing with no suppuration, gingival Edema, erythema and discomfort as compared to Coe-Pack alone.

In vivo studies by Mohseni *et al.* compared antimicrobial dressings conjugated with silver sulfadiazine (SSD) and silver nanoparticles (AgNPs) for chronic wound healing. Although at similar concentration SSD and AgNPs demonstrated strong and equal anti-microbial activity against *S. aureus*, AgNPs demonstrated higher biocompatibility, faster healing rate, epithelization, and dermal regeneration [8].

Tian *et al.* tested silver nanoparticles and SSD in a thermal injury model comparing the rate of healing of deep partial-thickness wounds. They found less hypertrophic scarring and nearly normal hair growth on the wound surface treated with silver nanoparticles and confirmed the accelerated wound healing by using silver nanoparticle [9].

The results in this study showed significantly less plaque attached underneath the dressings in Group 2. The rough and flint surface texture of hardened non-Eugenol pack attract more plaque on its irregular surface. Since, the AgNP membrane dressing has a smooth surface forming a firm, elastic covering; it accumulates less plaque which has similar co-relation with Madan *et al.*, [1] which had mean increase in plaque scores in Group II (Coe-Pak) from baseline to day 7 was found to be slightly less in comparison with Group I (barricade) and had a contradicting results for a study done by Kakar *et al.*, [10] who emphasized that his study implied both the dressings (Coe-Pak and Barricade) influence the plaque deposition or its regression over time on the tooth surfaces in a similar manner.

mSBI was used to assess the bleeding tendency of the gingival margin. AgNP membrane dressing was not associated with any significant increase in bleeding as seen in mSBI scores thus reflecting its acceptable biocompatibility and The Acticoat + Coe Pack group shows significantly lesser mean PI & MSBI scores compared to Coe Pack alone group. This finding is supported by a study conducted by Madan *et al.*, that there was mean increase in bleeding index scores on

day 7 as compared to baseline was statistically non-significant but lower for Group II (barricade) compared to group I (Coe-pak) [1] and contradictory findings were seen in study done by Kakar *et al* which concluded that inflammatory status of soft tissue at the surgical site and improvement of clinical gingival parameters from 7th to 14th day was influenced by both the dressings in a similar manner [10].

In our study the Coe Pack alone group showed 9.1% of atypical sensation, discomfort and Taste disapproval as compared to no such reporting in the Acticoat + Coe Pack group. However, the difference was not statistically significant for the patient perception regarding the periodontal dressing between 2 groups. However, it may be considered that periodontal dressing used in group 2, i.e. AgNP membrane may be of superior category considering its many actions including antibacterial action and accelerated wound healing, it may be used as an alternative dressing in periodontal phase II surgery.



Fig 1: Commercially available Silver nanoparticles membrane.



Fig 2: Silver nanoparticles membrane (white) between the two-silver foiling's.



**Fig 3a:** Suturing following the flap surgery



**Fig 4b:** Placement of Silver nanoparticles membrane with Coe-pak



**Fig 3b:** placement of Coe-pak alone.



**Fig 4a:** Placement of Silver nanoparticles membrane.



**Fig 5:** Plaque under periodontal dressing using two tone dye.

**Table 1:** Distribution of the interventions in various quadrants

Quadrant	Distribution of different Interventions in various Quadrants among study subjects			
	Acticoat + Coe pack		Coe pack Alone	
	n	%	n	%
1st Quadrant	3	27.3%	3	27.3%
2nd Quadrant	5	45.5%	3	27.3%
3rd Quadrant	2	18.2%	4	36.4%
4th Quadrant	1	9.1%	1	9.1%

*P*<0.05 – statistically significant\*

**Table 2:** Comparison of plaque index and modified sulcular bleeding index between 2 groups preoperatively.

Comparison of mean Plaque Index and Modified Sulcular Bleeding Index values between 2 groups at Pre-treatment Period using Independent Student t Test						
Parameter	Groups	N	Mean	SD	Mean Diff	P-Value
Plaque Index	Acticoat + Coe Pack	11	2.27	0.47	-0.09	0.66
	Coe Pack Alone	11	2.36	0.51		
Modified Sulcular Bleeding Index	Acticoat + Coe Pack	11	2.09	0.30	-0.09	0.56
	Coe Pack Alone	11	2.18	0.41		

*P*<0.05 – statistically significant\*

**Table 3:** Comparison of plaque index and modified sulcular bleeding index between 2 groups post operatively.

Comparison of mean Plaque Index and Modified Sulcular Bleeding Index values between 2 groups at Post Intervention Period using Independent Student t Test						
Parameter	Groups	N	Mean	SD	Mean Diff	P-Value
Plaque Index	Acticoat + Coe Pack	11	0.55	0.52	-0.72	0.003*
	Coe Pack Alone	11	1.27	0.47		
Modified Sulcular Bleeding Index	Acticoat + Coe Pack	11	0.91	0.30	-0.54	0.007*
	Coe Pack Alone	11	1.45	0.52		
<i>P</i> <0.05 – statistically significant*						

\* - Statistically Significant

**Table 4:** Comparison of mean Plaque & Modified Sulcular Bleeding Index scores b/w Pre and Post treatment time intervals in Acticoat + Coe Pack group

Comparison of mean Plaque Index & Modified Sulcular Bleeding Index scores b/w Pre and Post treatment time intervals in Acticoat + Coe Pack group using Student Paired t Test						
Parameters	Time	N	Mean	SD	Mean Diff	P-Value
Plaque Index	Pre Rx	11	2.27	0.47	1.72	<0.001*
	Post Rx	11	0.55	0.52		
Modified Sulcular Bleeding Index	Pre Rx	11	2.09	0.30	1.18	<0.001*
	Post Rx	11	0.91	0.30		
<i>P</i> <0.05 – statistically significant*						

\* - Statistically Significant

**Table 5:** Comparison of mean Plaque & Modified sulcular bleeding Index scores b/w Pre and Post treatment time intervals in Acticoat + Coe Pack group

Comparison of mean Plaque & Modified Sulcular Bleeding Index scores b/w Pre and Post treatment time intervals in Coe Pack group using Student Paired t Test						
Parameters	Time	N	Mean	SD	Mean Diff	P-Value
Plaque Index	Pre Rx	11	2.36	0.51	1.09	<0.001*
	Post Rx	11	1.27	0.47		
Modified Sulcular Bleeding Index	Pre Rx	11	2.18	0.41	0.73	0.004*
	Post Rx	11	1.45	0.52		
<i>P</i> <0.05 – statistically significant*						

\* - Statistically Significant

**Table 6:** Comparison of presence of Plaque under Dressing between 2 groups

Comparison of presence of Plaque under Dressing between 2 groups using Chi Square Test							
Variable	Category	Acticoat + Coe Pack		Coe Pack Alone		$\chi^2$ Value	P-Value
		n	%	n	%		
Plaque under Dressing	Yes	2	18.2%	9	81.8%	8.909	0.003*
	No	9	81.8%	2	18.2%		
<i>P</i> <0.05 – statistically significant*							

\* - Statistically Significant

**Table 7:** comparison of wound healing index scores between 2 groups

Comparison of Wound Healing Index Scores between 2 groups using Chi Square Test							
Variable	Category	Acticoat + Coe Pack		Coe Pack Alone		$\chi^2$ Value	P-Value
		n	%	n	%		
Wound Healing Index	Score 1	11	100.0%	4	36.4%	10.267	0.001*
	Score 2	0	0.0%	7	63.6%		
	Score 3	0	0.0%	0	0.0%		
<i>P</i> <0.05 – statistically significant*							

\* - Statistically Significant

**Note:** Score 1 - absence of suppuration, gingival Edema, erythema and discomfort.  
 Score 2 - uneventful healing, slight gingival Edema and Edema and slight discomfort  
 Score 3 - poor wound healing with significant gingival Edema and discomfort and flap dehiscence.

**Table 8:** Comparison of Patient Perception regarding the periodontal dressing between 2 groups.

Comparison of Patient Perception regarding the Periodontal dressing between 2 groups using Chi Square Test							
Variable	Category	Acticoat + Coe Pack		Coe Pack Alone		$\chi^2$ Value	P-Value
		n	%	n	%		
Atypical Sensation or Discomfort	Yes	0	0.0%	1	9.1%	1.048	0.31
	No	11	100.0%	10	90.9%		
Comfortable with Appearance	Yes	0	0.0%	0	0.0%	..	..

	No	11	100.0%	11	100.0%		
Taste Disapproval	Yes	0	0.0%	1	9.1%	1.048	0.31
	No	11	100.0%	10	90.9%		
<i>P</i> <0.05 – statistically significant*							

The Coe Pack alone group showed 9.1% of Atypical sensation and Taste Disapproval as compared to no such reporting's in the Acticoat + Coe Pack group. However, the difference was not statistically significant for the patient perception regarding the periodontal dressing between s2 groups.

### Conclusion

Within the limitations of this study, it was found that the clinical gingival tissue response and patient compliance following placement of periodontal dressings after periodontal flap surgery was better for AgNP dressing. Although non-Eugenol dressing retained more plaque on its under surface than AgNP membrane dressing, AgNP group had better impact on the clinical gingival parameters, which were suitable and comparable in both groups, signifying that AgNP membrane had better effects on gingival healing after periodontal surgery. A greater number of patients showed a preference for AgNP dressing, based on its superior aesthetics, no coarse taste, smooth and better retentive feature of the dressing. However, it is vital to highlight that a larger number of subjects has to be taken up and histological evaluation of gingival tissue and scanning electron microscopy of the removed dressing can associate the efficiency of these dressings.

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