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The Effect of Dentures and Denture Adhesives on Mouth Alcohol Retention

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ABSTRACT: A total of 24 alcohol-free, denture-wearing subjects were tested for mouth-alcohol retention times with an Intoxilyzer® 5000. The subjects were given 30 mL doses of 80 proof brandy to swish in their mouths without swallowing for 2 min prior to expectorating the dose. Subjects were tested under three conditions: 1) with dentures removed, 2) with dentures held loosely in place without an adhesive, and 3) with dentures plus an adhesive. Beyond 20 min following expectoration, mouth alcohol made no significant contribution to the apparent breath alcohol concentration (BrAC), with trace (≤0.01 g/210 L) readings found in only two of the subjects. Denture use, both with and without the concurrent use of adhesives does not significantly affect BrAC as long as a pretest alcohol deprivation period of 20 min is observed.

KEYWORDS: toxicology, breath-alcohol testing, mouth alcohol, dentures

Breath alcohol[7] testing is a mainstay in the enforcement of operating a motor vehicle while intoxicated (OMVWI) laws throughout the United States and many other countries. The validity of breath alcohol testing is dependent on the assumption that the analyzed sample approximates alveolar air. Contributions to breath alcohol concentration (BrAC) arising from alcohol in the mouth can falsely elevate the reading [*1*]. In order to mitigate this possibility, breath testing protocols typically include a period of close observation of the subject prior to the actual test to ensure that no additional alcohol is consumed or regurgitated. It is well established that a pretest observation period of 15–20 min provides sufficient time for the dissipation of residual mouth alcohol [*2–4*]. The rate of mouth alcohol dissipation has been found to approximate an exponential decline [*5–6*].

Allegations of a prolonged retention of mouth alcohol causing potentially large errors in BrAC results have been made in the literature and abound in OMVWI trials. Among

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[7]The unmodified term "alcohol" refers to ethanol in this article, unless otherwise specified.

these allegations are claims that alcohol trapped by dentures and/or denture adhesives can cause alcohol to persist in the mouth beyond 20 min and cause significantly large errors [*7,8*]. There is little research to support or refute these claims in the scientific literature, although others have reported that denture-wearing subjects exhibited no significant mouth alcohol retention beyond 20 min [*9–11*]. The few subjects tested in these studies had only brief oral contact with alcohol and no recorded use of denture adhesives at the time of testing.

In order to investigate the effects of dentures and denture adhesives on mouth alcohol retention, we studied a group of denture-wearing subjects undergoing prolonged oral exposure to alcohol both with and without the concurrent use of adhesives. Of primary concern was determining whether mouth alcohol persisted beyond 20 min after the alcohol dose was expectorated.

Dentures and Dentures Adhesives

Dentures are composed of polymethylmethacrylate in various proprietary formulations. Denture adhesives are widely advertised and readily available as an aid to the stabilization and retention of dentures. The adhesives employ compounds that "swell, gel, and, show increasing and varying degrees of viscosity in water" [*12*]. Substances commonly employed in denture adhesives include karaya gum, sodium carboxymethyl cellulose, and polyethylene oxide [*13*]. These compounds, in gel form, spread under pressure from the jaw to exclude air and saliva from the fitting surface [*14*]. Adhesives are manufactured in the form of powders, creams, liquids, and adhesive pads.

Materials and Method

Intoxilyzer 5000

Two Intoxilyzer™ 5000 instruments (CMI/Federal Signal[8]) were used in this study. The Intoxilyzer 5000 is an automated infrared breath alcohol analyzer using two analytical and one reference wavelengths (3.39, 3.48, and 3.80 μm respectively). The programmed analytical test sequence for the instruments used in this study consisted of two successive breath samples, each preceded and followed by a system purge with room air. BrAC results were recorded from the LED display on the instruments.

Breath Sampling

The Intoxilyzer 5000 monitors breath pressure, duration of exhalation and rate of BrAC change to determine the approach of an alveolar alcohol plateau. It is necessary to exhale at a minimum 6 in. water pressure to activate the pressure switch and then to maintain 4 in. water pressure for a minimum period of 4 s in order to provide an adequate breath sample. An audible tone indicates sufficient breath pressure during the exhalation. Additionally, the instrument uses slope detection software to monitor the rate of BrAC change during an exhalation by comparing readings taken every 0.6 s. The breath sample is not acceptable to the instrument until consecutive readings during the exhalation indicate the approach of the alveolar alcohol plateau.

The instrument's slope detector software also functions as a residual mouth alcohol detector. An initial sharp rise in BrAC followed by a steady decline during an exhalation typifies residual mouth alcohol. When this pattern occurs, the instrument is designed to trigger a "flag," which causes "INVALID SAMPLE" to be displayed in lieu of a numeric

[8]Currently manufactured by CMI/MPD, Owensborough, KY.

reported value.[9] Our experience with the Intoxilyzer 5000 indicates that the residual mouth alcohol flag does not function at apparent BrACs ≤ 0.02 g/210 L, making it suitable for use in the present study.

Instrument Calibration

Instrument calibration was monitored throughout the study by the analysis of ethanol vapor generated in a Toxitest II (CMI/Federal Signal[10]) breath alcohol simulator from a known alcohol/water solution heated to 34 ± 0.2°C. Solutions were prepared in-house to provide the equivalent of a 0.10 g/210 L BrAC. Actual solution alcohol concentrations were verified by gas chromatography. A minimum of three calibration checks were performed at the beginning and end of each day's testing session.

Dentures and Denture Adhesives

Subjects wore their own dentures during the course of this experiment. Denture adhesives were purchased from a large drugstore chain or obtained as professional samples provided by one of the authors. Table 1 lists the 15 adhesives employed in this study.

Method

Denture-wearing subjects were recruited through referrals from two of the authors (JT,DS), through an article in the State Laboratory of Hygiene employee newsletter and by word of mouth. The subjects were required to normally wear at least a full upper denture; that is, one that covers the roof of the mouth. Any combination of lower dentures or retainers and a full upper denture was also acceptable. Subjects were asked to refrain from alcohol consumption during the 12 h period prior to their testing session. Each

[9]Versions of the Intoxilyzer 5000 in use elsewhere may employ different breath-testing parameters (breath-pressure requirements, for example) and flag notations than those indicated in this paper.
[10]Currently manufactured by CMI/MPD, Owensborough, KY.

TABLE 1—*Denture adhesive assignment.*

Adhesive Used	Manufacturer	Subject Number
Powders		
Corega	Block Drug Co.	9, 21
Dentu-Grip	Block Drug Co.	15,16
Fasteeth	Richardson-Vicks Inc.	10, 25
Klutch	I. Putnam, Inc.	2, 20
Rigident	Carter-Wallace, Inc.	6
Super Poli-Grip	Dentco, Inc.	12, 17
Super Wernet's	Block Drug Co.	4, 24
Creams		
Brace	Norcliff Thayer, Inc.	11
Effergrip	Warner-Lambert Co.	3
Fixodent	Richardson-Vicks, Inc.	8
Orafix Special	Norcliff Thayer, Inc.	13
Poli-Grip	Dentco, Inc.	5
Super Poli-Grip	Dentco, Inc.	14, 19
Liquid		
Dentrol	Block Drug Co.	7
Pad		
Sea Bond	Combe, Inc.	1, 18, 22

subject was paid $30 for participating in the study. Test sessions were conducted at the offices of two of the authors (JT,DS) and at the laboratory of the Wisconsin Division of State Patrol, Chemical Test Section. Subject testing was conducted over an 8 month period. Approximately 1 h was required to complete testing on each subject.

At the start of the testing session each subject was asked to answer questions regarding their denture and adhesive use. The subject was then familiarized with the test protocol and given instruction on providing breath samples to the Intoxilyzer. A BrAC test was then conducted to verify the subject's alcohol-free status.

Dosing

Thirty mL of 80 proof (nominal 40% v/v) brandy was measured into a graduated cylinder and poured into a clean paper cup. The subjects were asked to place the dose into their mouths and hold it there for 2 min without swallowing prior to expectorating. During this period they were asked to thoroughly swish the brandy around the oral cavity. A digital timer was used to monitor elapsed time from expectoration of the alcohol dose. The first "BrAC" was measured approximately 4 min after expectoration, with subsequent measurements at approximate 4 min intervals. After the third BrAC test (approximately 12 min after expectoration), the testing frequency for subjects still indicating a positive BrAC was increased to as little as 2 min between measurements.

The above dosing protocol was used with each subject for each of the following denture/adhesive conditions: 1) No Dentures or Adhesives—subjects were asked to remove their dentures prior to dosing; 2) Dentures, no Adhesives—subjects were asked to place their dentures loosely in their mouths without adhesive and to keep them loose while swishing the alcohol dose; and 3) Dentures plus Adhesives—subjects removed their dentures and applied an adhesive according to the manufacturer's instructions. They then placed the dentures in their mouths and pressed them firmly into place. At least one minute was allowed for the adhesive to "set" in the mouth prior to dosing.

The denture adhesive assigned to each subject is listed in Table 1.

Results

Both of the Intoxilyzer 5000s used in this study performed well with no instrument malfunctions. Calibration checks of the instruments were all well within 0.10 ± 0.01 g/210 L. All subjects were alcohol-free at the start of testing. The test protocol ensured that only residual mouth alcohol contributed to the BrAC readings obtained. Data were excluded from subjects who were observed to swallow or admitted to swallowing any of the alcohol dose. Intoxilyzer results ≥ 0.01 g/210 L that were not flagged as residual mouth alcohol were truncated to two decimal places. Results below 0.01 g/210 L were not truncated. Duplicate BrACs were averaged prior to truncating. Elapsed times from alcohol expectoration were rounded to the nearest minute.

A total of 25 subjects (7 women, 18 men) were tested. Data was excluded from one female subject (#23) who had particularly poor fitting dentures and was unable to avoid swallowing during the dosing period. The mean subject age was 55 years (range 36 to 79). All subjects wore at least a full upper denture except for Subject 1, who only had a partial upper denture. In addition to an upper denture, 18 of the subjects also used some sort of lower denture or retainer.

Collective Data

The mean elapsed times after alcohol expectoration for the BrAC to decrease to zero (mouth alcohol retention times) and standard deviations are as follows:

Condition	*Time to Zero*	*SD*
No Dentures or Adhesives	13 min.	2.4
Dentures, no Adhesives	14 min.	2.6
Dentures plus Adhesives	15 min.	4.1

Mean mouth alcohol retention times were compared using the Student's *t*-test. Compared to the no-dentures/adhesives condition the difference between mean retention times was significant ($P = 0.05$) for both the dentures and dentures-plus-adhesives conditions.

Data from the dentures plus adhesives condition were also grouped according to the type of adhesive used. The mean mouth alcohol retention times and standard deviations for these groups were:

Adhesive Type	*Time to Zero*	*SD*
Cream ($n = 7$)	13 min.	1.5
Powder ($n = 13$)	15 min.	3.6
Other ($n = 4$)	18 min.	7.0

Student's *t*-test analysis of this data showed no significant difference in mean mouth alcohol retention times among any of the types of adhesives ($P = 0.05$).

Individual Data

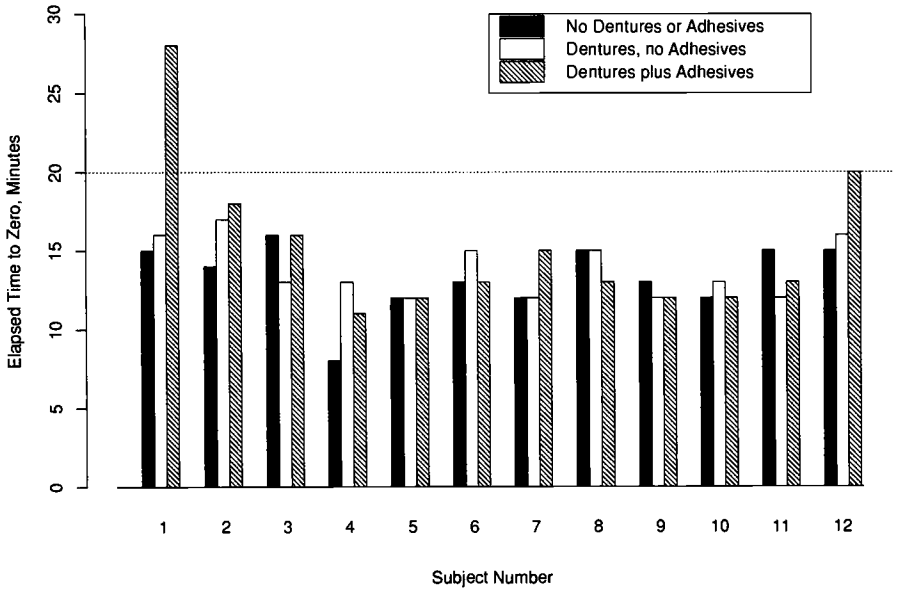
The elapsed times for BrAC readings to decrease to zero were graphed for each subject and testing condition (Fig. 1). Of the 24 subjects included in the study, two (#1, #17) showed trace BrACs (≤0.01 g/210L) beyond 20 min, both in conjunction with adhesive use. Unflagged BrACs for these two subjects were plotted versus elapsed time after alcohol expectoration (Figs. 2 and 3).

Subject 1 Retest

When using an adhesive, Subject 1 exhibited the longest mouth alcohol retention time of any subject. During the initial test session, Sea Bond adhesive pads were used on both the upper and lower dentures. The upper and lower dentures used by this subject have very small surface areas, especially the lower one. Further inspection revealed that the upper denture, with only three teeth, did not completely cover the roof of the mouth, in spite of being described by the subject as being "full." The lower denture (one tooth) had an even smaller surface area.

The subject complained that the adhesive pad "raised" the lower denture from its normal position during testing. It seemed that this could have caused an inordinate amount of contact between the circulating alcohol and the absorbent cellulose matrix of the adhesive pad, resulting in alcohol absorption into the pad. This subject was retested at a later date with a Sea Bond pad applied only to the upper partial denture. During both test sessions the adhesive pads were trimmed to fit the denture as per the manufacturer's instructions.

Figure 4 shows BrAC plotted vs. elapsed time for both the original and retest of the dentures-plus-adhesives condition for this subject. Mouth alcohol retention time data from this second test session were not included with the original data in any of the previously mentioned data summaries.



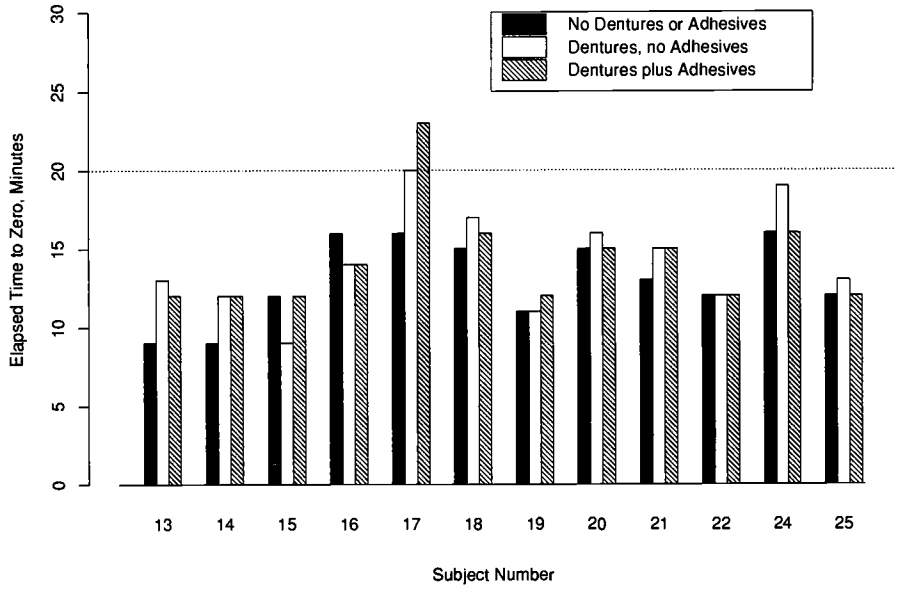


FIG. 1—*Mouth alcohol retention times, subjects 1–12* (top). *Mouth alcohol retention times, subjects 13–25* (bottom).

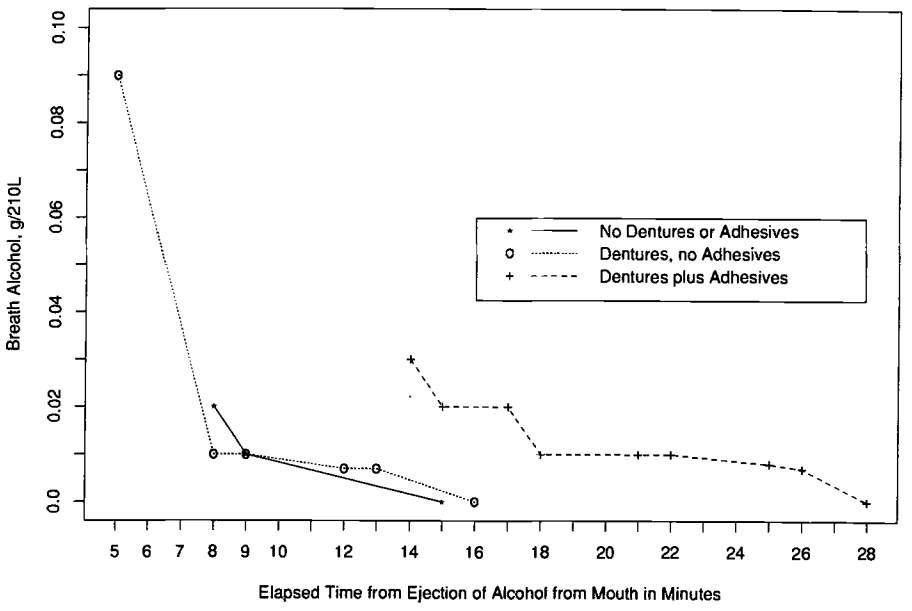


FIG. 2—*Mouth alcohol decay curves, subject 1.*

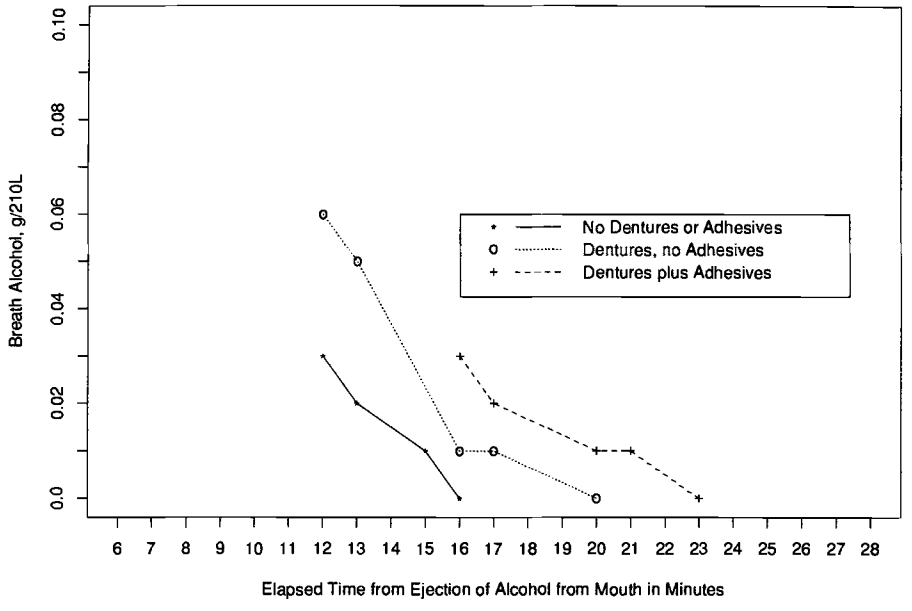


FIG. 3—*Mouth alcohol decay curves, subject 17.*

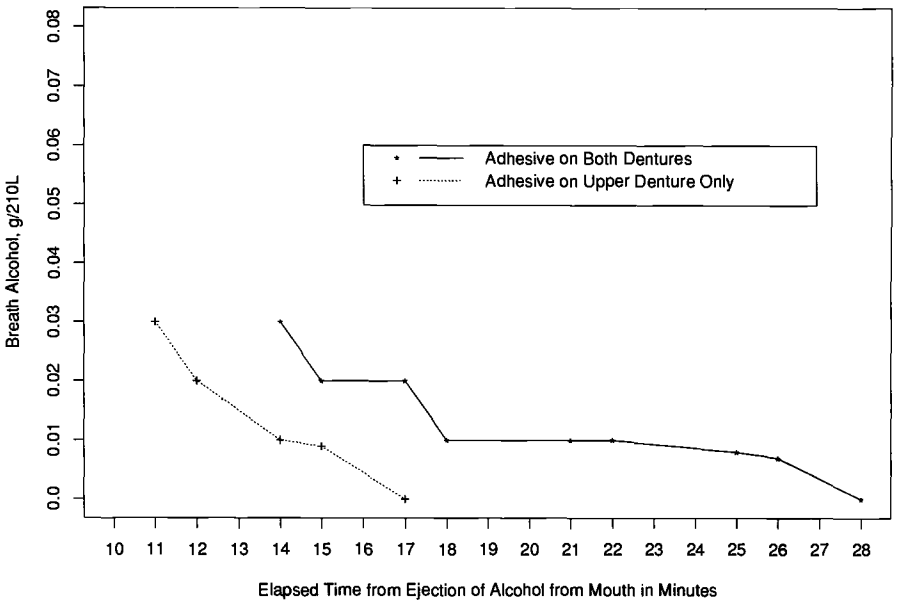


FIG. 4—*Original and retest mouth alcohol decay curves (denture plus adhesive condition) for subject 1, using Sea Bond (pad) adhesive.*

Discussion

Our experience with the Intoxilyzer 5000 has shown that its residual mouth alcohol flagging program (that is, the slope detector) is not entirely reliable under the extreme experimental conditions employed in the present study. In this experiment we were able to obtain apparent BrACs as high as 0.18 g/210 L in spite of this feature. The slope detector was never intended to be a substitute for residual mouth alcohol detection and prevention protocols such as a pretest alcohol deprivation period and requiring agreement within 0.02 g/210L for successive BrACs taken 2 to 10 min apart [*15*]. Since this study focused only on the time it took for a subject to become alcohol-free after the oral cavity was exposed to alcohol, the Intoxilyzer was suitable for our purposes.

The experimental conditions in this study were deliberately chosen to be a "worst possible case" compared to what one would reasonably expect to occur in actual drinking situations related to an OMVWI offense. The protocol was designed for alcohol to have maximum contact with the oral mucosa, to facilitate alcohol retention between dentures and the roof of the mouth and to promote alcohol absorption by denture adhesives. As such, we believe that the protocol represents a true "worst case" scenario.

Under these stringent experimental conditions, positive apparent BrACs occurring more than 15 min after alcohol expectoration were observed in 9 of the 24 subjects. Two subjects showed trace BrACs beyond 20 min. The initial increased mouth alcohol retention time exhibited by Subject 1 when using Sea Bond adhesive pads on partial upper and lower dentures could not be reproduced when the adhesive was only used on the partial upper denture. Eliminating the adhesive from the lower partial denture (one tooth) clearly eliminated the threat of increased mouth alcohol retention time. This subject had never before used an adhesive and indeed, the surface area of both of these dentures did not lend itself to adhesive use.

Conclusion

The use of dentures, either with or without the concurrent use of denture adhesives, does not significantly affect mouth alcohol retention time and contribute to BrAC readings beyond twenty minutes. Dentures need not be treated as foreign objects in the mouth and removed prior to conducting a BrAC test, which includes a 20 min pretest alcohol deprivation period as part of the test protocol. Given the favorable findings under the atypical conditions employed in this experiment we believe that even a 15 min pretest alcohol deprivation period could provide adequate insurance against mouth alcohol contamination of BrAC readings obtained from denture-wearing subjects.

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