et al. as well as Agarwal et al.[2,3] The measurement tool should be validated in the future as a measurement tool for assessing plastic surgery scope of practice.

Our findings indicate that a single succinct information session is an effective means of educating students on the scope of practice of plastic surgeons and increasing general and research interest in plastic surgery. From our experience, a career night event hosted by plastic surgery faculty and residents is an effective means of promoting awareness and understanding of the field of plastic surgery, and provides a valuable networking opportunity among medical students, residents, and staff plastic surgeons.

Conflict of interest

None.

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References

1. Agarwal JP, Mendenhall SD, Hopkins PN. Medical student perceptions of plastic surgeons as hand surgery specialists. *Ann Plast Surg* 2014;**72**:89–93.
2. Agarwal JP, Mendenhall SD, Moran LA, Hopkins PN. Medical student perceptions of the scope of plastic and reconstructive surgery. *Ann Plast Surg* 2013;**70**:343–9.
3. Rogers AD, dos Passos G, Hudson DA. The scope of plastic surgery. *S Afr J Surg* 2013;**51**:106–9.
4. Mendenhall S, Agarwal J. Improving medical student understanding of the scope of plastic surgery. *Ann Plast Surg* 2013;**71**:130.
5. Conyard C, Schaefer N, Williams D, Beem H, McDougall J. The understanding of plastic and reconstructive surgery amongst Queensland medical students. *JPRAS Open* 2016;**8**:14–8.

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A fast and improved method of rapid prototyping for ear prosthesis using portable 3D laser scanner

Dear Sir,

Introduction

When reproducing an anatomically correct morphology of an ear, operators usually face difficulty in wax sculpting. This procedure is extremely time consuming and operators had to rely on skilled artistic approaches. Furthermore, to achieve an acceptable result, it is essential to recreate a mirror image of contralateral healthy side in the defect portion.[1–3]

A review of the literature has highlighted a computer-assisted rapid prototyping technique to sculpture facial prostheses.[4–8] Several techniques have been reported to fabricate a mirror-image wax cast for maxillofacial prostheses. However, to support these methods, the patient is exposed to considerable amounts of radiation under computed tomography (CT) or costly magnetic resonance imaging (MRI) for obtaining three-dimensional (3D) data.[9,10] To overcome this issue, laser-scanning techniques and CAD/CAM systems were used to design and develop auricular prostheses.[11] However, several limitations need to be addressed in terms of laser scanning, such as the cost, size and mobility of laser scanners, and sometimes, the positioning of the subject to the scanner.

This article describes the use of a portable 3D laser scanner in a congenital ear defect case; where a model of the opposing healthy ear was simultaneously scanned from different directions. The obtained data was mirrored, followed by 3D printing of the prosthesis. This system is both portable and easy to use.

Technique

Impression

1. A combination of a light and regular body of polyvinyl siloxane (Aquasil, Dentsply, USA) was used to take the impression of defect side. For the non-defect side's impression, alginate (Kerr, Switzerland) was used (Figure 1).
2. A model of the non-defect side and a refractory cast of the defect side was made using dental stone type IV (Suprastone, Kerr, Switzerland).

Data accession

3. Using a portable laser scanner (Next Engine Desktop 3D Scanner, model 2020i, NextEngine Inc., Santa Monica, CA) the ear cast was scanned. The scanner was connected to a laptop (Dell Precision M4800, Intel Core i7-4600M CPU @ 2.90GHz, 8 GB RAM, Dell Inc., Texas) to

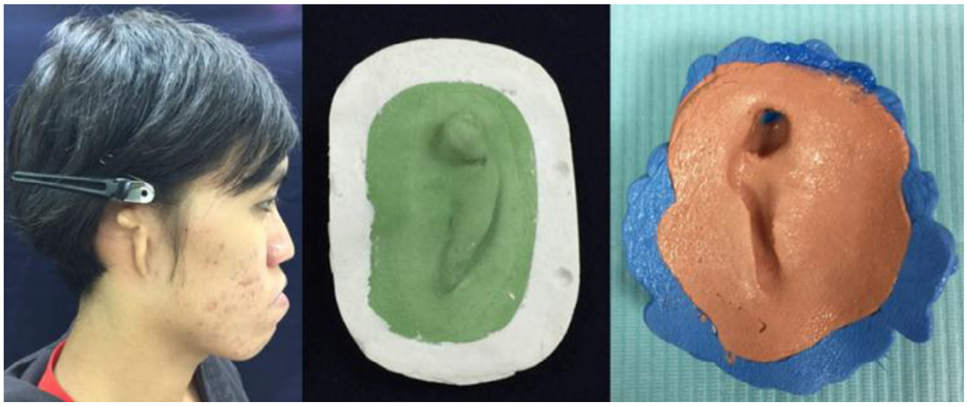

Figure 1 Impression of defected ear.

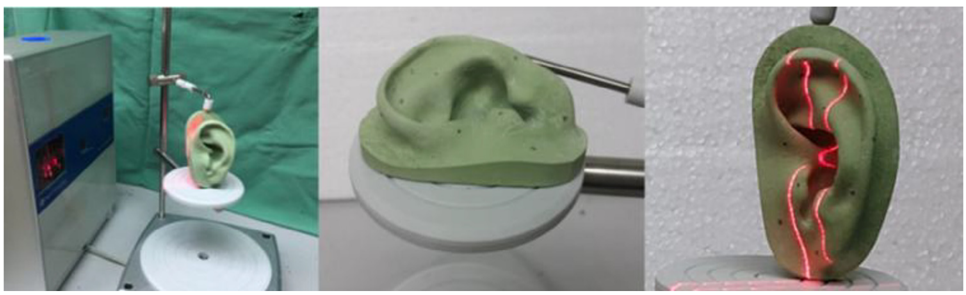

Figure 2 Scanning of normal ear cast.

acquire the 3D images and coordinates using built-in software (NextEngine ScanStudio Pro software) (Figures 2 and 3).

4. The cast was positioned in two ways. Several dots were placed on the cast using a pencil to align the images later. Every position was scanned using 16 angles – making 32 angles overall for 2 positions – in order to increase the precision of the scan.
5. The data was captured as a set of XYZ points, which were then automatically converted into a mesh surface comprised of triangles.

CAD/CAM technology and rapid prototyping procedure

6. The 3D scanned data was imported into Rapidworks64, Version 4.1.0 (3D System, Inc., Rock Hill, USA); which also came with the Next Engine 3D Scanner.
7. The Mesh Buildup Wizard was used to merge 2 differently positioned images. After preparing the images, editing the noise, and aligning the image based on the (pencil) dots with the corresponding one in the other position, the 2 images were finally merged.
8. The Mesh mode was used to repair various defects in the mesh using the healing wizard. The editing tools were used to refine the scanned data or remove noise.
9. A mirror image was created by applying the mirrored mesh function (Figure 4a).
10. Split function was used to cut the base (Figure 4b).
11. Mesh was in surface mode; which was very thin for 3D printing.
12. The model was created using the Thicken function i.e., thickening the entire mesh to create a thin-walled mesh by 2-mm (Figure 4c).
13. It was then exported to STL format.
14. The model with the correct dimensions, anatomy and angulation was printed (Figure 5) using Objet30 Scholar 3D Printer (Stratasys, Eden Prairie, MN) (Figure 6).
15. Industrial grade silicone (Aftek industrial grade silicon, NSW, Australia) was used to produce a mould from the 3D printed model by negative impression. The silicone mould had the exact dimensions, anatomy and angulation as the printed model (Figure 7a). Industrial grade silicone was the choice of material for the mould as it was cheaper and had better stability during removal of wax replica in the next step.
16. A wax replica was created by pouring molten modelling wax (Modelling wax, Dentsply, USA) into the silicone mould (Figure 7b). The wax replica was adapted onto the refractory cast of defective side; and used for final try-in for checking the fitting surface to the soft tissue of the patient and to modify the angulation and positioning of the future prosthesis compared to normal ear (Figure 7c). The adaptability and easy manipulation of wax always make it convenient to perform the adjustments in the try-in stage. Consequently, the three-piece mould was produced using the wax replica (Figure 8a).

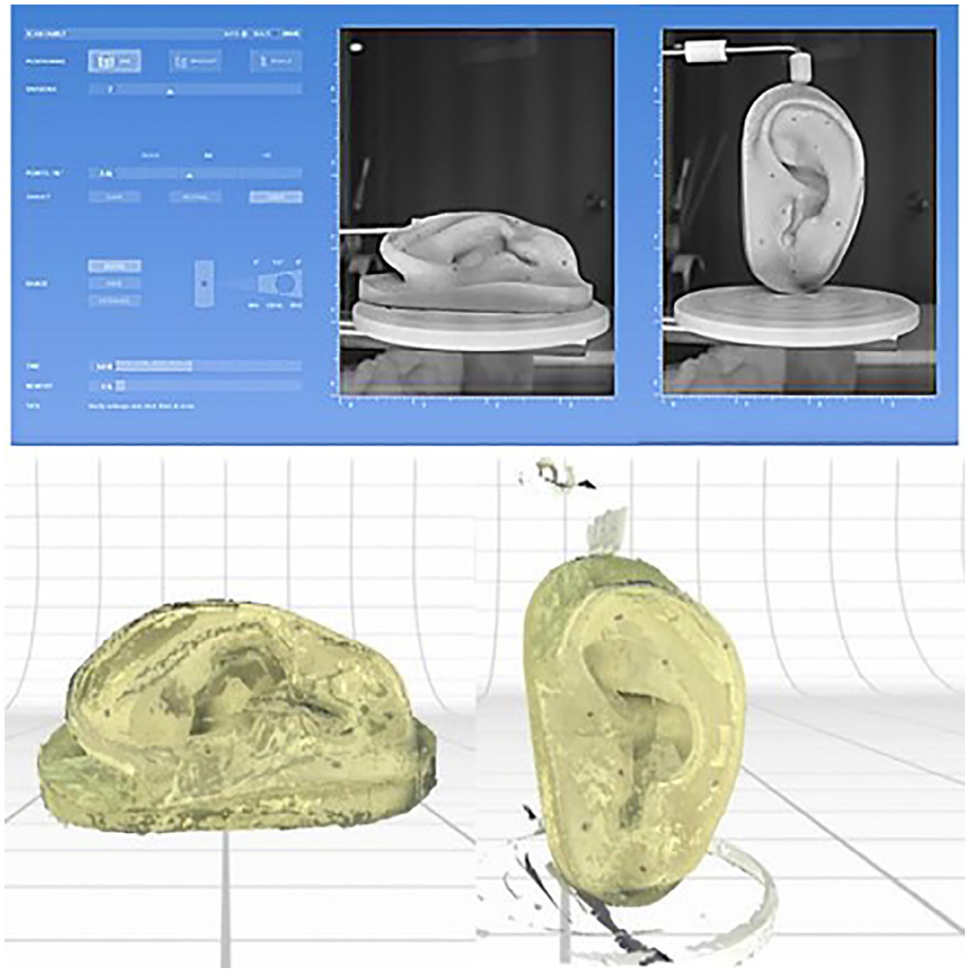

Figure 3 Results of two scans in NextEngine ScanStudio Pro software before merging.

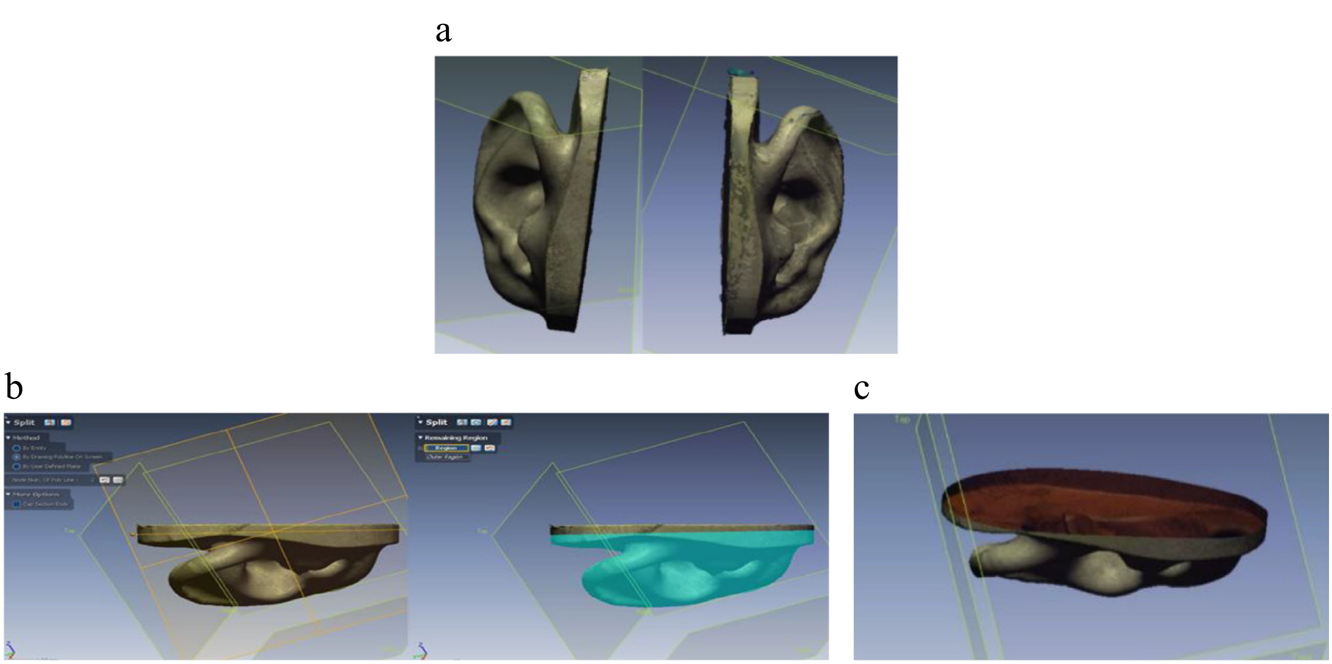

Figure 4 A. Mirror imaging of the merged 3D model of the normal ear. B. Splitting the base on 3D model. C. The surface of the model design of the ear prosthesis.

Figure 5 Final design of the model.

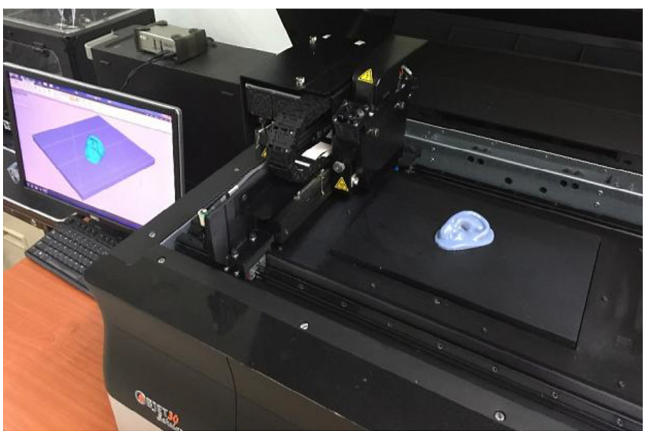

Figure 6 Printing of the ear prosthesis CAD model using Objet 3D printer.

17. Intrinsic colours (Intrinsic; Factor II, RTV A 2006) and extrinsic colours (Extrinsic; Factor II, Lakeside, AZ) were applied, and using acetoxy silicone adhesive (A-564; Factor II) the colouration was sealed onto the silicone.
18. Water soluble adhesive (Daro, Factor II) was used to retain the prosthesis (Figure 8b).

The procedural workflow is summarised in Figure 9.

Discussion

Several studies have reported on the various methods of rapid prototyping of craniofacial prosthesis.[2–8] Among them, several mentioned techniques about the laser-scanning method.[3,6,8,10–13] Some of these studies involved laser scanning of patients using hand held scanner or fixed optical 3D laser scanner from different angled positions.[3,13] But, our implied method does not require the presence of patients since the normal ear cast is only scanned. Thus, sparing the time of patients from the elaborate process of laser scanning.[8]

Few previous studies utilised the scanning of contralateral ear casts same as our technique.[6,10] However, our described method utilises a small, economical and portable Next Engine laser scanner, which is user-friendly and can be mobilised to peripheral hospitals for scanning compared to a 3Shape surface laser scanner incorporated with 2 cameras and 3-axis motion system.[6] Previous studies applied a pin system around the ear cast, prior to duplication, with 8 laser measurements of the surface from new angles to cover all positions.[10] However, in the current technique, several dots were placed onto the cast using a pencil for image aligning purposes. Each position was scanned at 16 angles. Therefore, 32 angles for 2 positions increased the precision of the scan.

The introduction of computer-assisted design (CAD) model and rapid prototyping (RP) in the fabrication of auricular prostheses saves valuable clinic time and effort of the maxillofacial prosthetist.[8] Our proposed technique is faster than the conventional approach as it eliminates at least two or three appointments over one to two weeks required by the anaplastologist to achieve the correct size, shape, internal details and angulation in the hand-sculpted wax prototype. It is very time consuming to manually recreate the anatomy of a lost structure that requires adjustment after correct orientation and angulation on to the defect side.[4–7,14] Moreover, only few anaplastologists have the high artistic skills and training to imagine and manually recreate the mirror image of the contralateral side in wax.[2,3,6,7] In this case, only two days was needed to produce the wax replica with exact dimensions, anatomy and angulation due to the fabrication of the silicone mould created from the 3D printed model by CAD and RP (Table 1). Additionally, the software in-built with the 3D laser scanner for the CAD is easy and has simple instruction. So, no special training or software engineers are required for this technique.

Although, this technique could have been faster if the wax try-in stage could be skipped and manual three-piece mould fabrication avoided by constructing direct negative mould using CAD and RP. However, that might have caused the final outcome to be unpredictable due to the absence of marginal adaptation and alignment adjustments otherwise done in the wax try-in phase.[13] In addition, the three-piece mould facilitates the incorporation of different intrinsic base shades in the finished silicone prosthesis comparable to the normal ear. Three-piece mould

Figure 7 A. CAD 3D model and silicone mould after negative impression of the model. B. Fabrication of wax replica from silicone mould. C. Wax try-in on the patient to fix the ear base.

fabrication and a wax prototype clinical try-in on the patient are therefore essential for an acceptable aesthetic outcome.[13]

The technique proposed is preferable as it facilitates the rapid fabrication of a prototype, a clinical try-in with the possibility of adaptation, and an acceptable aesthetic outcome.

One drawback of the current technique is that it cannot print the silicon prosthesis with a matched skin colour. Further developments might include 3D printing of an aesthetically acceptable colour mixed definitive silicone prosthesis after software processing.

Summary

The technique described in this article provides a fast and accurate way of producing auricular prosthesis using a a

b

Figure 8 A. Fabrication of three-piece mould and silicone loading. B. Final prosthesis issued to the patient.

CAD/CAM technology and a rapid prototyping machine. The patient is not affected by radiation from the CT scan. A laser scanner was used to develop a 3D model of the ear, which was then mirrored and used to fabricate the mould of the replacement ear using a rapid prototyping machine. The technique presented requires less clinic time, and is a fast, accurate and relatively cheap method of fabricating auricular prostheses, as well as orbital, nasal and mid-facial prostheses.

Conflict of interest

None.

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Table 1 Time comparison between CAD/CAM and the manual procedure.

Steps	Manual (required time)	Rapid prototyping (required time)
Impression	1 appointment	1 appointment
Wax sculpture	1 to 2 weeks	1 to 2 days
Try-in	2 to 3 appointments	1 appointment
Issue of prosthesis	1 appointment	1 appointment
Total time	2 to 3 weeks	Within 1 week

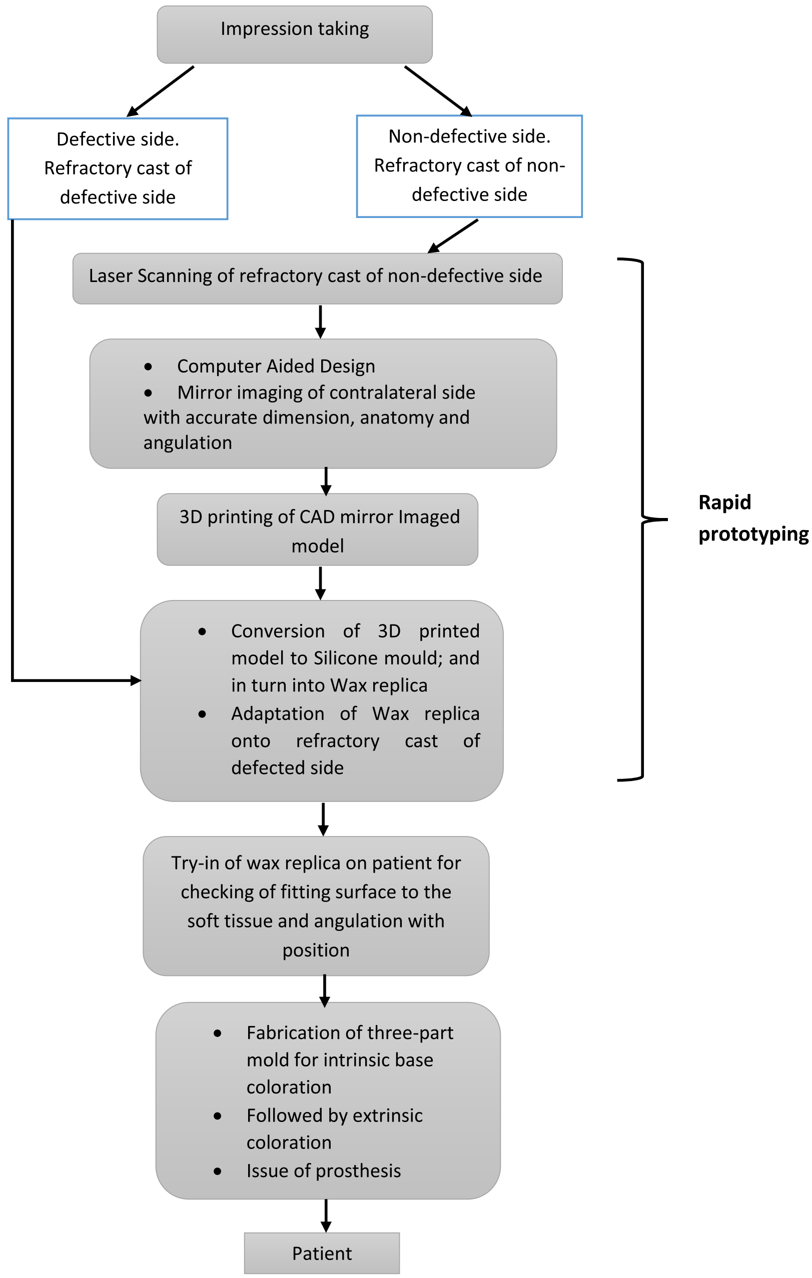

Figure 9 Procedure workflow.

References

1. Toso SM, Menzel K, Motzkus Y, et al. Anaplastology in times of facial transplantation: still a reasonable treatment option? *J Craniomaxillofac Surg* 2015;**43**:1049–53.
2. Jiao T, Zhang F, Huang X, Wang C. Design and fabrication of auricular prostheses by CAD/CAM system. *Int J Prosthodont* 2004;**17**:460–3.
3. Singare S, Zhong S, Xu G, Wang W, Zhou J. The use of laser scanner and rapid prototyping to fabricate auricular prosthesis. In E-Product E-Service and E-Entertainment (ICEEE), International Conference on IEEE 2010;1–3.
4. Karatas MO, Cifter ED, Ozenen DO, Balik A, Tuncer EB. Manufacturing implant supported auricular prostheses by rapid prototyping techniques. *Eur J Dent* 2011;**5**:472–7.
5. Liacouras P, Garnes J, Roman N, Petrich A, Grant GT. Designing and manufacturing an auricular prosthesis using computed tomography, 3-dimensional photographic imaging, and additive manufacturing: a clinical report. *J Prosthet Dent* 2011;**105**:78–82.
6. Watson J, Hatamleh MM. Complete integration of technology for improved reproduction of auricular prostheses. *J Prosthet Dent* 2014;**111**:430–6.
7. Feng Z, Dong Y, Zhao Y, et al. Computer-assisted technique for the design and manufacture of realistic facial prostheses. *Br J Oral Maxillofac Surg* 2010;**48**:105–9.
8. De Crescenzio F, Fantini M, Ciocca L, Persiani F, Scotti R. Design and manufacturing of ear prosthesis by means of rapid prototyping technology. *Proc Inst Mech Eng H* 2011;**225**:296–302.
9. Coward TJ, Scott BJJ, Watson RM, Richards R. A comparison between computerized tomography, magnetic resonance imaging, and laser scanning for capturing 3 dimensional data from a natural ear to aid rehabilitation. *Int J Prosthodont* 2006;**19**:92–100.

10. Ciocca L, Scotti R. CAD-CAM generated ear cast by means of a laser scanner and rapid prototyping machine. *J Prosthet Dent* 2004;**92**:591–5.
11. Reitemeier B, Notni G, Heinze M, Schone C, Schmidt A, Fichtner D. Optical modelling of extraoral defects. *J Prosthet Dent* 2004;**91**:80–4.
12. Cheah CM, Chua CK, Tan KH, Teo CK. Integration of laser surface digitizing with CAD/CAM techniques for developing facial prosthesis. Part 1: design and fabrication of prosthesis replicas. *Int J Prosthodont* 2003;**16**:435–41.
13. Unkovskiy A, Brom J, Huettig F, Keutel C. Auricular prostheses produced by means of conventional and digital workflows: a clinical report on esthetic outcomes. *Int J Prosthodont* 2017;1–4. doi:10.11607/ijp.5446.
14. Saadi R, Lighthall JG. Prosthetic reconstruction of the ear. *Oper Tech Otolayngol Head Neck Surg* 2017;**28**:130–2.

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Biodurability of Poly Implant Prothèse (PIP) breast implants: A prospective analysis of 1028 prostheses in 514 patients☆

Dear Sir,

Introduction

Poly Implant Prothèse (PIP) was a company that manufactured substandard breast implants using cheaper non-medical grade silicone. Around 40,000 women in the UK are thought to have PIP implants inserted.[1] The advice for women in Wales is: seek clinical advice prior to requesting routine removal. If there is clinical need, the National Health Service (NHS) in Wales funds removal and replacement of PIP breast implants inserted privately. This is in contrast to NHS in England where only PIP implants placed on the NHS are replaced.

The Department of Health estimates the rate of implant rupture or significant silicone bleed for PIP implants could rise to 15%–30% after 10 years; whilst other brands demonstrate rupture rates of 10%–14% after 10 years. Therefore, this is an important issue to address in terms of outcomes, implant longevity and health economics. We present the largest heterogenous (private and public health services) experience case series of PIP breast implants to date.

Patients and methods

We performed a prospective cohort study of all Welsh patients requesting assessment of their PIP breast implants between April 2012 and July 2015.

All patients suspected of rupture were offered an ultrasound scan. All patients with viable concerns of any nature were offered implant removal and replacement. Implant removal +/− replacement was conducted under general anaesthetic by a consultant plastic surgeon. Rupture was defined as a break in the continuity of the implant shell and the presence of implant rupture was documented by the operating surgeon. PIP implants were replaced with the same volume Mentor® MemoryGel® implant.

Binary Logistic Regression analysis was used to determine if symptoms/concerns or rupture was related to patient age, implant size and time to rupture.

Results

646 patients were referred, of which 514 patients attended clinic (80%). The mean implant size was 330 cc (Mode 270 cc).

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