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# **Effectiveness of modified carnoys compared to carnoys solution in preventing recurrence of odontogenic keratocysts: An original research**

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**Abstract**---Introduction: Carnoy's solution (CS), has been barred for 7 years, without data to support its effectiveness. Hence in the present study we evaluate the effectiveness of modified carnoys (MC) compared to carnoys solution in preventing recurrence of odontogenic keratocysts. Material and Methods: We conducted a retrospective cohort study comparing CS or for the recurrence and time to recurrence. The values obtained were compared. Results: we observed that in both the recurrence was similar, Median time to recurrence was 2 years. Preserving adjacent teeth was associated with a significant increase in recurrence. Conclusion: We observed no significant difference in recurrence rate or distribution of time to recurrence between OKCs treated with CS or MC.

**Keywords**---Carnoy's solution, Modified carnoys, Odontogenic keratocysts.

## Introduction

The odontogenic keratocyst (OKC) is known for its locally aggressive behavior and high recurrence rate. Carnoy's solution (CS) was found to improve outcomes. The fixative solution kills vital OKC daughter cells, epithelial islands, and cells remaining in the cyst cavity at the lesion periphery, all of which are potential causes of recurrence.<sup>1</sup> The FDA banned CS in 2013 because it contains chloroform, labeled as "reasonably anticipated to be a human carcinogen" based on animal studies.<sup>2-5</sup> This led surgeons to substitute the non-chloroform containing modified Carnoy's solution (MC). No data supported the use of MC as an alternative at that time. Only 2 studies addressing recurrence with use of MC exist: 1 was performed in 2015, suggesting that MC (35% recurrence) is not as effective as CS (10% recurrence).<sup>3</sup> This retrospective cohort study involved a single center and combined outcomes from 3 different surgeons, with 1 surgeon treating 84% of the CS group and 58% of the MC group.<sup>1,5</sup> The other study followed a group of 29 patients for between 3-6 years and found no recurrences when using EC, peripheral ostectomy, and non-chloroform containing MC, but the conclusions from this study are limited by lack of a comparison group. Hence in the present study we evaluate the effectiveness of modified carnoys (MC) compared to carnoys solution in preventing recurrence of odontogenic keratocysts.

## Materials and Methods

We conducted a retrospective cohort study on patients with OKC treated surgically with adjunctive chemical cautery from 2004 and 2019. Inclusion criteria was OKC treated with enucleation, curettage, and peripheral ostectomy followed by application of either CS or MC, and at least 1 follow-up appointment at least 12 months after surgery to determine recurrence. Along with the demographics we noted the variable of the recurrence. Data was collected and noted for the various treatment outcomes and the type of the carnoys used. We compared between the two groups as CS & MC. We considered  $p < 0.05$  as significant.

## Results

We observed that out of the 77 patients the CS group consisted of 36 patients, while the MC group consisted of 41 patients, and no significant demographic differences were noted between groups. Overall recurrence rate was 14.3%: 13.9% in the CS group and 14.6% in the MC group. Median time to recurrence in both groups was 24 months, and there was no significant difference in distribution of time to recurrence by group ( $P = 0.30$ ). The longest time to first recurrence for a patient was 134 months. Although use of CS or MC was not significantly associated with recurrence ( $P = 0.93$ ), all recurrences in our study were found in males ( $P = 0.013$ ). To visualize the probability of recurrence between groups over time, we generated Kaplan-Meier plots. Although the curve for MC appears at first glance to have a steeper rise for probability of recurrence, the 95% confidence interval is nearly completely overlapped with that of the CS curve (Fig 1). There was a significant association between preserving 1 or more teeth in close proximity to the lesion and having a recurrence ( $P = 0.004$ ).

## Discussion

We observed that there was no significant statistical difference in recurrence for OKC based on treatment by CS or MC. MC was seen as an effective chemical cautery solution when used in combination with enucleation, curettage, and peripheral ostectomy, with a recurrence rate of 14.6%. Moreover, the median time to recurrence was 2 years for both groups, also demonstrating MC's effectiveness. Our recurrence rate when adjunctively using MC is comparable to other reports for recurrence rate with chloroform-containing Carnoy's solution and improved from the 25-60% recurrence rate expectable from enucleation and curettage alone.<sup>2-8</sup> Our study did besides find a significant relation between preservation of 1 or more teeth adjacent to the OKC during the first procedure and having a recurrence. This point would seem to be obvious, as it has been shown that an aggressive surgery such as resection has less recurrence rate.

In contrast to our study, a retrospective study by Dashow et al.<sup>6</sup> found an amplified recurrence rate of 35% with MC likened to 11% with CS, concluding that chloroform may be an vital element in the solution. In our research, 4 out of 5 CS recurrences happened within the first 6 years, with 3 out of 5 recurring in the first 2 years. The 5th recurrence was seen at 134 months, and if this recurrence were excepted, the overall recurrence rate of CS at 6 years in our study would be 11.4%. This difference between MC and CS recurrence rates is still far from the magnitude of the difference recognized in the Dashow et al.<sup>6</sup> study, which stated there was a lack of follow-up data beyond 7 years, and it is unlikely that the difference in our study would be clinically significant. Caminiti et al.<sup>9</sup> argue that 5-FU is a more specific therapy as it is currently used with relatively decent tolerance in patients with superficial basal cell carcinomas. This new study on 70 patients found that when using a protocol involving enucleation, peripheral ostectomy, then placement of a sterile radiopaque ribbon gauze coated in 5% 5-FU cream into the surgical wound with a small edge left out of the wound closure to allow for removal 24 hours post-operatively, no recurrences were identified compared to 25% recurrences in patients treated with EC and peripheral ostectomy with MC. Fascinatingly, the authors of this study did not

find a significant difference between permanent nerve paresthesia in MC (36%) vs. 5-FU (20%) treatment, despite nerve paresthesia being a major concern of critics of the use of CS and MC. Our study agrees with this data, as we found no significant difference in paresthesia in the CS group (42%) vs. the MC group (27%), and as Caminiti et al.<sup>9</sup> propose, this may be due to the location and size of the lesion relative to the nerve rather than contact with the adjunctive agent. The limitation of our study is small sample size and the poor follow-ups. There was no comparative group

## Conclusion

We can conclude that use of chemical cautery, in the form of MC, as an adjunctive to EC and peripheral ostectomy remains among the effective methods currently available to treat OKCs despite the ban on chloroform compounding. Further studies are encouraged with various other chemicals like topical application of 5-FU.

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**FIGURE 1.** Kaplan-Meier curves for probability of recurrence over time, with 95% confidence intervals (shaded areas). Pluses indicate when a data point was censored due to no additional follow-up time points. A, Carnoy's group (blue) vs. Modified Carnoy's group (red). B, Any/all adjacent teeth extracted (blue) vs. 1 or more adjacent teeth preserved (red).

