Applications of PEEK in Implant Retained Finger Prosthesis

Pokpong Amornvit[1], Dinesh Rokaya[2], Sasiwimol Sanohkan[3]*

1. Maxillofacial Prosthetic Clinic, Golden Jubilee, Medical Centre, Mahidol University, Salaya, Nakon Pathom 73170, Thailand.
2. Dental Biomaterial Science, Faculty of Dentistry, Chulalongkorn University, Bangkok 10330, Thailand.
3. Department of Prosthetic Dentistry, Prince of Songkla University, Hatyai, Songkhla 90110, Thailand.

Abstract

This article presents and describes the use of polyether ether ketone (PEEK) to fabricate an abutment in implant retained finger prosthesis using computer-aided design and manufacturing (CAD/CAM) technology.

The titanium implant was scanned by conventional implant impression coping and a model was fabricated from computer software and the height of the abutment was increased to 15 mm in length. The custom designed implant abutment for the finger prosthesis was milled with PEEK and it was tried on the patient. After its use, tissue reactions were absent. The thumb prosthesis was fabricated by silicone connected with abutment by polyvinyl siloxane which had good retention and function. PEEK abutment was fabricated for the implant retained finger prosthesis using 3D technology.

PEEK abutment had better biocompatible with peri-implant tissue than metal alloy abutment and improved the retention.

Case report (J Int Dent Med Res 2019; 12(4): 1606-1609)

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Introduction

Retention is the key factor for the success of finger prosthesis, i.e. for not only esthetics but also for function. The finger prosthesis requires optimum retention for functions such as grasping push, carrying and holding.[1] The use of bone-anchored implant retained silicone finger prosthesis presents to improve retention for some normal life activity especially in total amputation.[2,3]

Although Ti and its alloys have been used widely in orthopedic and dentistry as an implant biomaterial, some patients may show tissue reactions with extraoral implant abutment.[4,5] In addition, they have significantly higher elastic modulus than human bone and results in severe stress-shielding and failure.[6] Polyetherether-ketone (PEEK) is a semicrystalline white synthetic polymeric compound that has been used for biomedical applications.[7,8] PEEK has excellent properties which are suitable for a range of dental and orthopedic applications, such as, biocompatible, radiologically transparent, resistant to fatigue strain, and low Young's (elastic) modulus (3-4 GPa) being close to the human bone.[9-11] Recently, PEEK biomaterials can be manufactured using three dimensional (3D) milling technology.[12]

The article introduces the use of PEEK for finger prosthesis and describes the process of fabrication of abutment for implant retained finger prosthesis using computer-aided design and manufacturing (CAD/CAM) technology. The feasibility and advantages of this material in finger prosthesis are presented and discussed throughout the manuscript.

Case Report

A 25-year-old male patient complained of less retentive thumb prosthesis. On examination, it showed that he was using implant retained thumb prosthesis and the impression coping used as an abutment to add the retention but was only 5-6 mm above the tissue and the retention was inadequate of the finger prosthesis (Figure 1). In addition, he complained of exudate around the abutment after 2 months of use from the Ti abutment and diagnosed with mild

*Corresponding author:
Sasiwimol Sanohkan
Department of Prosthetic Dentistry,
Prince of Songkla University,
Songkhla, Thailand.
E-mail: sanohkan.psu@gmail.com

inflammation of peri-implant tissues around the implant abutment. On examination, it showed the length of 5 mm tissue level from the shoulder of the implant. Our aim to fabricate a new abutment for finger prosthesis with improved retention and decreasing the tissue reactions, and we selected PEEK material.

Scanning: The Ti implant was scanned with the intraoral scanner (TRIOS Intraoral scanner system Model S1P (3Shape Trios A/S, Copenhagen, Denmark) using conventional impression coping. To locate the angulation of the finger prosthesis, directions were marked with opaldam (supra and infra tissue level).

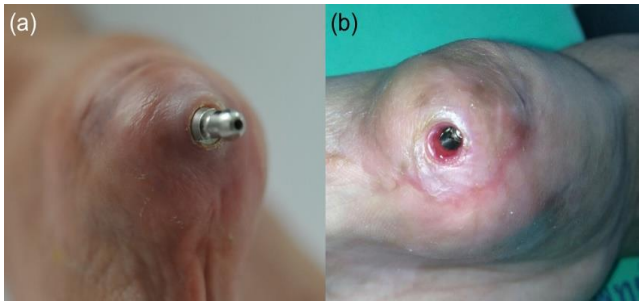

Figure 1. Metal alloy abutment and showing mild tissue reactions around the implant (a), and tissue height of 4 mm from the shoulder of the implant (b).

Designing: The abutment was designed using computer software Exocad (*Exocad* GmbH, Germany, 2010). The abutment was designed longer (15 mm) using keeping the lower part of the implant abutment same as Ti abutment as shown in Figures 2 (a) and 2 (b). In addition, the cylindrical part of the abutment was made rough, the triangular part was made smooth, and a ball was made on the tip to aid retention.

Fabrication: Then, the abutment was milled with PEEK in 5 axis milling machine following manufacturer's instructions as shown in Figure 2 (c). It was tried for the fitting with implant analog as shown in Figure 2 (d). Then, the milled PEEK abutment was tried in the patient as shown in Figure 3(a).

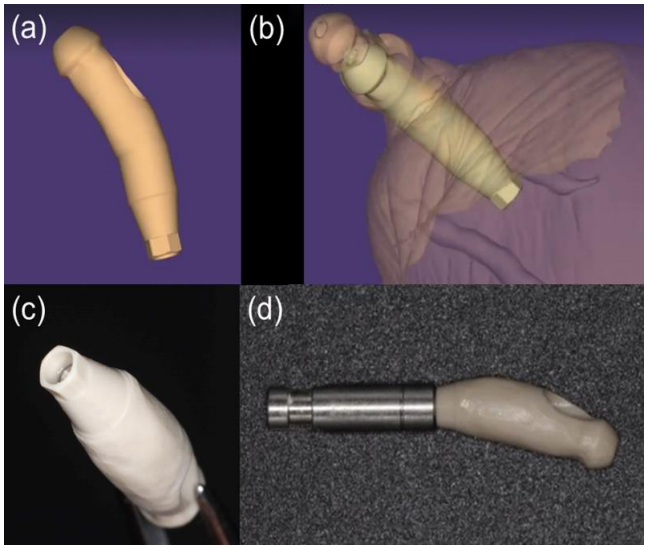

Figure 2. PEEK abutment for implant retained finger prosthesis. Computer software designing (a and b), and milling of PEEK abutment (c and d).

The silicone prosthesis was fabricated as shown in Figures 3 (b) and 3 (c) and connected with the PEEK abutment using the polyvinyl siloxane as shown in Figure 3 (d). The patient was satisfied with the new retention of finger prosthesis. At 3 months follow up, the patient was happy with the prosthesis with slight decrease in the retention. After changing the polyvinyl siloxane retentive part on the on the silicone prosthesis. The functions, such as grasping was improved due to better retention. It was advised to change the retentive part on the prosthesis every 4-5 months which can be done by the patient himself or at the clinic.

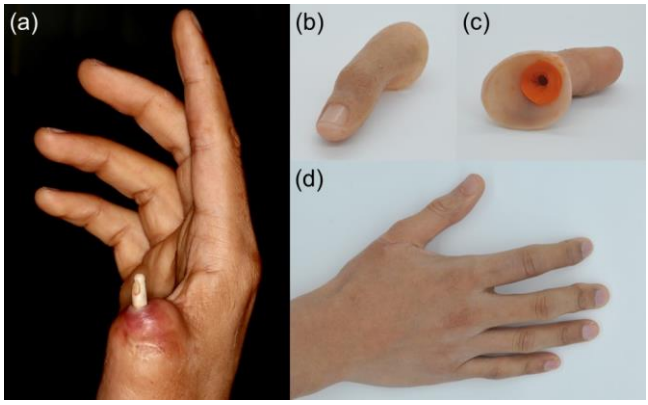

Figure 3. PEEK abutment tried on the patient (a), fabricated final finger prosthesis (b and c), and finger prosthesis retained with PEEK abutment (d).

Discussion

Most of the finger defects are acquired and caused from machine injuries, car accident, explosion, assaults, and others.[13] The conventional silicone finger prosthesis presents an aesthetics alternative to surgical reconstruction.[14-16] In addition, the implant retained finger prosthesis adds an advantage of some functions (press, push and pull),[3] and also includes tactile sensation (osseoperception) by transferring stimuli to the bone through implant because of the direct pressure of the implant on the bone. Rydevik et al. mentioned that osseoperception occurs as a result of the transfer of tactile stimuli to inter-osseous nerves via the osseointegrated implant.[17] In our case, the patient was able to perform writing, holding or grabbing objects like cups, etc. But, to perform these functions, there should be good retention for finger prosthesis and it is a challenge to produce good retention.

Stock abutment for the finger prosthesis is only possible to make a height of 4 mm above the tissue. Due to the short abutment height, the retention is compromised. Another method to increase the height of the abutment is by casting abutment using UCLA abutment by gold alloys. But the consideration is needed for the tissue reactions. By using PEEK, the implant abutment height was increased around 10 mm above the tissue with better tissue reaction and increased retention of the prosthesis.

The suitable current option for the material of the abutment of implant retained finger prosthesis includes Ti and PEEK. There are various types of retention such as magnet and mechanical. For the adequate retention of the prosthesis, there should be an adequate height of the abutment (10 mm above the tissue). In this case, PEEK abutment with 10 mm above the tissue showed adequate retention. In addition, we used the retentive part made from the polyvinyl siloxane which can be changed after 3-4 months once by the patient himself which is cost effective for the patient.

Brauner et al found a problem of gingival hyperplasia around dental implants in jaws reconstructed with free vascularized flaps.[18] They mentioned that this hyperplastic granulomatous reactive tissue around the prosthetic abutment of the implant seem to be directly related to the characteristics of the periimplant tissue and of the manufacturing materials of the prosthesis and abutments. This complication is frequent as seen in 7 of 40 patients (17.5%) but it does not seem to significantly affect the survival rate of implants.

It has been shown that PEEK has suitable mechanical properties (flexural strength, fatigue limit, and hardness) of the PEEK materials for the biomedical applications.[19,20] Schwitalla et al. found that the PEEK materials in consideration were able to resist the pressure caused by maximum masticatory forces of 2000 N.[19] Pokpong et al. found that maximum force generated in implant retained finger prosthesis is less than 50 N during finger functions.[3,21] Hence, for finger prosthesis the forces are less and the PEEK materials are able to function better.

In addition, PEEK showed better tissue reaction than the alloy abutment Hence, it is a suitable material for the abutment of finger prosthesis. One important factor for the PEEK is it needs the proper technical procedure for its processing.[12] Furthermore, a long-term clinical evaluation is needed regarding the performance of PEEK for the finger implants.

Conclusions

Metal alloy abutment may show some tissue reactions. PEEK can be used for the fabrication abutment for the implant retained finger prosthesis using 3D technology. PEEK abutment has advantages with better tissue reaction and suitable mechanical properties.

Declaration of Interest

The authors report no conflict of interest and authors certify that they have obtained all appropriate patient consent form.

References

1. Pereira BP, Kour AK, Leow EL, Pho RW. Benefits and use of digital prostheses. J Hand Surg Am 1996;21(2):222–8.
2. Lundborg G, Branemark PI, Rosen B. Osseointegrated thumb prostheses: a concept for fixation of digit prosthetic devices. J Hand Surg [Am] 1996;21(2):216–21.
3. Amornvit P, Rokaya D, Keawcharoen K, Thongpulsawasdi N. Stress Distribution in Implant Retained Finger Prosthesis: A Finite Element Study. J Clin Diagn Res 2013;7(12):2851–4.
4. Magnusson B, Bergman M, Bergman B, Soremark R. Nickel allergy and nickel-containing dental alloys. Scand J Dent Res 1982;90(2):163–7.
5. Hosoki M, Nishigawa K, Miyamoto Y, Ohe G, Matsuka Y. Allergic contact dermatitis caused by titanium screws and dental implants. J Prosthodont Res 2016;60(3):213–9.
6. Lee W, Koak J, Lim Y, Kim S, Kwon H, Kim M. Stress shielding and fatigue limits of poly-ether-ether-ketone dental implants. J Biomed Mater Res Part B: Appl Biomater 2012;100(4):044–52.

7. Najeeb S, Zafar MS, Khurshid Z, Siddiqui F. Applications of polyetheretherketone (PEEK) in oral implantology and prosthodontics. J Prosthodont Res 2016;60(1):12–9.
8. Pokorný D, Fulín P, Slouf M, Jahoda D, Landor I, Sosna A. Polyetheretherketone (PEEK). Part II: application in clinical practice. Acta Chir Orthop Traumatol Cech 2010;77(6):470–8.
9. Skinner HB. Composite technology for total hip arthroplasty. Clin Orthop 1988;235:224–36.
10. Stratton-Powell AA, Pasko KM, Brockett CL, Tipper JL. The Biologic Response to Polyetheretherketone (PEEK) Wear Particles in Total Joint Replacement: A Systematic Review. Clin Orthop Relat Res 2016;474(11):2394–404.
11. Rokaya D, Srimaneepong V, Sapkota J, Qin J, Siraleartmukul K, Vilailuck Siriwongrungson V. An Overview of Polymeric Materials and Films in Dentistry. J Adv Res 2018;14:25–34.
12. Honigmann P, Sharma N, Okolo B, Popp U, Msallem B, Thieringer FM. Patient-Specific Surgical Implants Made of 3D Printed PEEK: Material, Technology, and Scope of Surgical Application. Biomed Res Int 2018;2018:4520636.
13. Amornvit P, Bajracharya S, Rokaya D, Keawcharoen K, Raucharernporn S. Thongpulsawasdi N. Incidence of the Finger Defect in Golden Jubilee Medical Center: A 2-Year Retrospective Study. World J Dent 2014;5(3):143–6.
14. Rokaya D, Amornvit P, Shrestha B. Rapid fabrication of a digital prosthesis. Singapore Dent J 2015;36:45–8.
15. Aydin C, Karakoca S, Yilmaz H, Yilmaz C, Yamalik K. The use of dental implants to retain thumb prostheses: a short-term evaluation of 2 cases. Int J Prosthodont 2008;21(2):138–40.
16. Amornvit P, Rokaya D, Keawcharoen K, Raucharernporn S, Thongpulsawasdi N. One- Vs Two Stage Surgery Technique for Implant Placement in Finger Prosthesis. J Clin Diagn Res 2013;7(9):1956–68.
17. Rydevik B, Shubayev V, Myers R. Osseoperception. In: Brnemark P-I, Chien S, Gröndahl H-G, Robinson K, eds. The Osseointegration Book: From Calvarium to Calcaneus. 6th ed. Berlin: Quintessence; 2005:149–56.
18. Brauner E, Valentini V, De Angelis F et al. Gingival Hyperplasia Around Dental Implants in Jaws Reconstructed with Free Vascularized Flaps: A Case Report Series. J Int Dent Med Res 2018; 11(1):1–7.
19. Schwitalla AD, Zimmermann T, Tobias Spintig IK, Müller W-D. Fatigue limits of different PEEK materials for dental implants. J Mech Behav Biomed Mater 2017:69:163–8.
20. Schwitalla A, Müller WD. PEEK dental implants: a review of the literature. J Oral Implantol 2013;38(6):743–9.
21. Amornvit P, Rokaya D, Keawcharoen K, Thongpulsawasdi N. Influence of Different Angulations of Force in Stress Distribution in Implant Retained Finger Prosthesis: A Finite Element Study. World Applied Sci J 2014;30(4):481–5.