JOURNAL OF ENDODONTICS

Printed in U.S.A.
VOL. 26, NO. 7, JULY 2000

SCIENTIFIC ARTICLES

Gutta-Percha Softening: "Hemo-De" as a Xylene Substitute

Zvi Metzger, DMD, Vered Marian-Kfir, DMD, and Aviad Tamse, DMD

The putative hazardous nature of chloroform and xylene implies that safer substitutes should be considered. Standard cylindrical gutta-percha samples were immersed in Hemo-De, a xylene substitute, for 60 s at 37°C. Weight loss of a sample, after drying, was used as a measure of its solubility. Master and accessory cone gutta-percha of three brands were compared. The highest solubility of all kinds of gutta-percha was in chloroform, which served as a positive control. The average solubility of all samples in xylene and Hemo-De was 61% and 52% of that in chloroform, respectively. DMS gutta-percha was more soluble than of Hygienic and DeTrey. Master cone gutta-percha of all brands was more soluble than that of their accessory cones. These results indicate that (a) large differences exist in the solubility of gutta-percha and (b) Hemo-De dissolved gutta-percha in a range similar to that of xylene and may be considered as a potential substitute for this organic solvent.

Organic solvents have been used to soften or dissolve gutta-percha in a variety of endodontic procedures. Some of these, such as chloropercha methods, require a thorough dissolution of gutta-percha. Others, such as customizing master cones, call for a solvent that will evaporate immediately. For both procedures chloroform has been the preferred solvent because it effectively dissolves the material and evaporates fast with a vapor pressure of 195 mm Hg. On the other hand procedures such as removal of gutta-percha root canal fillings call for a softening agent that will facilitate the mechanical removal of the gutta-percha. Using fast evaporating solvents, such as chloroform, may result in a rather messy procedure with remaining residues of dissolved gutta-percha on the canal walls and in the pulp chamber (1, 2). For this kind of procedure a slowly evaporating softening solvent, such as xylene, that may allow more working time and a cleaner procedure may be desired (2).

The commonly used solvents, chloroform and xylene, have caused concern as putative hazardous materials and even as suspected carcinogens (3, 4). Proper handling may minimize a patient's exposure to these solvents; nevertheless the staff of an endodontic office is repeatedly exposed to the vapors of these materials and therefore they may constitute an occupational hazard (5).

This concern led to searching for safe but efficient chloroform and xylene substitutes for use in endodontics. In recent years several such solvents were proposed, including methyl-chloroform (5), halothane (1, 6, 7), and white rectified turpentine (8). The search was also extended to a variety of essential oils as well as industrial solvents (5, 6, 8, 9). Some of these materials may be less hazardous than the traditional organic solvents; however recent toxicity studies have shown that even halothane and white rectified turpentine, which were considered relatively safe, are toxic to fibroblasts and also have other potential negative effects such as hepatotoxicity and contact dermatitis (10–12).

Hemo-De is a xylene substitute that has been introduced for laboratory use in both histology and microbiology (13, 14). It is also used as a safe xylene substitute for aircraft part degreasing and is not classed or specified by OSHA's Federal Hazard Communication Standard.

Hemo-De, like xylene, is insoluble in water and evaporates slowly without any remaining residues: vapor pressure of 4.7 mm Hg, compared with 10.66 mm Hg for xylene and 195 mm Hg for chloroform. It is less flammable than xylene with a flash point of 57.8°C, compared with 26.2°C for the latter. The active ingredient of Hemo-De is *d*-limonene (4-isopropenyl-1-methyl-1-cyclohexane) that is a naturally occurring compound derived from citrus fruits. It is used as a food flavoring material and has been defined by the Food and Drug Administration as a "Generally Recognized As Safe" material (15, 16).

We therefore tested Hemo-De as a potential safe xylene substitute for softening gutta-percha. It was found to be a good solvent that has ~50% of the gutta-percha–dissolving capacity of chloroform and is almost as effective as xylene, which has 64% of that capacity.

MATERIALS AND METHODS

Solvents

"Hemo-De" (Scientific Safety Solvents, Keller, TX), a solvent introduced as a safe xylene substitute for histology and microbiology laboratories, was compared with xylene (*p*-Xylene, Puris, Fluka, Switzerland). Both were compared with chloroform (Merla, Germany), which served as a positive control, whereas distilled water was used as a negative control.

Gutta-Percha

Three gutta-percha brands were tested and compared. For each of them master cones and accessory cones were tested and compared. DMS (United Dental Manufacturers, Inc., West Palm Beach, FL) master cones (#90) and accessory cones (fine), batch #131122 and #131124, respectively. DeTrey master cones (#90) and accessory cones (fine), batch #311291 and #311290, respectively. Hygienic master cones (#90) and accessory cones (fine), batch #107405 and #107406, respectively.

Gutta-Percha Sample Preparation

Sample preparation was done as described by Tamse et al. (9). Gutta-percha cones were gently heated until a uniform mass of gutta-percha could be formed. Condensing the softened material into standard metal forms resulted in cylindrical samples with a 10 mm diameter and 2 mm height. Uniformity of the samples was verified by weight that was 378.5 (±9.8)mg and 375.0 (±4.8)mg for DMS master and accessory cones, respectively. DeTrey samples were 465.1 (±11.2)mg and 457.2 (±7.6)mg for master and accessory cones, respectively, whereas weight of Hygienic samples was 403.1 (±10.2)mg and 408.0 (±5.8)mg for master and accessory cones, respectively.

Gutta-Percha Solubility Assay

Solubility of the gutta-percha samples in each of the solvents was measured as previously described by Tamse et al. (9). The assay is based on weight loss of the sample after 1 min immersion in 1 ml of the solvent at 37°C, using a Vortex stirrer. Each sample was placed in a preweighed flat-bottomed glass vial and placed in an incubator at 37°C. One milliliter aliquots of the solvent in sealed glass tubes were also placed at 37°C. The designed solvent was then added to each sample and the vial stirred for 60 s in a chemical hood. The remaining sample was then picked up with a needle, removed from the solvent, placed on a preweighed glass microscope slide, and allowed to dry, first in the hood and later in a 37°C incubator. Evaporation of the solvent was followed daily by weighing the slides and considered complete when the weight remained stable for two consecutive days. A stirring time of 60 s was defined in a pilot experiment (Fig. 1) that verified that weight loss was in direct relation to stirring time. Longer stirring resulted in samples that were messy and difficult to handle and with a resulting wider spread of weight loss within the groups.

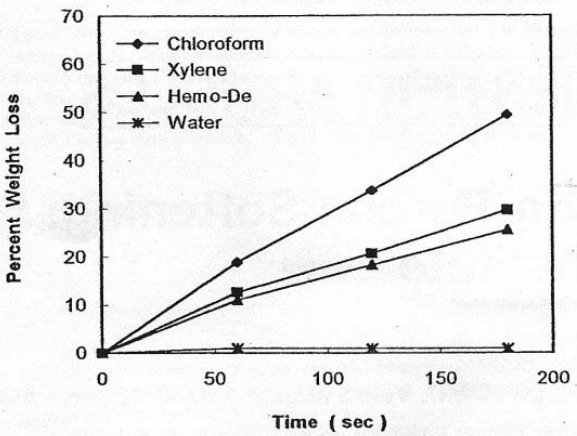

FIG 1. Kinetics of gutta-percha solubility. Gutta-percha solubility measured as weight loss of a standardized DMS gutta-percha sample immersed in each solvent at 37°C. Each *point* represents the mean weight loss of six samples. Standard errors were <5%.

RESULTS

Solubility in Chloroform

Chloroform, which was used as a positive control, was the best gutta-percha solvent ($p < 0.0001$; Figs. 1 and 2, Table 1). Average weight loss of all gutta-percha samples in chloroform was 13.93 (±0.52)%. The highest solubility in chloroform was that of DMS gutta-percha: 17.89 (±0.95)% and 17.05 (±0.35)% for master and accessory cones, respectively (Fig. 2). Hygienic gutta-percha followed with a loss of 15.67 (±0.32)% and 14.98 (±0.48)% for master and accessory cones, respectively. The lowest solubility in chloroform was that of DeTrey gutta-percha with a weight loss of 10.42 (±0.39)% and 7.60 (±0.41)% for master and accessory cones, respectively.

Solubility of master cone gutta-percha of all brands in chloroform was higher than that of accessory cone gutta-percha with an average weight loss of 14.62 (±0.67)% for the former and 13.21 (±0.79)% for the latter.

There was no solubility of gutta-percha in water (Fig. 1).

Solubility in Xylene

Gutta-percha solubility in xylene was significantly lower than that in chloroform ($p < 0.0001$, Table 1). An average weight loss of all samples in xylene was 8.57 (±0.49)%, compared with 13.93 (±0.52)% in chloroform.

Xylene, like chloroform, better dissolved the DMS gutta-percha samples: 10.96 (±0.49)% and 9.83 (±0.31)% weight loss for master and accessory cones, respectively (Fig. 2). Hygienic gutta-percha followed with a 9.55 (±0.15)% and 8.05 (±0.35)% weight loss for master and accessory cones, respectively. The lowest solubility in xylene was that of DeTrey gutta-percha that lost 7.93 (±0.34)% and 5.11 (±0.16)% of its weight for master and accessory cones, respectively (Fig. 2). The average solubility of all master cones in xylene was greater than that of accessory cone gutta-percha: 9.48 (±0.30)% and 7.66 (±0.40)%, respectively.

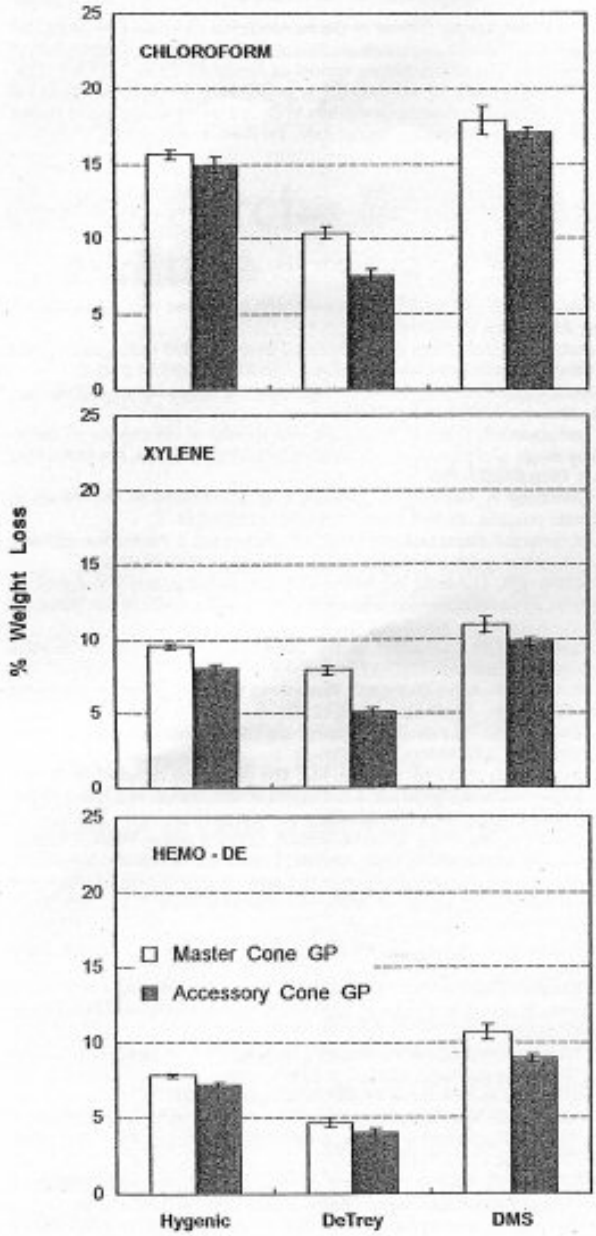

FIG 2. Solubility of master and accessory cone gutta-percha in chloroform, xylene, and Hemo-De. Gutta-percha solubility measured as weight loss of standardized gutta-percha samples immersed in either chloroform, xylene, or Hemo-De for 60 s at 37°C. Each *bar* represents the mean weight loss of 10 samples (±SEM). Master cones and accessory cones of three brands of gutta-percha were compared.

Solubility in "Hemo-De"

Hemo-De dissolved gutta-percha in a range close to that of xylene but slightly less. The average weight loss of all samples in Hemo-De was 7.23 (±0.32)%, compared with 8.57 (±0.27)% in xylene ($p = 0.0017$). This preparation dissolved DMS gutta-percha better than Hygienic, which was better than DeTrey. DMS gutta-percha lost 10.65 (±0.42)% and 8.96 (±0.23)% of its weight for master and accessory cones, respectively (Fig. 2). Hygienic lost 7.83 (±0.15)% and 7.16 (±0.18)%, with DeTrey following with a weight loss of 4.72 (±0.30)% and 4.05 (±0.18)%, respectively.

The average weight loss of all master cones in Hemo-De was 7.73 (±0.48)%, whereas that of all accessory cones was 6.72 (±0.39)%.

Solubility by Gutta-Percha Brands

The relative solubility of the three brands tested, as an average of master and accessory cone gutta-percha, is presented in Fig. 3.

DISCUSSION

Chloroform was found, as in most other studies, to be the most efficient gutta-percha solvent (5–7, 9, 10). Nevertheless even with this potent solvent significant differences were demonstrated between the solubility of various gutta-percha preparations. The difference between master and accessory cone gutta-percha of each of the brands tested may suggest that master cone gutta-percha differs in its composition from the material used for manufacturing accessory cones. Variability in solubility of master cones in chloroform may have clinical implications. High solubility of DMS master cones makes them easier to use in chloroform-dipped customized master cone preparation (17, 18). For this technique fast softening of the outer surface of the tip of the cone, combined with fast evaporation of the solvent, is essential. Master cones with lower solubility in this volatile solvent may be more difficult to use.

Removal of a gutta-percha root canal filling, on the other hand, may call for a milder solvent with a slower evaporation rate, such as xylene. Chloroform tends to be messy and inconvenient in such procedures as it dissolves rather than softens the gutta-percha,

TABLE 1. Statistical analysis (p values, *t* test)

	Chloroform Vs. Xylene	Chloroform Vs. Hemo-De	Xylene Vs. Hemo-De	Master Vs. Accessory
DMS	<0.0001	<0.0001	=0.182	= 0.231
Hygenic	<0.0001	<0.0001	<0.0001	= 0.0005
DeTrey	<0.0001	<0.0001	<0.0001	p = 0.310

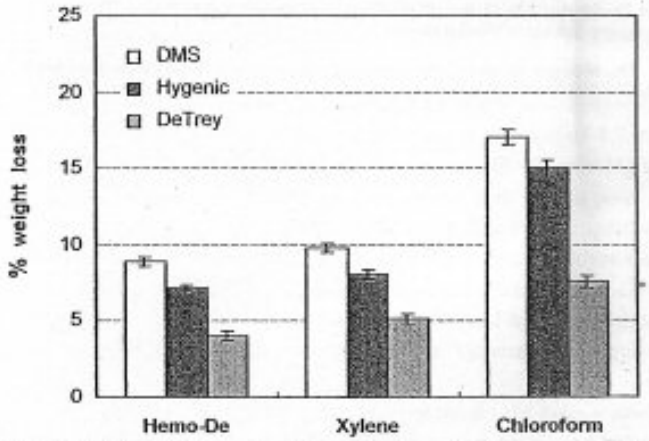

FIG 3. Solubility of different gutta-percha brands. Gutta-percha solubility measured as weight loss of standardized gutta-percha samples immersed in each solvent for 60 s at 37°C. Each *bar* represents the mean weight loss of 20 samples of both master cone and accessory cone gutta-percha (combined) (±SEM).

leaving residues on the walls of the pulp chamber. Its fast evaporation makes it essential to add more and more solvent as soon as it evaporates. Xylene on the other hand dissolves the gutta-percha more slowly, thus allowing a better control and removal of softened rather than liquefied gutta-percha (2). Furthermore, Sjogren et al. (19) have recently demonstrated that chloroform-dissolved gutta-percha evokes an inflammatory tissue reaction. It is therefore desirable to avoid as far as possible the passage of *dissolved* gutta-percha into the periapical tissues. Softening and mechanical removal of the gutta-percha, rather than dissolving it, may prove to be not only efficient but also a biologically safer procedure.

A slow softening of the root canal filling, before any attempt to remove it, is an extremely useful procedure. This may be accomplished by sealing a cotton pellet moist with a solvent in the pulp chamber and removing the root canal filling at the following appointment. Because aged root canal fillings tend to become harder and more difficult to remove, such a procedure is of potential importance. The potentially toxic nature of xylene may be a concern that may limit the use of this efficient agent. Therefore an alternative safe substitute, similar to xylene in its efficiency as a solvent and less volatile may enhance the use of this method.

Hemo-De was almost as effective as xylene in dissolving gutta-percha. Our results are in agreement with those of Uemura et al. (20), who have also recently demonstrated that *d*-limonene is a good gutta-percha solvent. Similarly in their study the passage of a #15 file through the laterally condensed root canal filling took twice as long with *d*-limonene as with chloroform.

Hemo-De is a less volatile and safe solvent that may be a proper safe material for the two-step gutta-percha removal technique mentioned previously. Its active ingredient *d*-limonene is a naturally occurring compound derived from citrus fruits. It is used as a food flavoring material and has been defined by the Food and Drug Administration as a "Generally Recognized As Safe" material. The lower volatility of Hemo-De may also be of benefit in a direct softening of gutta-percha, because the material will not evaporate as fast as xylene and much slower than chloroform, thus allowing the operator more working time.

The excellent technical assistance of Mrs. Miri Dotan is gratefully acknowledged.

This study was conducted as part of the requirements for the DMD degree for Dr. Marian-Kfir at the Alpha Omega Research Laboratories, The Goldschleger School of Dental Medicine.

Dr. Metzger is associate professor, Departments of Oral Biology and Restorative Dentistry and is director of the Alpha Omega Research Laboratories, The Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel. Dr. Tamse is associate professor and coordinator, Department of Endodontology, The Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel. Dr. Marian-Kfir is currently in private practice in Tel Aviv, Israel. Address requests for reprints to Dr. Zvi Metzger, School of Dental Medicine, Tel Aviv University, Ramat Aviv, Tel Aviv, 96978, Israel.

References

1. Wilcox LR. Endodontic retreatment with halothane versus chloroform solvent. J Endodon 1995;21:305–7.
2. Metzger Z, Ben-Amar A. Removal of overextended gutta-percha root canal fillings in endodontic failure cases. J Endodon 1995;21:287–8.
3. Squire RA. Ranking animal carcinogens: a proposed regulatory approach. Science 1981;214:877–80.
4. Torkelson TR, Oyen F, Rowe VK. The toxicity of chloroform as determined by single and repeated exposure of laboratory animals. Am Indus Hyg Assoc J 1976;37:697–705.
5. Wennberg A, Orstavik D. Evaluation of alternatives to chloroform in endodontic practice. Endod Dent Traumatol 1989;5:234–7.
6. Wourms DJ, Campbell AD, Hicks ML, Pelleu-GB J. Alternative solvents to chloroform for gutta-percha removal. J Endodon 1990;16:224–6.
7. Hunter KR, Doblecki W, Pelleu-GB J. Halothane and eucalyptol as alternatives to chloroform for softening gutta-percha. J Endodon 1991;17: 310–1.
8. Kaplowitz GJ. Evaluation of the ability of essential oils to dissolve gutta-percha. J Endodon 1991;17:448–9.
9. Tamse A, Unger U, Metzger Z, Rosenberg M. Gutta-percha solvents—a comparative study. J Endodon 1986;12:337–9.
10. Barbosa SV, Burkard DH, Spangberg LS. Cytotoxic effects of gutta-percha solvents. J Endodon 1994;20:6–8.
11. Lunam CA, Hall PM, Cousins MJ. The pathology of halothane hepatotoxicity in a guinea-pig model: a comparison with human halothane hepatitis. Br J Exp Pathol 1989;70:533–41.
12. Rudzki E, Berova N, Czernielewski A. Contact allergy to oil of turpentine: a 10 year retrospective view. Contact Dermatitis 1991;24:317–8.
13. Egleton JH, Fraser GP, Gerber B, Logan AL, Rinehardt CJ, Reynolds SM, Neimeister R. Evaluation of xylene substitutes in Erlich indole test. J Clin Microbiol 1986;24:259–69.
14. Hinds IL. A comparison of three xylene substitutes. Lab Med 1986; 17:752–5.
15. Burdock GA, Wanger BM, Smith RL, Munro IC, Newberne PM. GRAS substances. In: Food technology. 1990 ed. Chicago: Institute of Food Technologists, 1990:78–82.
16. National Institutes of Health. NIH Technical Report No. 88-2802. Toxicology and carcinogenesis studies of d-limonene in F344 rats and B6C3PF1 mice. Bethesda, MD: National Institutes of Health, 1998.
17. Metzger Z, Nissan R, Tagger M, Tamse A. Apical seal by customized versus standardized master cones: a comparative study in flat and round canals. J Endodon 1988;14:381–4.
18. Metzger Z, Assif O, Tamse A. Residual chloroform and plasticity in customized gutta-percha master cones. J Endodon 1988;14:546–9.
19. Sjogren U, Sundqvist G, Nair PN. Tissue reaction to gutta-percha particles of various sizes when implanted subcutaneously in guinea pigs. Eur J Oral Sci 1995;103:313–21.
20. Uemura M, Hata G, Toda T, Weine FS. Effectiveness of eucalyptol and *d*-limonene as gutta-percha solvents. J Endodon 1997;23:739–41.