The advent of dental implants has resulted in many changes in clinical protocols. One area of implant dentistry that has not received adequate attention relates to impression-making and prevention of cross-contamination of subsequent component parts. It has been stated that the responsibility of ensuring impressions have been cleaned and disinfected before submitting them to the dental laboratory lies solely with the dentist. The Centers for Disease Control and Prevention recommends all surfaces in contact with human bodily fluid be disinfected with hospital-grade disinfectant. The ability of these components to harbor biologic contaminant material has not yet been determined, especially with regard to internal configuration, combined with the knowledge that many clinicians and laboratories use a spray disinfectant, which may limit disinfectant contact. The aim of this study was to determine the site and extent of contamination occurring on implant components following clinical impressions and laboratory procedures.

### Materials and Methods

The study design included forensic staining and subsequent analysis of 60 used impression copings, 10 used laboratory analogs, and 10 new components as controls.

### Results

Staining was found on 100% of impression copings used in vivo, indicating that biologic material had reached multiple sites on both internal and external surfaces of the components. Staining was also found on the internal aspect of used implant analogs, indicating transfer of biologic material from the impression coping and screw. None of the new control components presented staining at any site. Staining highlighted difficult areas to debride, particularly components with difficult or impossible access for cleaning and disinfection.

### Conclusion

Phloxine B staining indicated the ability of biologic material to reach all areas of the implant components. Having demonstrated the difficulty, sometimes impossibility, of accessing areas of these implant components, there is a need to develop protocols to reduce risk of potential transmission of infective material via implant components. Further study is warranted to determine the potential for transmission of infective material due to inadequate disinfection processes of implant componentry.

**Keywords:** biologic contamination, disinfection, implant components, implant impression
When considering impressions in non-implant-related dentistry, several methods of disinfection have been recommended depending on the impression material, cast materials, and tray material used. Disinfection with iodophores, sodium hypochlorite, and complex phenolics are recommended for use with many of the elastomeric impressions.\(^7\) The method of disinfectant application has also been studied, with immersion in sodium hypochlorite found to be more effective than the use of a spray disinfectant.\(^5,7\) Impression materials may also be sterilized via autoclave or various other methods,\(^2\) but these procedures require additional time, equipment, and an understanding of the protocols involved with the different materials.

In addition to impression material disinfection, dental gypsum may have disinfectants such as chlorhexidine\(^2\) or sodium hypochlorite\(^8-11\) incorporated within them. Once the casts are recovered, they may be subjected to microwave radiation to further enhance their antimicrobial properties.\(^12-14\) In contrast to traditional dentate or edentulous impression-making, implant impressions commonly require components to be impressed, picked-up, and passed onto the laboratory. These components are most often manufactured with a screw and a tubular metal form (or lumen) containing intricately machined parts, such as features to inhibit screw movement in an apical or coronal direction. These components are categorized as semi-critical due to contact with mucous membranes, which demands that high-level disinfection techniques be used. It has been suggested that even with high-level disinfection, there could be a one-in-1,000 chance that a contaminant could survive.\(^15\) However, this also assumes that the disinfectant is capable of reaching all contaminated sites. Given the physical complexity of implant componentry, it would be prudent to determine which sites may or may not come into contact with human bodily fluids, and assess potential access for disinfection procedures.

Staining dental components with phloxine B, a stain used in forensics as well as histology, has been done previously to highlight biologically derived remnants when evaluating new and used dental components.\(^12,13\) The purpose of this qualitative study was to investigate the likelihood of biologic material being retained within the components during and directly after impression-making. A discussion on the most appropriate means of decontaminating implant components with the ultimate goal of reducing the risk of cross-contamination will also be provided.

**MATERIALS AND METHODS**

Five dental laboratories provided 60 test implant impression copings (IIC) specimens previously used in vivo from various manufacturers to be tested (Fig 1 and Table 1). The IICs collected were of two types: analog open-tray and closed-tray designs retrieved directly from clinical impressions after fabrication of the cast from the laboratories and digital scan bodies.
retrieved after sterilization via steam autoclave from the dental clinic. It was reported that all impressions had first been disinfected by the dental office and then re-disinfected by the laboratory. Information on disinfection techniques used by the dental office was not collected; however, a second disinfection procedure using spray disinfectant was reported by the laboratories involved on delivery of the impression, prior to working on it. The laboratories reported using one of the following commercial disinfectants: Cavex Impression Safe (Cavex Holland BV), Opti-cide (Biotrol), or BioSyrf (Micrylum). After collection, the specimens were further steam autoclaved prior to examination.15

The test IICs and scan bodies were completely disassembled (screws removed), and all components were individually placed in a plastic bag containing phloxine B to stain any residual polypeptides and proteins. The bag was then placed in an ultrasonic bath for 20 minutes followed by 20 minutes of ultrasonic cleaning in deionized water.16 All components were then air dried using a stream of compressed air. In some IIC systems, the screw could not be removed as a result of the impression coping having a crimped end. In those instances, the screw threads were removed by sectioning the shaft, allowing removal of the shank. The IICs were also cross-sectioned after staining to reveal any internal staining from the phloxine B.

A second part of this study evaluated 10 laboratory analogs that had come into direct contact with IICs used in vivo as the casts were fabricated. These were also stained, then sectioned. As a control, six new and unused analog IICs, two new scan bodies, and two new and unused implant analogs were subjected to the same staining and sectioning protocols as mentioned earlier.

## RESULTS

All test implant impression copings showed staining both internally and externally with phloxine B, indicating presence of biologic material containing proteins (Table 2, Figs 2 and 3). In complex machined areas such as screw head seats or internal screw threads (Fig 4), a concentration of staining was always noted. In the

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Results from Staining Test Highlighting Sites of Interest</th>
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<tr>
<td><strong>Implant impression coping design</strong></td>
<td><strong>Percent showing staining</strong></td>
</tr>
<tr>
<td><strong>Used samples (n = 60, various types)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>IIC contamination site</strong></td>
<td></td>
</tr>
<tr>
<td>External</td>
<td>100</td>
</tr>
<tr>
<td>Internal</td>
<td>100</td>
</tr>
<tr>
<td>Screw head seat</td>
<td>100</td>
</tr>
<tr>
<td>Internal screw thread (where applicable)</td>
<td>100</td>
</tr>
<tr>
<td>Scan bodies</td>
<td>100</td>
</tr>
<tr>
<td><strong>Screw site</strong></td>
<td></td>
</tr>
<tr>
<td>Screw threads</td>
<td>100</td>
</tr>
<tr>
<td>Shank screw</td>
<td>100</td>
</tr>
<tr>
<td><strong>Laboratory analog (n = 10)</strong></td>
<td><strong>n = 10</strong></td>
</tr>
<tr>
<td>Attachment area</td>
<td>100</td>
</tr>
<tr>
<td>Screw threads</td>
<td>100</td>
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</table>

IIC = implant impression coping.
open-tray IIC design, an increase in concentration of stain was noted closer to the implant connection, especially within the screw threads. For the closed-tray designs, the screw threads were located toward the occlusal end of the IIC, and again, the threads showed marked staining. In IICs with a crimp disallowing removal of the screw, staining extended throughout the internal screw channel. Relative to screws, staining was always found in the IIC screw threads (Fig 4a). Some implant manufacturers provide rubber gaskets that sit within a recessed groove on the shank of the screw. On removal of this gasket, staining was evident within the recess (Fig 4b).

All 10 used implant analogs when sectioned revealed staining within the threads (Fig 5), indicating transfer of biologic material from the impression coping screw. When sectioned, all used scan bodies showed internal staining on the internal surface and their respective screws (Fig 6a). As with some conventional impression copings, some types of scan bodies did not allow screw removal due to plastic molding, hindering their ability to be cleaned prior to sterilization (Fig 6b). In contrast, none of the control samples had staining present (Fig 7). This included all areas internally as well as screw threads (Fig 8).

**DISCUSSION**

Phloxine B stain is used in both forensics and histology, specifically to highlight the presence of proteins and polypeptides. While it is not a direct stain for active biologic infective material, phloxine B serves as a proxy to highlight the extent of material present, which may have potential to cross contaminate. The biologic stain on these components is likely a result of saliva or blood contamination. The extent of these contaminants should be evaluated in future studies. Some factors that may contribute to contamination are: reuse of components, IIC design, height of the gingival cuff, impression site (maxilla or mandible), impression technique (open-tray or closed-tray), and procedures used to rinse and disinfect components prior to pouring casts (where IIC retention screws were...
removed or left in place). There was also the possibility that capillary rise action may have occurred within the components and that the action of screw removal affected potential fluid movement within the lumen of the IIC components. Finally, the pressure resulting from impression removal from the mouth produces a negative pressure that may contribute to fluids being sucked into the lumen of the IIC.

The present study highlights the presence of biologic material on and within used IIC from human bodily fluids, which is in direct contrast to the noncontaminated controls. The clinical significance of finding this material within the IICs suggests these contamination sites may have the potential to transmit disease. Disinfection of impressions to prevent cross-contamination is a necessity and should be a standard procedure carried out by all clinicians.16,17 Implant impression-making presents a greater issue due to intricate machining that provides multiple sites where biologically active material may remain, as well as limiting access to disinfectant. The ability to reach and adequately disinfect these sites is an area that must also be critically evaluated. Some spray disinfection has been shown to have limitations6 and is unlikely to achieve complete access within the screw channel; similarly, immersion disinfection may not be effective if the components are not disassembled and debris removed. The transfer of biologic material to the implant analogs also needs to be evaluated, as it may not just be a biologic contaminant but may interfere with the mechanics of screw tightening if it is further transferred to the abutment screw.18,19

Recommendations for disinfection of impression materials include appropriate methods and materials in the dental clinic1 combined with adequate cross-infection controls carried out by the laboratory. However, to date, there have been no recommendations with respect to the impression being made: conventional tooth or implant type. With the use of componentry that may harbor contaminants, a distinction should be considered, combined with manufacturer consideration as to how this can be adequately carried out with the components they provide.

It appears that implant manufacturers20–22 have concentrated on methods to prevent screw loss or slippage when using IICs without giving thought to ease of disinfection. The internal screw threads retain material, as do recesses under rubber gaskets. It is assumed that components with crimped ends represent the greatest risk for cross-contamination, especially to the laboratory technician when attaching the analog, as they all showed transfer of biologic material. The design features of IICs must be critically evaluated, and further microbial studies evaluating these components for active bio-contaminants are necessary to identify risk factors and site location.

The majority of IICs studied were for the open-tray technique, and they remain within the impression material as it is removed. With the closed-tray technique, components are not included when the impression is initially removed. The impression may then be disinfected, and a new identical and uncontaminated component may be put back into the impression to limit cross-contamination. This, however, increases costs, and exclusive use of the closed-tray technique may lead to a less-accurate impression and subsequent inaccurate implant analog positions in the master cast, especially in edentulous patients.23

Most of the IICs were labeled as single-use-only components, which should limit the degree of material transfer from one component to the next. However, even within this group, transfer was noted to the implant analogs, again indicating lack of cleaning prior to assembly. Multiuse components should not be recommended, as the possibility of material transfer likely increases with each subsequent use. Although IICs designated for multiuse may be sterilized,24 this study indicates transfer of biologic material may occur.

Currently, there are no directives that exist with regard to cleaning and disinfecting implant components. The literature does report on debridement, disinfection, and sterilization of medical components with different procedural times and materials that would assist in the development of such protocols. Development of such protocols should be considered urgent due to risk of cross-contamination. One solution to contamination and transfer of material is digital impression-making, where no direct contact is involved between components and the impression media. This would, however, mandate the use of a single-use scan body abutment or risk of biologic material cross-contamination. Digital impression-making would also solve the issue of cross-contamination of the implant analogs, as they are not required in the digital workflow.

A limitation of this study was that no biologic material from the specimens was assayed. This study was an initial investigation to determine if such a need existed. The next series of investigations should include microbial assay, determining how design features affect risk, evaluation of disinfection techniques as they directly relate to implant impressioning, and evaluation of closed vs open vs digital techniques as well as reuse of components.

**CONCLUSIONS**

Within the limitations of this study, all clinically used implant impression copings (analog and digital) and all used laboratory analogs showed stain for biologic contamination. Transfer of contaminants from implant...
impression coping to laboratory analog was demonstrated. No staining was evident on any of the control components.

ACKNOWLEDGMENTS

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REFERENCES