Fungal colonisation in digital silicone rubber prostheses

M. E. L. LEOW*, A. K. KOUR*'****, T. J. J. INGLIS**'***,
G. KUMARASINGHE*** and R. W. H. PHO*'****

**Department of Orthopaedic Surgery, The National University of Singapore, Singapore*
***Department of Microbiology, The National University of Singapore, Singapore*
****Department of Laboratory Medicine, National University Hospital, Singapore*
*****Department of Hand and Reconstructive Microsurgery, National University Hospital, Singapore*

Abstract

The fungal discolouration of silicone rubber prostheses is reported in four cases. In two of the cases, the discolouration was caused by the fungus *Candida tropicalis.* In the other two cases, two different fungal organisms, namely *Trichoderma* sp. and *Scedosporium prolificans* were incriminated. The non-porous silicone rubber layers create an enclosed environment in the suction cup of the prosthesis and preclude ventilation at the prosthesis-stump interface. The moisture as a result of sweat and body warmth in the stump assists fungal growth. Residual salts from the sweat, sebum from sebaceous glands and the residues from petroleum jelly (Vaseline™) applied to facilitate donning, can adhere to the surfaces of the prosthesis and provide the nutrients for fungal growth. Prolonged continuous usages of the prosthesis, the presence of sweaty palms in the users, donning me prosthesis during manual physical activities which induce perspiration, washing of hands with the prosthesis on and warm humid climatic conditions have been identified as factors predisposing the prosthesis to fungal colonisation. The fungal growth caused a black discolouration and marred the aesthetic quality of the prostheses. As a preventative measure, daily immersion of the prostheses in denture cleaner such as benzalkonium chloride, or water at 60°C for 15 minutes, or decontamination with 70% alcohol is recommended. Prior cleaning to remove organic matter before decontamination is emphasised.

All correspondence to be addressed to Professor Robert W. H. Pho, Department of Orthopaedic Surgery, The National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260. Tel: (+65)7724340; Fax: (+65)7732558

Introduction

Silicone elastomers are widely used in the manufacture of maxillofacial and finger prostheses. One of the problems identified with the use of this material is a black discolouration caused by fungal growth (Masella *et al.,* 1975; Makila and Hopsu-Havu, 1976; Pigno *et ah,* 1994). In nasal prostheses, this has been attributed to the continual exposure to moist air and secretions that constantly pass through the nasal aperture. Although silicone digital prostheses have been prescribed to patients for over a decade (Pillet, 1983; Beasley, 1987; Alison and McKinnon, 1992; Campbell *et al.,* 1992; Leow *et al.,* 1996; Pereira *et al,* 1996; O'Farrell *et al.,* 1996) there have been no reported incidences of fungal colonisation. However, the conditions associated with the use of the finger prostheses can make them susceptible to fungal growth.

The authors report four cases of black discolouration in finger prostheses for which a fungal cause was found.

Materials and methods

The authors have developed a custom-made digital prosthesis using a silicone elastomer (Leow *et al.,* 1996; Pereira *et al.,* 1996). The prostheses are made from a medical grade of silicone elastomer (Cosmedica Ltd, Newport, UK). Colour pigments (Cosmedica Ltd, Newport, UK) are intrinsically mixed with the silicone to match the basic colour of the patient's skin. No anti-fungal agents are

incorporated. The prostheses are moulded with layers of the silicone rubber tinted to differing shades of colour, the outer layers of the prostheses which correspond with the epidermis and superficial dermis are rendered translucent while the inner layers which correspond to the inner dermis and subcutaneous tissues are rendered opaque. This is to mimic the stratified anatomy of the skin and achieve a life-like appearance. A layer of touch-up colouration is "sandwiched" between the layers of silicone rubber at the finger joints and nail to enhance the details and colouration at these areas. The hollow part of the prosthesis which corresponds with the deficit in the segment is packed with a filler material comprising a mixture of silicone elastomer and polystyrene beads. The contact surface of the silicone polystyrene core which sits snugly on the distal stump is sealed with a layer of silicone rubber to prevent moisture from entering.

In a follow-up review of 34 cases fitted with the prostheses for over two years or more, four cases of black discolouration in the prostheses caused by fungal growth were encountered (Figs. 1 and 2). The discolouration was rough in texture (Fig. 1) and found to be extremely resistant to cleaning with 70% alcohol. Besides the black discolouration, the problems of wear and tear and a yellowing discolouration caused by exposure to sunlight was also noted.

Laboratory investigations and microscopy: Scrapings were taken from the areas affected by the black discolouration for bacteriological and myocological investigations. Transverse sections were made through the areas affected

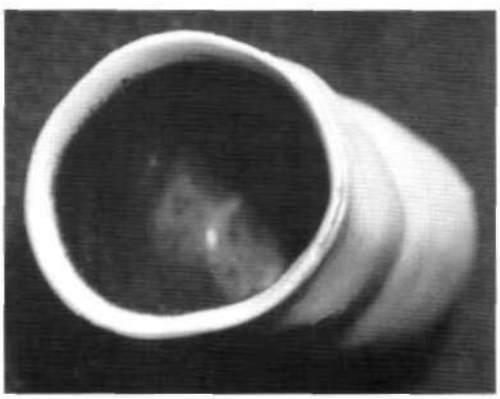

Fig 1. An affected prosthesis showing a black discolouration caused by fungal growth on the internal surfaces.

Fig 2. Another prosthesis in which the black discolouration had invaded the translucent outer layers, causing an unsightly blemish.

with the black discolouration for examination under the light microscope using the xlO and x40 objective lenses. Each section was examined from end to end, with particular attention to the distribution of the black discolouration.

Results

Laboratory investigations revealed fungal growth to be responsible for the black discolouration. Brightfield microscopy showed a distinct layer of mycelial growth in the sections taken through the areas affected with the discolouration.

Laboratory investigations and microscopy: Various strains of bacteria were identified in the scrapings from the affected areas of the prostheses. These included *Straphylococcus, Micrococcus, Corynebacterium* spp., and *Flavobacterium meningosepticum.* Three fungal species were isolated from all the affected prostheses, namely *Candida tropicalis,* from two of the cases, and *Trichoderma* sp. and *Scedosporium prolificans* each from the other two cases. Investigations also reveal an invasion of the inner layers of the prostheses by fungal growth. Fungal hyphae were seen forming a distinct layer in the silicone material (Fig. 3).

The fungal discolouration was seen as black spots and patches on the inner surfaces of the prosthesis in contact with the stump, including the sealed surfaces of the silicone-polystyrene core. In all four cases, the patients reported it to have occurred between 10-18 months post-fitting. This progressed to cover a wider area and penetrated deeper into the material over a 3-4 week period with continued use (between 8-10 hours per day). As the outer layers of the prosthesis are translucent, the black discolouration became visible when the fungus penetrated through the opaque inner layers and

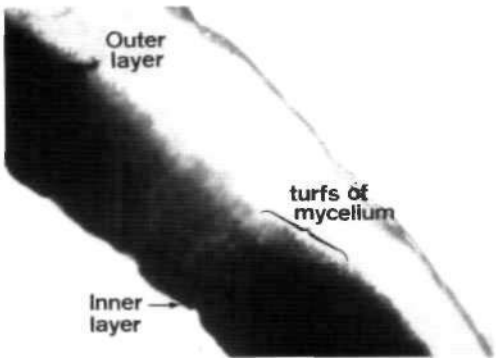

Fig 3. A transverse section through the affected areas of the prosthesis (shown in Fig. 2) as seen under Brightfield microscopy (magnification 10 x 40).

invaded the outer-inner layer interface. In one case, the black discolouration had spread to the outer layers of the prosthesis causing an unsightly blemish (Fig. 2). Brightfield microscopic observation revealed turfs of fungal hyphae (mycelia) invading the outer layers of the prosthesis (Fig. 3). The discolouration marred the aesthetic quality of the prosthesis.

The stump covered by the prosthesis was moist upon removal of the prosthesis. All patients indicated perspiration in their stump as one of the problems they encountered with the daily use of their prosthesis. No physical signs of fungal growth were observed on the stump in any of the affected cases. There were no allergic reactions in the stump in any of the four cases. However, two patients experienced discomfort due to the surface roughness (Fig. 1) created by the fungal colonisation within the suction cup.

Discussion

Various commensals are present in the skin. The types of micro-organisms and their distribution are transient and vary from time to time. Their multiplication is contained under normal use of the hand. However, if there is an increase in the level of moisture and warmth with availability of nutritional support, some fungal species may thrive. In the silicone soft lining (Silastic 390) of dentures, two fungus strains, *Candida albicans* and *Candida tropicalis* were reported to be responsible for the black discolouration often encountered with their use (Masella *et ai,* 1975). In this study, *Candida tropicalis* and two other fungal species, namely, *Trichoderma* sp. and *Scedosporium prolificans* were incriminated in the silicone rubber prostheses affected with a similar discolouration. The non-porous property of silicone rubber added to the conditions associated with the use of the prostheses provided the conditions of moisture, warmth and nutritional support for fungal growth.

Entrapped perspiration in the suction cup prosthesis: A secure prosthetic fit created an airtight seal between the non-porous prosthesis and the stump. Doffing of the prosthesis is achieved by creating an inlet for the entry of air to diffuse the vacuum effect. This same requirement for a suction cup prosthetic fit has the disadvantage of precluding cutaneous ventilation. It not only precipitates perspiration but traps the sweat on the stump when the prosthesis is donned for extended hours. The problem can be compounded by a humid tropical climate. The moisture from perspiration and body warmth of the stump provide an ideal milieu for sustaining fungal growth. An observation noted in these cases was the presence of a sweaty palm. This is a contributing factor in promoting the conditions for fungal growth.

Besides moisture and warmth, additional nutritional support is needed to sustain fungal growth. These nutrients can possibly come both extrinsically and intrinsically from the inside surface of the prosthesis. The authors have noted in this study that patches of residues composed of traces of petroleum jelly (Vaseline™) applied to facilitate donning, residual salts from sweat and sebum from the sebaceous secretions adhered to the inside surface of the prosthesis. This provided the initial extrinsic nutritional requirements for fungal growth to start with. It is also possible that the vaseline and sebaceous secretion are absorbed into the silicone material. This may provide the intrinsic source of nutrients which encouraged the fungus to penetrate into the silicone elastomer.

Of relevance was the patients' care of the prostheses. Instructions on the care of the prosthesis as advised to the patients included cleaning the inner surfaces of the prosthesis daily using a cotton-bud soaked with a mild soapy solution. As moisture encourages bacterial and fungal growth, the importance of keeping the surfaces of the prosthesis dry was emphasised. A more thorough maintenance regime thus becomes necessary when prescribing a silicone rubber prosthesis to

prevent fungal growth. Masella and coworkers (1975) showed that daily immersion of the dental prostheses in benzalkonium chloride (Zephiran, Winthrop Laboratories, New York), or water at 60°C for 15 minutes was found to be an effective measure to prevent the growth of the *Candida albicans* and *Candida tropicalis* in silicone lining on dentures. Since the black discolouration in the finger prostheses of the above patients was caused by fungal invasion, a similar preventive measure could be adopted. Cleaning the inner surfaces of the prosthesis is important to remove dirt and grease before immersing in a disinfectant, or before applying 70% alcohol for decontamination. Pigno *et ah,* (1994) also found that using an antifungal agent (Clotrimazole) incorporated into the silicone rubber elastomer was effective in inhibiting the growth of fungus *in vitro.* However, the clinical application and long term results were not investigated in this study.

Acknowledgements

The authors wish to acknowledge the financial support provided by the National Science and Technology Board through two RDAS grants (BM/87/01 and BM/90/06).

REFERENCES

ALISON A, MACKINNON SE (1992). Evaluation of digital prostheses. *J Hand Surg* **17A,** 923-926.

BEASLEY RW (1987). Hand and finger prostheses. *JHandSurg* **12A,** 144-147.

CAMPBELL GS, GOW D, HOOPER G (1992). Low cost cosmetic hand prostheses. *J Hand Surg* **17B,** 201-203.

LEOW EL, KOUR AK, PEREIRA BP, PHO RWH (1996). Colour-matching in hand and finger prostheses: the Asian perspective. *Hand Surg (Asia Pacific)* 1, 37-43.

MAKILA E, HOPSU-HAVU VK (1976). Mycotic growth and soft denture lining materials. *Acta Odont Scand* 35, 197-205.

MASELLA RP, DOLAN CT, LANEY WR (1975). The prevention of the growth of Candida on silastic 390 soft liner for dentures. *J Prosthet Dent* 33, 250-257.

O'FARRELL DA, MONTELLA BJ, BAHOR JL, LEVIN LS (1996). Long-term follow-up of 50 Duke silicone prosthetic fingers. *J Hand Surg* **21B,** 696-700.

PEREIRA BP, KOUR AK, LEOW EL, PHO RWH (1996). Benefits and use of a digital prostheses. *J Hand Surg* **21A,** 222-228.

PIGNO MA, GOLDSCHMIDT MC, LEMON JC (1994). The efficacy of antifungal agents incorporated into a facial prosthetic silicone elastomer. *J Prosthet Dent* **71,** 295 -300.

PILLET J (1983). Esthetic hand prostheses. *J Hand Surg* 8,778-781.