IN BRIEF

- Of 133 decontaminated Siqveland matrices recovered from general dental practices, residual blood was detected on 21% of the matrix bands and 19% of the retainers.
- Ultrasonic baths were significantly more effective than hand scrubbing for removal of blood.
- Adequate pre-sterilisation cleaning cannot be achieved reliably, if Siqveland matrices are re-processed in the assembled state.

A study of blood contamination of Siqveland matrix bands

A. H. Lowe,[1] J. Bagg,[2] F. J. T. Burke,[3] D. MacKenzie[4] and S. McHugh[5]

Aims To use a sensitive forensic test to measure blood contamination of used Siqveland matrix bands following routine cleaning and sterilisation procedures in general dental practice.

Materials and methods Sixteen general dental practices in the West of Scotland participated. Details of instrument cleaning procedures were recorded for each practice. A total of 133 Siqveland matrix bands were recovered following cleaning and sterilisation and were examined for residual blood contamination by the Kastle-Meyer test, a well-recognised forensic technique.

Results Ultrasonic baths were used for the cleaning of 62 (47%) bands and retainers and the remainder (53%) were hand scrubbed prior to autoclaving. Overall, 21% of the matrix bands and 19% of the retainers gave a positive Kastle-Meyer test, indicative of residual blood contamination, following cleaning and sterilisation. In relation to cleaning method, 34% of hand-scrubbed bands and 32% of hand-scrubbed retainers were positive for residual blood by the Kastle-Meyer test compared with 6% and 3% respectively of ultrasonically cleaned bands and retainers ($P < 0.001$).

Conclusions If Siqveland matrix bands are re-processed in the assembled state, then adequate pre-sterilisation cleaning cannot be achieved reliably. Ultrasonic baths are significantly more effective than hand cleaning for these items of equipment.

Medical or dental treatment carries the potential for transmission of infectious diseases between individuals. Blood borne viruses represent a particular hazard and the hepatitis B virus (HBV) is especially infectious. Serum of infected patients is estimated to contain 10^8–10^{10} virions per ml,[1,2] while the infective dose of HBV is thought to be only 10^2–10^3 virions.[3] Since there are an estimated 40,000 hepatitis B carriers in the United Kingdom at any one time,[3] the risks are self-evident. Within the dental environment, universal infection control precautions have been introduced to reduce the risks to both patients and staff.

[1]General Dental Practitioner, Glasgow; [2]*Associate Dean for Dental Research, Infection Research Group, Glasgow Dental Hospital and School; [3]Professor of Primary Dental Care, The University of Birmingham School of Dentistry; [4]Chief MLSO, Infection Research Group, Glasgow Dental Hospital and School; [5]Research Statistician, Dental School and Department of Statistics, University of Glasgow
*Correspondence to: Prof J. Bagg, Level 9, Glasgow Dental Hospital and School, 378 Sauchiehall Street, Glasgow G2 3JZ
Email: j.bagg@dental.gla.ac.uk

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Both blood and saliva contaminate dental instruments during routine use. Around 44 million claims are made annually for provision of NHS treatment in the UK[4] and it is not financially viable to consider all instruments as disposable. Thus the practice of reuse or re-circulation has become accepted. According to the Medical Devices Agency,[5] reuse is defined as 'repeated episodes of use of a device in circumstances which make some form of reprocessing necessary'. The wide variety of instruments used in dentistry presents a spectrum of risk with respect to infection. However, all re-usable instruments contaminated with oral and other body fluids must be sterilised after use. The instrument re-circulation process comprises the three stages of cleaning, sterilisation and storage. Cleaning of contaminated instruments may be performed by hand, ultrasonic bath, enzyme-based cleaning solution or instrument washer, and should be viewed as an essential phase of the overall sterilisation process.

The effectiveness of decontamination procedures may be assessed using a range of microbiological and biochemical techniques. One such test, which is used widely in forensic medicine to detect blood, is the Kastle-Meyer test.[6] This method has been employed in several studies to detect blood on dental surgery surfaces.[7,8,9] The Kastle-Meyer test is highly sensitive and it has been shown that filter papers impregnated with a 1:6400 dilution or less of horse or sheep blood gives a positive reaction within 10 seconds.[9] This test is therefore applicable to the determination of effectiveness of cleaning of surgical and dental instruments after their clinical use. Current guidelines[10] advocate the steam autoclave as the method of choice for sterilisation of all dental instruments following cleaning. However, if pre-cleaning is sub-optimal, the presence of debris or other contamination may prevent exposure to the steam and its latent heat, thus leaving potentially viable microorganisms present on the instrument surface. In addition, heat sterilisation does not reliably inactivate prions and in the light of current concerns over possible transmission of CJD, the critical importance of instrument cleaning during reprocessing is being heavily stressed.[11]

Use of selected items of disposable equipment greatly reduces the effort and exposure risks associated with the reprocessing operation, but the financial implications must be considered. Items such as saliva ejectors, aspirator tips, bibs, burs, scalpel blades, beakers and impression trays are all now available as high quality disposables. However, one item that is rarely considered in relation to possible transmission of blood-borne viruses is the matrix band and retainer.

In Scotland, the Siqveland matrix band is used by most dental practices[12] and dental teaching institutions. It comprises a thin steel

band attached to a mechanical retention device. The diameter of the matrix loop is adjustable by means of a screw mechanism to ensure close adaptation to teeth of varying circumference. Clinical techniques are simple and components are readily available at low cost. However, with regard to decontamination and sterilisation, the design of this instrument presents significant potential for both the band and holder to become contaminated by blood and saliva during use. Capillary action may facilitate fluid spread into the internal aspects of the device, which are poorly accessible to cleaning. However, as a result of the time taken to disassemble and change bands after each use, the custom of cleaning and sterilising the assembled instrument has become common practice.

To date there have been no studies to demonstrate the degree of blood contamination of these bands in use, nor to evaluate the effectiveness of cleaning methods prior to sterilisation. There is no evidence to support or refute the practice of reusing matrix bands and manufacturers' advice with regard to cleaning and sterilisation is limited. The aim of this investigation was to employ a forensic technique to measure the degree of blood contamination of Siqveland matrices following their re-processing in the assembled state within general dental practice.

MATERIALS AND METHODS

Kastle-Meyer test

The reagent for the Kastle-Meyer test[6] was prepared by mixing phenolphthalein (2 g), potassium hydroxide (20 g), powdered zinc (30 g) and distilled water (100 ml) in a conical flask. This mixture was boiled until colourless and then stored over powdered zinc. In this form the solution is stable for several weeks.

All sampling was performed by one investigator (AHL). Sample collection involved folding a 10 cm diameter filter paper (Whatman Catalogue No. 1001 070) into quarters and wiping the pointed end across the sample site. Each filter paper was placed in a plastic bag and returned to the laboratory. A paper-lined plastic tray was used to contain the test materials and all reagents were dispensed with the aid of disposable pipettes. Positive and negative control samples were included in every testing session. The folded filter paper samples were opened out and tested by applying one drop of Kastle-Meyer solution to the central area of the filter paper. At this stage the sample should remain colourless. This was followed by one drop of isopropyl alcohol, and finally, one drop of hydrogen peroxide (10 volumes). A positive result was indicated by the appearance of a vivid pink colour within a maximum of 20 seconds.

Vegetable materials, for example potato and horseradish, may elicit a false positive result. In order to validate the use of the Kastle-Meyer test in the dental environment, a series of experiments were carried out to eliminate false positive reactions to commonly used dental materials. Those tested were zinc oxide-eugenol cement, zinc phosphate cement, zinc polycarboxylate cement, amalgam, glass ionomer lining and restorative materials, compomer materials: composite resin materials; dentine-bonding adhesive systems, copal varnish, calcium hydroxide and gutta percha.

In addition, samples were collected from two smears of bovine blood on glass slides, which had been autoclaved at 134°C, to confirm that the Kastle-Meyer test would not be affected by steam sterilisation.

Pilot Study

A pilot study assessed the degree of contamination of various components of the Siqveland matrix system during normal clinical use. A total of 18 matrix bands were examined, six immediately after clinical use, six following ultrasonic cleaning and six after the sterilisation process. Visible blood contamination on the outer surfaces prior to decontamination was recorded (Figure 1), together with Kastle-Meyer test results after ultrasonic cleaning and after sterilisation. The areas most inaccessible to cleaning procedures were identified as the working end of the band /retainer mechanism and the matrix band itself. It was therefore decided that these areas would be the sampling sites for each matrix band and retainer examined during the main study.

Figure 1. Visible blood contamination on a used Siqveland matrix band and retainer.

Recruitment of study participants and specimen collection

General dental practitioners participated in this arm of the project. Through co-operation with established research networks, such as GRID (Glasgow Research Initiative in Dental Practice) and other interested groups, dentists were invited to assist with collection of samples for subsequent analysis. Nine practices were visited by the investigator to undertake matrix band and retainer examination and sample collection. A further seven practices, at more distant locations, also participated. These seven practices were each provided with 10 new, assembled Siqveland matrices. They were instructed to use them according to their normal procedures. After two weeks each practice was contacted and asked to submit the sterilised bands and retainers by post to Glasgow Dental School for laboratory analysis.

No attempt was made to standardise cleaning and sterilisation methods, each practice being instructed to follow their usual procedures. A record was made of the cleaning method for each band, either hand scrubbing or ultrasonic cleaning, but details of the practice from which each band was collected were not recorded. The matrix bands and retainers were sterilised in the practice autoclave before the samples for the Kastle-Mayer test were collected.

Statistical Methods

Data were entered into a Microsoft Access database and were subsequently analysed using Minitab version 11. Primary analysis of categorical data was carried out using descriptive statistics and cross tabulation. Differences in residual blood contamination between the two cleaning methods were analysed by the Chi-square test of association.

RESULTS

Preliminary Kastle-Meyer test results

None of the dental materials tested in the preliminary laboratory studies gave a positive reaction with the Kastle-Meyer reagents. The test blood smears, which had been subjected to autoclaving, gave positive results in the Kastle-Meyer test.

Cleaning methods

Samples were obtained from 133 assembled Siqveland matrix bands. Ultrasonic cleaning baths were used during the decontamination procedure for 62 bands and retainers (47%), with the remaining 71 (53%) being cleaned by manual scrubbing or soaking only.

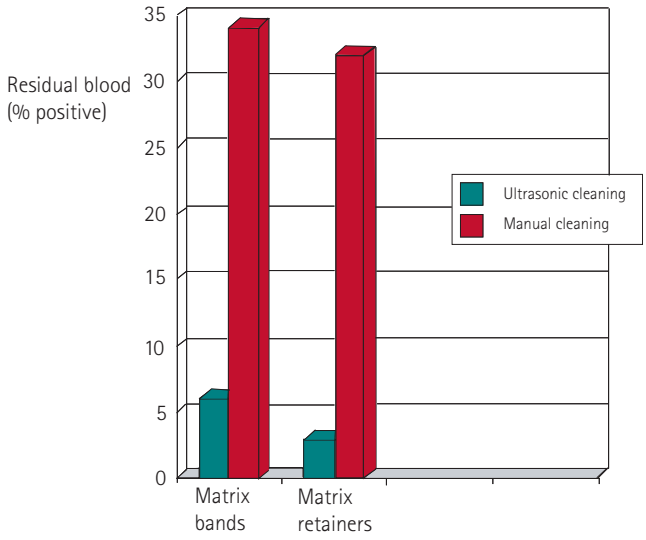

Figure 2. Results of ultrasonic and manual cleaning of bands and retainers (% positive for residual blood)

Blood contamination determined by the Kastle–Meyer test

Analysis of samples collected from 133 matrix bands elicited a positive Kastle-Meyer test result in 28 cases (21%) following cleaning and autoclaving. Similarly, 19% of retainers yielded positive blood detection.

When examined with respect to cleaning method, 24 (34%) hand scrubbed bands gave a positive result after autoclaving compared with 4 (6%) of ultrasonically cleaned bands. Likewise, blood was detected on 23 (32%) manually scrubbed retainers after autoclaving compared with 2 (3%) retainers in the ultrasonically cleaned group (Figure 2). These differences between cleaning methods were statistically highly significant ($p<0.001$) by the Chi-square test of association for both matrix bands and retainers.

DISCUSSION

The results of this investigation have important clinical implications. They indicate that not only do matrix bands and retainers frequently become contaminated with blood during clinical use, but that current cleaning and sterilisation procedures do not reliably remove this blood. In relation to the cleaning process, the results of this study show that ultrasonic cleaning is significantly more effective than hand-scrubbing.

The Siqveland matrix is currently the most popular choice in general dental practice[12] and the findings of this study are therefore applicable to a large number of practising clinicians. When compared with other systems, the intricate design of Siqveland matrices may facilitate the ingress of fluid into the internal surfaces and reduce effectiveness of cleaning procedures. In this study no assessment has been made of the effectiveness of cleaning with regard to other matrix systems. Alternatives such as the Tofflemire matrix have the advantage of simple replacement of used bands. Single-use mechanical matrices are currently available and demonstrate satisfactory clinical performance. However, the increased costs associated with disposable equipment may present a barrier to universal acceptance. Sectional matrices are favoured by a small proportion of practitioners, but require increased time for placement and use of rubber dam to ensure airway protection.

This study required a simple, rapid blood detection technique. The Kastle-Meyer test[6] has additional advantages of a well-defined end-point producing dependable results with a high degree of sensitivity. The principal disadvantage arises due to the presumptive rather than definitive nature of the test, with the potential for false positive results when in contact with certain organic vegetable components.[13] However, the possibility of false positive reactions from a range of dental materials was excluded in a pilot study. Collection of samples from the used bands and retainers followed standard forensic technique. Due to the limited facilities available during practice visits it was considered vital to simplify the method as far as possible. Those areas of the matrix most frequently contaminated by blood were identified during the preliminary pilot phase of the project. The active end of the instrument was considered most appropriate for evaluation, as it is this portion which is likely to be in contact with the tissues of subsequent patients.

Due to the practice-based nature of this project, it was impossible to control all variable factors affecting the outcome of the investigation. For example, the number of occasions and circumstances of matrix band use and re-use, the level of blood contamination prior to re-processing and the length of time spent on cleaning were not recorded. However, it is worth remembering that these results will represent the best possible scenario, since the practitioners had all shown an interest in participating in the research project and all knew that the matrix bands were to be tested for residual blood contamination. The quality of the matrix bands was variable and many of those sampled by the investigator within the surgery demonstrated varying degrees of surface damage. This latter factor may increase the potential for retention of debris following cleaning. Two possible drawbacks with the study design should be considered. It was not possible to look at 'practice effects', or to formally compare those practices which were visited and those which participated by post. This was because of the anonymous processing of the specimens.

A positive Kastle-Meyer result reveals a fundamental failure of pre-sterilisation cleaning. Discipline at all stages of the instrument processing system is vital for infection control to be effective, particularly in the light of prion diseases. If, as the results of this investigation suggest, there is a potential risk of cross infection associated with the re-use of Siqveland matrices, the way in which they are used should now be carefully considered and appropriate guidelines issued. The best practice is to disassemble the device, discard the matrix band, clean and sterilise the retainer and fit a new band for the next patient. Cleaning of the assembled unit in an ultrasonic bath is a generally effective, but not completely reliable, method for pre-sterilisation decontamination. Re-use of assembled units that have been manually cleaned prior to autoclaving cannot be supported as a safe practice. Further investigation of other cleaning methods, such as enzymatic cleaning solutions and clinical dishwashers would be of value. Clearly, the use of disposable matrix systems, such as Omni-matrix, would totally eliminate the risks associated with re-use, although cost may be a barrier to widespread acceptance.

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