Availability of manufacturers' information on efficacy and compatibility of detergents used for cleaning dental instruments

G. Calvert,¹ C. A. Murray,² A. J. Smith³ and D. Hurrell⁴

VERIFIABLE CPD PAPER

IN BRIEF

- Highlights the importance of the appropriate selection of detergents for instrument cleaning in optimizing the efficacy of the cleaning process, staff safety and cost-effectiveness.
- Discusses the challenges in obtaining detailed information to support procurement decisions for detergents.
- Emphasizes that benchmarking for detergent efficacy would be beneficial to general dental practitioners.

Aim To review physico-chemical data supplied for commercially available detergents marketed for manual and/or ultrasonic cleansing of reusable dental instruments. **Method** Manufacturers/suppliers of commercially available detergents for manual or ultrasonic cleaning of dental instruments within primary dental care were invited to supply product information. A structured questionnaire requested details on a range of physical and chemical properties for each detergent. **Results** Seventeen detergent manufacturers/suppliers, encompassing 31 commercially available detergents were identified. Ten of the 17 manufacturers provided information on 23 (74%) of the detergent formulations. Nine detergents were of neutral pH, ten mild alkalis (pH 7.5–10.5) and four strong alkalis (pH >10.5). Sixteen detergents were recommended for ultrasonic and manual cleaning, four stated ultrasonic use and three manual only. Ten detergents cited enzymatic activity as their main mode of action, but only six manufacturers provided detailed information. Four detergents recommended by manufacturers as suitable for manual washing had a strong alkaline pH (>10.5), presenting chemical hazards to users. Two strong alkaline detergents did not warn users of potential adverse effects of such alkaline solutions (corrosion) upon aluminium containing instruments. Only one detergent had investigated the potential toxicity of detergent residuals remaining on instruments after reprocessing. **Conclusion** It has proven challenging to collate physico-chemical data on detergents suitable for use in manual and/or ultrasonic cleaning of dental instruments in general dental practice. Standardisation of information on the nature and efficacy of dental detergents in a readily accessible form would be beneficial to dental practice.

INTRODUCTION

The ability to clean reusable surgical devices effectively, such as dental instruments, has assumed a greater importance in reducing the risk of iatrogenic Creutzfeldt-Jakob disease (CJD) transmission and other infectious agents.^{1–4} Reprocessing of dental instruments to reduce the risk of iatrogenic CJD is challenged by the high avidity of infectious prions for stainless steel surfaces^{5,6} and their relative resistance to thermal denaturing during steam sterilisation processes.^{7–9} Therefore, cleaning

which physically removes potential pathogens before sterilisation, has become of prime importance.^{10,11}

Previous studies have demonstrated short-comings in the decontamination of dental instruments in general dental practice.¹² One of the critical control steps in reprocessing dental surgical instruments is the cleaning stage. Cleaning, the physical removal of debris, has two major effects: reducing the number of micro-organisms present and removing organic matter such as blood, tissue and other debris that may interfere with sterilisation and disinfection.¹³ Previously, large-scale studies of decontamination in general dental practice highlighted many areas of concern.^{14,15} The solutions used to clean dental instruments ranged from tap water only (41%), surgical handscrub (36%), domestic washing up liquid (13%) and kitchen cleaning agents (7%).

Detergents and their physico-chemical properties are a vital component of the cleaning process.^{2,10,16,17} In addition to

detergents, cleaning requires close attention to several key determinants within the cleaning process to improve the likelihood of success. Key determinants include temperature, time, water quality and mechanical energy (usually in the form of water jets, ultrasonics or manual cleaning).¹⁸ Detergents should be effective in either solubilising the contaminant or removing the contaminant from the surface in a solid state and then maintaining the displaced material in suspension. The chemical composition of detergents to achieve this is complex, requiring a detailed knowledge of the contaminants and surfaces on which they interact. Detergents are complex chemical formulations consisting of many chemical groups each with a specific function during the cleaning process. Surfactants lower the surface tension of a solution, solubilise fat and disperse pigment.¹⁹ Lowering the surface tension may promote foaming which inhibits the action of ultrasonic cleaners and causes cavitation in the

¹–³Infection and Immunity Research Group, University of Glasgow Dental School and Hospital, 378 Sauchiehall Street, College of Medicine, Veterinary and Life Sciences, Glasgow, UK; ²Healthcare Science Ltd, Unit 4 Northend Industrial Estate, Burymead Road, Hitchin, Herts SG5 1RT Health Protection Scotland, 1 Cadogan Square, Cadogan Street, Glasgow, G2 7HF.

*Correspondence to: Gareth Calvert
Email: gareth.calvert@nhs.net; Tel: 0191 282 4664

Online article number E16

Refereed Paper – accepted 12 April 2012

DOI: 10.1038/sj.bdj.2012.419

©British Dental Journal 2012; 212: E16

pumping system of automated washer disinfectors. Non-ionic surfactants produce less foaming than ionic surfactants and have an anti-foam property at higher temperatures.⁵ Builders remove divalent cations such as Ca^{2+} and Mg^{2+} that make water hard,²⁰ otherwise calcium ions may promote bridging of proteinaceous soils to stainless steel instruments.^{21,22} Alkaline chemicals are used to hydrolyse and solubilise proteinaceous materials.⁵ Sequestering agents, such as EDTA, remove various metal salts to destabilise biofilms.^{23,24} Enzymatic reagents are intended to convert water insoluble soil into a removable soluble form²⁵ and have been suggested to be more efficient at removing prion proteins, including CJD.^{26–28} Alcohols in cleaning agents allow them to dissolve fats, act as a stabiliser for the solution, serve as a preservative to increase the shelf life and ensure the cleaning solution maintains its effectiveness at lower temperatures.²⁹ However, alcohols may have an adverse fixative effect upon proteins by disrupting hydrogen bonding between amide groups resulting in residues becoming difficult to remove.³⁰

Furthermore, detergents should not contain any particles or colouring and should not leave any residues on the cleaned surface.²⁹ These must be non-hazardous, non-toxic and non-flammable.²⁵ Finally, the detergent should be available at a reasonable cost.

There is a need therefore to both increase the general knowledge of the complexity of the cleaning process and the importance of the chemical composition of detergents. It is vital that dental practitioners are guided through these technical complexities and supported by relevant and accessible data for use in general dental practice if improvements in instrument cleaning efficacy are to be maintained.

AIM

The aim of this study was to investigate the availability and suitability of detergents for cleaning of reusable dental instruments by manual or ultrasonic processing based on manufacturer's documentation.

METHOD

A list of detergents was compiled from a review of distributors and manufacturers in catalogues targeted at primary care

dental practitioners and previously recommended detergents in cleaning guidance documents.^{31,32} Manufacturers were selected if they produced a detergent solution for manual or ultrasonic cleaning of reusable medical devices, including dental instruments. A questionnaire was compiled to ascertain information from companies whose products met the above criteria. Following initial contact by telephone to acquire an appropriate correspondence address, each company was sent, via email, a questionnaire together with a covering letter outlining the purpose of the survey. Two repeat requests were sent to companies who did not respond to the initial questionnaire correspondence.

A structured questionnaire designed to capture data relating to key physico-chemical attributes of detergents and requirements found in the *Scottish health technical memorandum 2030 part one*²⁹ and the International Organization for Standardization's *Washer-disinfectors – part 1: general requirements, terms and definitions and tests*³³ was compiled and sent to 17 detergent manufacturers responsible for 31 detergents (Table 1). In addition, an internet search was used to locate the material safety data sheet (MSDS) to complete questionnaires not returned by the manufacturer.

RESULTS

Response rates from manufacturers are given in Table 1. In summary, data was obtained on 23 of the 31 (74%) products. Subsequent internet searching identified MSDS information for a further three products, recording a final total of 84%. Results of which are detailed in Table 2.

Returned information covered three different detergent types, nine neutral (pH 6.5–7.5), ten mild alkaline (pH 7.5–10.5) and four strong alkaline (pH >10.5) solutions. No detergent had a pH lower than 6.5. Sixteen solutions were claimed to be suitable for both manual and ultrasonic cleaning. Four detergents were recommended for use in ultrasonic baths only (Table 3). Ten of the detergents claimed enzymatic activity. Four of these manufacturers did not supply data on the nature of the enzymatic component, stipulating it was confidential. The remainder (n = 6) contained protease(s), lipases, and/or amylases (Table 3).

Table 1 List of manufacturers contacted for their product information. Manufacturers and detergents grouped by their time of response, first, second or no response after three attempts

First time responders	
Manufacturer	Detergent
Alconox, Inc.	Alconox Tergazyme Liquinox
Decon	Neutracon
Haemo-Sol	Haemo-Sol regular Haemo-Sol enzyme
Peskett solutions	Endozyme XP Endozyme AW plus Liquizime
Schulke & Mayr	Gigasept enzymatic Gigasept instrument Gigasonic Gigasept FF Rotasept
Sultan chemist	Pro portion
15 of the 31 detergents (48%)	
Second time responders	
Manufacturer	Detergent
Alkapham UK	Alkazyme
ColteneWhaledent	Biosonic UC30 Biosonic UC31 Biosonic UC38 Biosonic enzymatic
Durr	ID212 ID220
Rapidex	Rapizyme
8 of the 31 detergents (26%)	
No response	
Manufacturer	Detergent
Prostar Medical	HOSPEC
Panadent	Ruson
Quayle	Nusonic NAC solution
SSW	Gleam II
Septodont	Glutasept
Wright Cottrell	Instrument disinfectant Instrument decontaminant
Walker	WELclean disinfectant
8 of the 31 detergents (26%)	

Other chemical constituents within the detergents are shown in Table 4. The most common additional constituents were non-ionic surfactants, buffers, colouring, perfume and isopropyl alcohol. The optimum operating temperature specified by manufacturers for the detergents varied

Table 2 Information found in MSDS documents. Detergent information found via the internet for manufacturers that did not respond

Name	Manufacturer	Type of detergent	Use in manual cleaning	Use in ultrasonic cleaning	Colour/perfumed	Storage temperature (°C)
GleamII	SSW	Strong alkaline	Not specified	Yes	Yes/Yes	<5
Nusonic	Quayle	Mild alkaline	Not specified	Yes	Yes/Yes	<5
WELclean	Walker	Mild alkaline	Not specified	Not specified	Yes/Yes	<5

When diluted to working strength in purified water, strong alkaline = pH >10.5; mild alkaline = pH 7.5-10.5; neutral = pH 6.5-7.5; acidic <pH 6.5.

Table 3 Detergent solutions recommended by manufacturers for use in manual or ultrasonic cleaning

Manufacturer	Name	Type of detergent alkaline/neutral/acid	Use in manual cleaning	Use in ultrasonic cleaning	Enzyme content
AlconoxInc	Alconox	Mild alkaline	Yes	Yes	Nil
	Tergazyme	Mild alkaline	Yes	Yes	Protease
	Liquinox	Mild alkaline	Yes	Yes	Nil
Alkapharm UK Ltd	Alkazyme	Mild alkaline	Yes	Yes	N/c
ColteneWhaledent	Biosonic UC30 General purpose cleaner	Neutral	No	Yes	Nil
	Biosonic UC-31 general purpose	Mild alkaline	No	Yes	Nil
	Biosonic UC38 germicidal ultrasonic cleaner	Mild alkaline	No	Yes	Nil
	Biosonic enzymatic ultrasonic cleaner	Neutral	No	Yes	N/c
Decon	Neutracon	Neutral	Yes	Yes	Nil
Durr	ID 212	Strong alkaline	Yes	No	Nil
	ID 220	Strong alkaline	Yes	No	Nil
Haemo-Sol	Haemo-Sol regular	Strong alkaline	Yes	Yes	Nil
	Haemo-Sol enzyme active	Mild alkaline	Yes	Yes	Protease
Peskett solutions	Endozime XP	Neutral	Yes	Yes	Protease lipase amylase
	Endozime AW Plus	Neutral	Yes	Yes	Protease lipase amylase
	Liquizime	Mild alkaline	Yes	Yes	Protease lipase amylase
Schulke Et Mayr	Gigasept Enzymatic	Neutral	Yes	Yes	N/c
	Gigasept Instrument AF	Mild alkaline	Yes	Yes	Nil
	Gigasonic	Mild alkaline	Yes	Yes	Nil
	Gigasept FF	Neutral	Yes	No	Nil
	Rotasept	Strong alkaline	Yes	No	Nil
Sultan Chemists	PRO.PORTION enzymatic cleaning solution	Neutral	Yes	Yes	N/c
Rapidex	Rapizyme	Neutral	Yes	Yes	Protease amylase

Listed manufacturers that information was available for, with a summary of detergent properties. When diluted to working strength in purified water, strong alkaline = pH >10.5; mild alkaline = pH 7.5-10.5; neutral = pH 6.5-7.5; acidic <pH 6.5. N/c = no comment

between 20°C and 60°C but a wide range of operating temperatures was also specified (5-100°C) in Table 5.

The recommended dilution for each of the detergents varied between 7.8 ml and 16 ml per litre of diluent and 2 mg and 5 g per litre of diluent. The dilution factor quoted

was the same regardless of the calcium carbonate (water hardness) concentration in the diluting water supply. No manufacturer recommended treatment with a neutralising agent following their detergent use. Compatibility of the detergents with different types of material used for medical

device fabrication is shown in Table 6. All products were claimed to be compatible with stainless steel instruments, while pH neutral enzymatic cleaners had the widest range of material compatibility. Of interest, two products were strongly alkaline and claimed to be compatible with aluminium instruments.

Table 4 Frequency of claimed constituents by the manufacturers

Company	Manuf. A			Manuf. B				Manuf. C					Manuf. D		Manuf. E	Manuf. F	Manuf. G			Manuf. H		Manuf. I	Manuf. J
Detergent	D-1	D-2	D-3	D-1	D-2	D-3	D-4	D-1	D-2	D-3	D-4	D-5	D-1	D-2	D-1	D-1	D-1	D-2	D-3	D-1	D-2	D-1	D-1
Property																							
Does the detergent contain phosphates (eg to improve hard water compatibility)																	Yes	Yes		Yes	Yes		
Does the detergent contain anionic surfactants							Yes				Yes				Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Does the detergent contain cationic surfactants									Yes	Yes													
Does the detergent contain amphoteric surfactants																							
Does the detergent contain non-ionic surfactants	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes			Yes	Yes			Yes
Does the detergent contain chelating agents	Yes	Yes	Yes				Yes								Yes		Yes	Yes	Yes			Yes	
Does the detergent contain buffering agents	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes			Yes						Yes	Yes	Yes				
Does the detergent contain anti-microbial agents				Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes		Yes						Yes	
Does the detergent contain viscosity control agents													Yes										
Does the detergent contain colouring	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes							Yes	
Does the detergent contain perfume				Yes		Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes							
Isopropyl alcohol	Yes	Yes	Yes	Yes	Yes	Yes	Yes					Yes	Yes									Yes	
Ethylene glycol																							
Other										Ethanol													

Manuf. A–J: manufacturer responses anonymised

D-1–D-3: different detergent types associated with manufacturer

The shelf life of the detergent varied between 24 and 60 months. The minimum recommended storage temperature ranged between 0°C and 15°C and the maximum recommended storage temperature ranged between 25°C and 72°C. The detergents were available in sizes ranging from 5 g sachets to 2.25 kg tubs for solid forms and 30 ml packets to 20 litre containers for liquid presentations.

The biocompatibility testing of the detergents revealed of the 17 manufacturers and 31 products, only one product had been investigated for topical toxicity. No manufacturer had investigated toxicity effects in line with ISO 10993-17.³⁴ Furthermore no company was able to specify a lower limit of detection for residual detergent on reprocessed instruments.

DISCUSSION

Considering the importance of detergents as part of the cleaning process, it has proved difficult to obtain comprehensive information on detergents for manual and/or ultrasonic cleaning. This perhaps explains the inappropriate chemical use found in a large observation survey of instrument decontamination in general dental practice.¹⁴

Table 5 Temperature range for detergents as recommended by the manufacturer

Company	Manuf. A			Manuf. B				Manuf. C					Manuf. D		Manuf. E	Manuf. F	Manuf. G			Manuf. H		Manuf. I	Manuf. J
Detergent	D-1	D-2	D-3	D-1	D-2	D-3	D-4	D-1	D-2	D-3	D-4	D-5	D-1	D-2	D-1	D-1	D-1	D-2	D-3	D-1	D-2	D-1	D-1
Operating temperature																							
Minimum (°C)	5	5	5	20	20	20	20	15	15	15	15	15	N/c	N/c	20	20	15	15	N/c	18	18	20	5
Optimum (°C)	30	30	30	25	25	25	25	20	20	20	20	20	20	20	25	30	60	50	60	52	52	38	45
Maximum (°C)	70	70	70	30	30	30	30	30	30	30	30	30	N/c	N/c	30	40	100	55	N/c	52	77	60	70

N/c = no comment by the manufacturer
 Manuf. A-J: manufacturer responses anonymised
 D-1-D-3: different detergent types associated with manufacturer

Table 6 Material compatibility of detergents. Listed responses supplied by detergent manufacturers

Company	Manuf. A			Manuf. B				Manuf. C					Manuf. D		Manuf. E	Manuf. F	Manuf. G			Manuf. H		Manuf. I	Manuf. J
Detergent	D-1	D-2	D-3	D-1	D-2	D-3	D-4	D-1	D-2	D-3	D-4	D-5	D-1	D-2	D-1	D-1	D-1	D-2	D-3	D-1	D-2	D-1	D-1
Material compatibility																							
Stainless steel	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Carbon steel	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aluminium	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Anodised aluminium	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other non-ferrous metals (all):																							
Copper	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brass	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lead	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nickel	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Titanium	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Non-reflective coated instruments																							
Silicone rubber	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other requirements																							
Requires a neutralising agent	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Storage																							
Shelf life (month)	36	36	36	24	24	24	24	36	36	36	24	36	24	24	26	24	24	24	24	60	60	36	60
Minimum storage temp (°C)	0	0	0	10	10	10	10	15	15	15	15	15	5	5	N/c	5	15	15	15	N/c	N/c	10	N/c
Maximum storage temp (°C)	72	72	72	40	30	30	30	25	25	25	25	25	25	25	N/c	30	30	30	30	N/c	N/c	30	N/c

Manuf. A-J: manufacturer responses anonymised
 D-1-D-3: different detergent types associated with manufacturer

Detergents are an integral part of the cleaning process^{16,2} and therefore must have demonstrated compatibility and efficacy with the other variables in the cleaning process such as types of soil encountered, cleaning equipment, reusable instruments, temperature of the process and water quality. We were unable to

obtain any validation data on the cleaning efficacy of the detergents in this survey. In some instances, there will be a necessity for compatibility with manual hand washing, which precludes use of strongly alkaline detergents due to their corrosive nature. Of interest, four products formulated with a strong alkaline pH (>10.5)

were recommended for manual cleaning. In addition these four products are especially corrosive, requiring special handling and protective work wear, probably being unsuitable for primary care facilities. It is also recommended^{29,33} that no toxic residues remain on the instruments after cleaning with detergents which may have

adverse effects on patients, instruments or the steriliser. Recent work has also highlighted potential occupational asthma and rhinitis associated with enzymes contained within detergents.³⁵

Temperatures exceeding 65°C can cause the emulsion of fat and detergent formed to be destroyed. Moreover, higher temperatures in excess of 55°C may cause protein residues and enzymes to denature,⁷⁻⁹ making their removal more difficult. Three enzymatic detergents in this study specified an upper temperature limit of 72°C. Ideally only soft water (water containing little or no calcium/magnesium ions) should be used for cleaning as the chemical action of detergents can be seriously impaired by hard water. Also, the use of hard water may give rise to precipitations of inorganic salts on instruments, ultrasonic baths and washer disinfectors.¹¹ Therefore, hard water will require the use of water conditioning or sequestering agents to remove these mineral ions. It may also be necessary to incorporate an acid rinse into the cleaning cycle to prevent scale formation in areas with hard water.

CONCLUSION

In conclusion, this study has demonstrated the difficulty in obtaining relevant information on detergents for manual and ultrasonic cleaning for use in primary healthcare facilities. Some recommended chemicals are clearly unsuitable for manual washing. An agreed method for objective assessment of detergent efficacy in soil removal would help select appropriate products and make informed financial judgements on product procurement. Furthermore, clear information will help reduce adverse effects on instruments, patients and/or staff. At present there is no cleaning efficacy standard that detergents must meet in the medical device reprocessing industry. The results of

this survey imply that guidance and standards in the use of cleaning detergents for healthcare are urgently required.

Many thanks to G. Irvine and A. Conacher for their contributions to format and questionnaire design.

1. Department of Health. Economics, Statistics and Operational Research Division. *Assessing the risk of vCJD transmission via surgery: an interim review*. Department of Health. London: The Stationery Office, 2005.
2. Hervé R, Secker T J, Keevil C W. Current risk of iatrogenic Creutzfeld-Jakob disease in the UK: efficacy of available cleaning chemistries and reusability of neurosurgical instruments. *J Hosp Infect* 2010; **75**: 309–313.
3. Lipscomb I P, Pinchin H, Collin R, Keevil C W. Effect of drying time, ambient temperature and pre-soaks on prion-infected tissue contamination levels on surgical stainless steel: concerns over prolonged transportation of instruments from theatre to central sterile service departments. *J Hosp Infect* 2007; **65**: 72–77.
4. Taylor D M. Preventing accidental transmission of human transmissible spongiform encephalopathies. *Br Med Bull* 2003; **66**: 293–303.
5. Flechsig E, Hegyi I, Enari M, Schwarz P, Collinge J, Weissmann C. Transmission of scrapie by steel-surface-bound prions. *Mol Med* 2001; **7**: 679–684.
6. Zobeley E, Flechsig E, Cozzio A, Enari M, Weissmann C. Infectivity of scrapie prions bound to a stainless steel surface. *Mol Med* 1999; **5**: 240–243.
7. Bernoulli C, Siegfried J, Baumgartner G et al. Danger of accidental person-to-person transmission of Creutzfeld-Jakob disease by surgery. *Lancet* 1977; **1**: 478–479.
8. Peretz D, Supattapone S, Giles K et al. Inactivation of prions by acidic sodium dodecyl sulfate. *J Virol* 2006; **80**: 322–331.
9. Starace C A. Detergent enzymes: developments during the last decade. *J Am Oil Chem Soc* 1981; **58**: 165–170.
10. NHS Estates. *A guide to decontamination of reusable surgical instruments*. London: NHS Estates, 2003.
11. Holah J T, Thorpe R H. Cleanability in relation to bacterial retention on unused and abraded domestic sink materials. *J Appl Microbiol* 1990; **69**: 599–608.
12. Smith A J, Bagg J, Hurrell D, McHugh S. Sterilization of re-usable instruments in general dental practice. *Br Dent J* 2007; **27**: 203.
13. Molinari J A, Harte J A. *Cottone's practical infection control in dentistry*. 3rd ed. Philadelphia: Lippincott Williams & Wilkins, 2009.
14. Bagg J, Smith A J, Hurrell D, McHugh D, Irvine G. Pre-sterilization cleaning of re-usable instruments in general dental practice. *Br Dent J* 2007; **12**: 202.
15. Department of Health. *The dental national decontamination survey 2010*. London: Department of Health, 2010.
16. Zühlendorf B, Emmirch M, Floss H, Martiny H. Cleaning efficacy of nine different cleaners in a washer-disinfector designed for flexible endoscopes. *J Hosp Infect* 2002; **52**: 206–211.
17. Wasek S. 11 Common endoscope handling mistakes. *Outpatient Surgery Magazine* 2003; **5**: 52–59.
18. Tomlinson A, Carnali J. A review of key ingredients used in auto-dishwashing formulations past and present and the physico-chemical processes they facilitate. In Johansson I, Somasundaran P (eds). *Hand book for cleaning/decontamination of surfaces*. 1st ed. pp. 197–255. Sweden: Elsevier B. V., 2007.
19. Perkins W. Surfactants: A primer. *America's Textiles Int* 1998; **8**: 57.
20. Hollingsworth M W. Role of detergent builders in fabric washing formulations. *J Am Oil Chem Soc* 1978; **55**: 49–51.
21. Nagarajan M K, Paine H L. Water hardness control by detergent builders. *J Am Oil Chem Soc* 1984; **61**: 1,475–1,478.
22. Camper A K, Hayes J T, Sturman P J, Jones W L, Cunningham A B. Effects of motility and adsorption rate coefficient on transport of bacteria through saturated porous media. *Appl Environ Microbiol* 1993; **59**: 3,455–3,462.
23. Changa D M. The binding of free calcium ions in aqueous solution using chelating agents, phosphates and poly(acrylic acid). *J Am Oil Chem Soc* 1983; **60**: 618–622.
24. Gibson H, Taylor J H, Hall K E, Holah J T. Effectiveness of cleaning techniques used in the food industry in terms of the removal of bacterial biofilms. *J Appl Microbiol* 1999; **87**: 41–48.
25. Hutchisson B, LeBlanc C. The truth and consequences of enzymatic detergents. *Gastroenterol Nurs* 2005; **28**: 372–376.
26. Lawson V A, Stewart J D, Masters C L. Enzymatic detergent treatment protocol that reduces protease-resistant prion protein load and infectivity from surgical-steel monofilaments contaminated with a human-derived prion strain. *J Gen Virol* 2007; **88**: 2,905–2,914.
27. Jackson G S, McKintosh E, Flechsig E et al. An enzyme-detergent method for effective prion decontamination of surgical steel. *J Gen Virol* 2005; **86**: 869–878.
28. Yan Z X, Stitz L, Heeg P, Pfaff E, Roth K. Infectivity of prion protein bound to stainless steel wires: a model for testing decontamination procedures for transmissible spongiform encephalopathies. *Infect Control Hosp Epidemiol* 2004; **25**: 280–283.
29. National Health Service Scotland. *Scottish Health Technical Memorandum 2030*. Scotland: NHS, 2001.
30. Prior J, Fernie K, Renfrew A, Heneaghan G. Alcoholic fixation of blood to surgical instruments—a possible factor in the surgical transmission of CJD? *J Hosp Infect* 2004; **58**: 78–80.
31. Scottish Dental Clinical Effectiveness Programme. *Decontamination into practice: part 1 – cleaning of dental instruments*. Scotland: SDCEP, 2007.
32. Scottish Dental Clinical Effectiveness Programme. *Decontamination into practice: part 2 – sterilization of dental instruments*. Scotland: SDCEP, 2007.
33. International Organization for Standardization. *Washer-disinfectors – part 1: general requirements, terms and definitions and tests*. *BS EN ISO* 2006; **15**: 883–881.
34. International Organization for Standardization. *Biological evaluation of medical devices – Part 17: Establishment of allowable limits for leachable substances*. *ISO 10993-17*: 2002
35. Adishes A, Murphy E, Barber C M, Ayres J G. Occupational asthma and rhinitis due to detergent enzymes in healthcare. *Occup Med* 2011; **61**: 364–369.