

CANCELLOUS BONE VERSUS TRICALCIUM PHOSPHATE (TCP) FOR BONE GRAFTING: A LITERATURE REVIEW AND CASE REPORT OF ALVEOLAR BONE GRAFTING IN CIPTO MANGUNKUSUMO HOSPITAL

M. Iqbal Maulana^{1*}, Akmal Primadian², Julieta Pancawati³, Kristaninta Bangun⁴

1. *Research Assistant of Gentur Cleft Foundation, Jakarta, Indonesia*
2. *Indonesia Red Crescent, FKUI, Jakarta, Indonesia*
3. *Orthodontist, Cleft & Craniofacial Center RSUPN dr.Cipto Mangunkusumo, Jakarta, Indonesia*
4. *Universitas Indonesia, Department of Surgery, Division of Plastic Reconstructive and Aesthetic Surgery, RSUPN Cipto Mangunkusumo, Jakarta, Indonesia*

ABSTRACT

Background: In the last decade, there are various methods of bone grafting in plastic surgery. Cancellous bone is more often used as bone graft than cortical bone due to its high osteoconductivity and osteogenic capability. The synthetic materials for bone graft such as tricalcium phosphate (TCP) and hydroxy-apatite can be use as new alternative for bone grafting surgery.

Methods: The PubMed® databases were searched using the terms: 'bone graft OR bone grafting' AND 'cancellous bone OR iliac crest OR tibia' AND 'tricalcium phosphate OR tricalciumphosphate OR tri calcium phosphate', restricted to English language, and to a publication period from January 2010 to January 2017. The inclusion criteria were any kind of research paper that compared the utility of TCP synthetic graft and autograft as a bone graft.

Results: Out of 139 selected studies, only 8 met the inclusion criteria. In 6 publications TCP graft has similar outcome and in 1 publication have a better result in reducing post operative complication.

Conclusion: TCP graft can be used as substitution for autograft in particular clinical conditions and surgical methods.

Keyword: bone graft, cancellous bone, TCP

Latar Belakang : Dalam beberapa dekade terakhir, terdapat berbagai metode mencangkok jaringan tulang di bidang bedah plastik. Tulang spongiosa lebih sering digunakan sebagai cangkok tulang dibandingkan dengan tulang kortikal atau kompak karena kemampuan osteogenesis dan osteokonduktivitasnya yang tinggi. Bahan sintetis untuk cangkok tulang seperti tricalcium phosphate (TCP) dan hydroxy-apatite dapat digunakan sebagai alternatif baru dalam bedah cangkok tulang.

Metodologi : Pencarian sistematis dilakukan di *database* PubMed® dengan istilah: 'bone graft OR bone grafting' AND 'cancellous bone OR iliac crest OR tibia' AND 'tricalcium phosphate OR tricalciumphosphate OR tri calcium phosphate', artikel dalam bahasa Inggris, dan diterbitkan di antara Januari 2010 sampai dengan Januari 2017. Kriteria inklusi pada studi ini adalah penelitian yang membandingkan kegunaan cangkok sintetis TCP dan *autograft dalam operasi pencangkokan tulang*.

Hasil : dari 139 studi yang ditemukan didapatkan terdapat 8 artikel yang masuk dalam kriteria inklusi. Cangkok TCP memiliki hasil yang sama dalam 6 publikasi, dan hasil yang lebih baik dalam mengurangi komplikasi pasca operasi ditemukan dalam 1 publikasi.

Kesimpulan : Cangkok TCP dapat digunakan sebagai substitusi untuk *autograft* dalam kondisi klinis dan metode bedah tertentu.

Kata Kunci : bone graft, cancellous bone, TCP

Received: 28 November 2017, Revised: 14 December 2017, Accepted: 18 December 2017.

Presented in PIT PERAPI, Yogyakarta, Indonesia

ISSN 2089-6492 ; E-ISSN 2089-9734

This Article can be viewed at www.jprjournal.com

INTRODUCTION

In the last decade, there are various methods of bone grafting in plastic surgery. To obtain optimal outcome of surgery, the detail analysis of defect and thorough reconstruction procedure are needed. The current methods of reconstruction surgery uses autograft, allograft, xenograft, and other synthetic materials to filling the bone defect. Bone grafting using autologous material remains as the gold standard procedure. The selection of graft is determined by considering the clinical condition of the patient, history of radiation exposure, risk of infection, depth of bone defect, availability of donor site, and other clinical judgements.^{1,2} The bone grafting is used to fill the gap between bone which was caused by trauma, removal surgery, congenital defects, and other clinical conditions. The process of bone graft fusion is determined by the type of graft, vascularization, quality of bone, mechanic factor of graft, and other comorbidity.²

Cancellous bone is more oftenly used as bone graft than cortical bone due to its high osteoconductivity and osteogenic capability. Faster bony fusion and revascularization with remarkable changes could occur in 2 weeks, nevertheless it is only suitable for a defect with size less than 6 cm width and on *non-stress bearing* area. The most common donor sites are iliac crest, chest bone, tibial, and distal radius bone. Several disadvantages including pain, longer surgery time, and longer length of stay. The use of synthetic bone graft can be another solution to cover the weakness of autolog bone graft. The synthetic materials were made by using tissue engineering so that the materials have similar mechanical properties of human bone. They are able to induce osteogenesis and promote bone healing although not as superior as autolog graft. The synthetic materials for bone graft such as tricalcium phosphate (TCP) and hydroxy-apatite are commonly used worldwide in alveolar bone grafting surgery.²

METHODS

The aim of this study is to compare the utility of autograft materials and synthetic materials particularly tricalcium phosphate in alveolar bone grafting procedure. An electronic search was conducted in PubMed® on February 2017 restricted to English language, and to a publication period from January 2010 to January 2017. The search terms and Boolean operators used were: 'bone graft OR bone grafting' AND 'cancellous bone OR iliac crest OR tibia' AND 'tricalcium phosphate OR

tibia' AND 'tricalcium phosphate OR tricalciumphosphate OR tri calcium phosphate', The inclusion criteria were any kinds of research paper that compared the utility of TCP synthetic graft and. The exclusion criteria include case report study, discussion, prevalence study, and editorial. The final selection was based on the full text version of the potentially relevant articles that were assessed by the reviewers.

RESULTS

The PubMed search resulted in 139 citations and after abstract review 8 were obtained to had the full version reviewed by the reviewers (tabel 1). Those included 3 articles that used TCP graft in alveolar bone grafting, 3 articles used TCP graft in orthopedic procedure, and 2 articles used TCP graft in spinal procedure.

Case Report

A 9 year-old girl was admitted to Cranifacial and Cleft Center, Ciptomangunkusumo Hospital, Jakarta with the chief complaint of alveolar cleft at 21-23 region. The patient was born with complete unilateral cleft lip and palate. The cleft lip and palate were repaired at 2 months and 2 years respectively. A residual alveolar cleft was present and periodically evaluated. Patient had 6 months orthodontic treatment and evaluation prior alveolar bone grafting. Secondary alveolar bone graft was done at 9 years. Alveolar bone graft using autologous cancellous bone and the donor site taken from the patient's right iliac crest with 2 mL in volume. The alveolar bone grafting procedure lasted for 3 hours. The length of stay for post-operative care was 7 days. Patient had moderate mobilization within 2 weeks after surgery. A Four years- evaluation after alveolar bone grafting showed a Bergland index score of 1 (perfect bone graft) and the Chelsea index score was A (ultimate outcome).

Disclosure: *The authors have no financial interest to disclose.*

Table 4. Cross Interaction Matrix between Maternal Age and Paternal Age

No.	Author	Year	Procedure	Type of Subject	Number Of Subject	Comparison	Results
1	Ruiter A et al ³	2010	Alveolar Bone Graft	Animal (Goat)	10	Autolog graft (iliac crest)	From surgical, orthodontic, histologic, and radiologic standpoints that in the repair of alveolar clefts created in goats, the bone substitute b-TCP (CuriOs) is at least as effective as autologous iliac crest bone.
2	Ruiter A et al ⁴	2015	Alveolar Bone Graft	Human	7	-	Bone volume acquired was satisfactory. Average bone volume percentage of 73%±6% compared with the original cleft volume.
3	Ru N et al ⁵	2016	Alveolar Bone Graft	Animal (Rat)	60	Natural bovine cancellous bone particles (Bio-Oss), and no graft	b-TCP has better osteoconductive potential and biomechanical properties and induces less root resorption compared with Bio-Oss grafting and naturally recovered extraction site.
4	Leucht P et al ⁶	2013	Bone Grafting in Acetabular Fracture	Human	43	Autolog graft (cancellous bone)	Patients treated with tricalcium phosphate exhibit a significantly lower incidence of post-traumatic arthritis compared to patients treated with cancellous bone graft.
5	Johannes C et al ⁷	2010	Bone Grafting in Segmental Bone Defect	Animal (Sheep)	12	Autolog graft, medical grade polycaprolactone graft.	The highest amounts of bone neoformation with highest torsional moment values were observed in the autograft group and the lowest in the medical grade polycaprolactone and tricalcium phosphate composite group.
6	Martinkevich P et al ⁸	2016	Calcaneal Lengthening Osteotomy	Human	11	Autolog graft (iliac crest)	At six months the data showed that the osteotomy had been compressed by a mean 1.97 mm more in the HATCP group than in the autograft group. Migration of the CLO grafted with HATCP stabilised at six months rather than at six weeks with autograft.

7	Delawi D et al ⁹	2013	Spine Fusion Surgery	Goat	9	Iliac crest autograft, fresh-frozen allograft, TCP combined with local autograft (50:50)	TCP is capable of achieving fusion at a similar rate to iliac crest autograft in posterolateral fusions, while almost completely resorbing within 16 weeks. Despite the lower fusion volume, the TCP is a promising alternative despite the disadvantages of autograft and allograft.
8	Yamagata T et al ¹⁰	2015	Anterior Cervical Discectomy and Fusion	Human	100	Autolog graft (iliac crest)	Significant neurological recovery after surgery was obtained in both groups. Cage subsidence was noted in 14 of 72 cages (19.4 %) in the autograft group and 12 of 64 cages (18.8 %) in the β -TCP group. A total of 66 cages (91.7 %) in the autograft group showed osseous or partial union, and 58 cages (90.6 %) in the β -TCP group showed osseous or partial union by 2 years after surgery. There were no significant differences in cage subsidence and the bony fusion rate between the two groups.

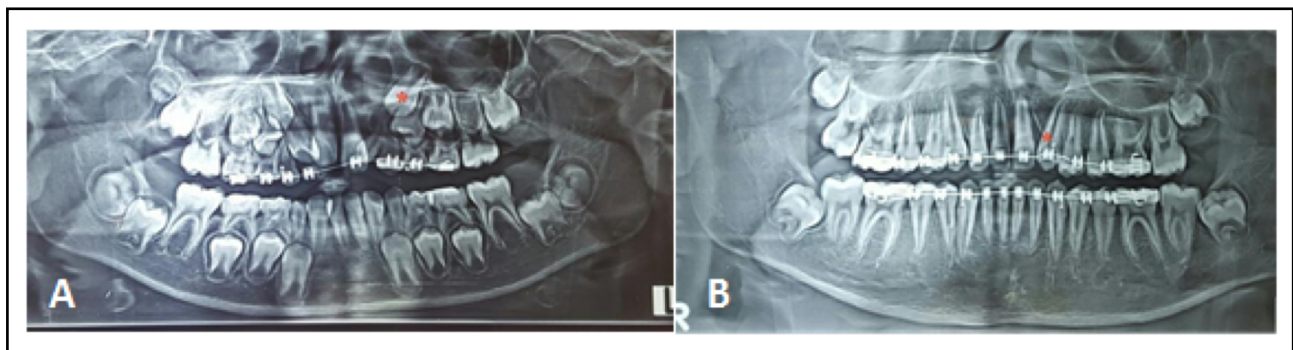


Figure 1. Panoramic photographs: (A) Pre-alveolar bone graft. Notice there is no canine eruption and left incisor agenesis; (B) 4 years post-alveolar bone grafting. Notice the excellent canine eruption replace the agenesis second incisor. Notice there is bone tissue at the *cemento enamel junction* adjacent cleft side (Chelsea type A). Interdental septum height close to normal (Bergland scale 1: Resorption <25%)

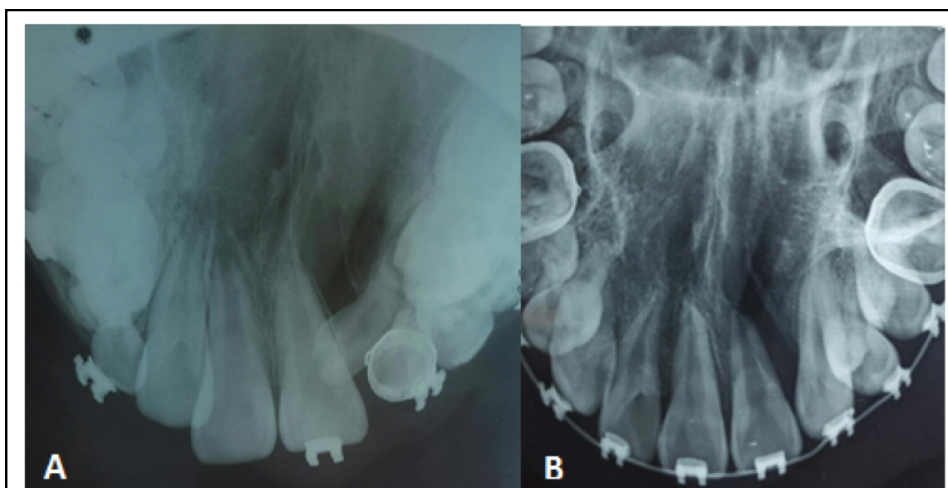


Figure 2. Occlusal photographs: (A) Pre-alveolar bone graft; (B) 4 years post-alveolar bone graft. Notice the bonny area in *cemento-enamel junction* adjacent cleft area, interdental septum height close to normal.

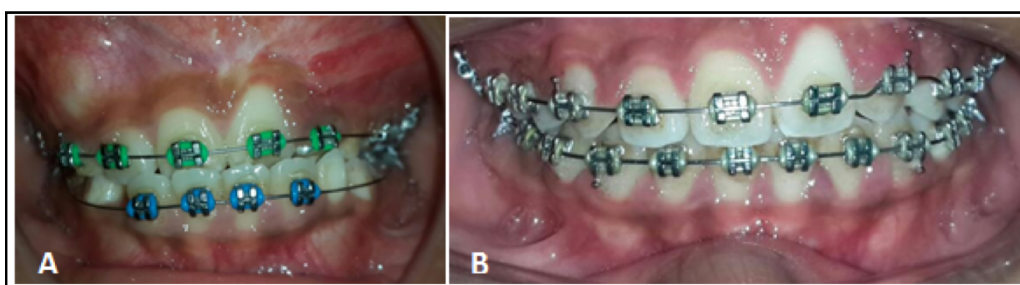


Figure 3. Front view photographs: (A) Pre-alveolar bone graft; (B) 4 years post-alveolar bone graft. Note the excellent dental alignment.

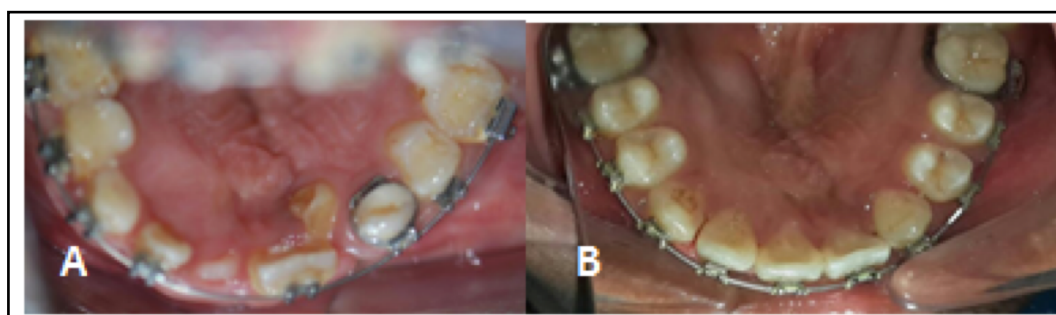


Figure 4. Intraoral photographs (A) Pre-alveolar bone graft; (B) 4 years post-alveolar bone graft. Note the canine eruption replace the left agenesis second incisor. Note the minimal soft tissue depression in palatal cleft area. Note the gingiva hiperplasia in left canine buccal area caused by poor oral hygiene.



Figure 5. Donor site photograph after 4 years shown tangible scar.

DISCUSSION

Synthetic grafts are commonly used for various kinds of surgical procedures both in humans and animals. The research conducted by Ruiter A et al proof that TCP graft was as effective as iliac bone autograft in terms of histology, radiology evaluation, and surgical perspectives. It was then established that TCP graft made better bone regeneration than the autograft did.³ According to an experiment on mice conducted by Ru N et al, TCP graft had higher osteoconductivity and better biomechanic property than cancellous bone graft or without graft.⁴ Another research on humans has shown that there was remarkable bone volume addition ($73\% \pm 6\%$ of its initial volume) during 6 months after bone grafting with TCP. Hence, TCP graft has shown several potentials to be used as a substitution of autograft materials instead.⁵

TCP grafts have also been widely used by orthopedic surgeons to repair bone defects in certain clinical conditions. Leucht P et al showed that there were no significant differences of functional scores between the use of TCP graft and autograft in repairing acetabulum fractures with marginal impaction. In addition, the incidence of post-operative arthritis in groups of those who used TCP was lower than in those groups who used autograft. These results concluded that TCP graft provides similar benefits as autograft with lower risk of post-operative complication.⁶ A research conducted by Johannes C et al showed that the use of autograft gave better results than TCP graft to repair segmental defects on a long bone in sheep model experiment. It was also stated that the autograft is superior than TCP graft in terms of making bone formation and providing capability of resisting weight force, therefore it is not recommended to use TCP graft to repair segmental defects on long bones.⁷ Martinkevich P et al stated that the use of Hydroxy Apatite-TCP (HATCP) on human

calcaneal lengthening osteotomy gave more stabile results than that which use autograft. The autograft reached its stability during 6 weeks after surgery, while it took 6 months for TCP graft until it is completely stable, which conclude that TCP graft is not a good to be used on *calcaneal lengthening osteotomy*.⁸ Another superiority of TCP graft has been established by Delawi D et al. It was said that TCP graft had similar bone fusion rate like autografts and completely resorbed in 16 weeks. On the other hand, the TCP graft made smaller bone fusion volume than autograft did (autograft 7.8 mL, allograft 8.9 mL, TCP 6.1 mL, and TCP with local autograft 6.0 mL). However, TCP graft can be used as a substitution for autograft during spine fusion surgery.⁹ A significant neurology recovery was achieved by those group which use TCP graft during *Anterior cervical discectomy with titanium cage fusion*, as stated by Yamagata T et al. The cage subsidence were 14 of 72 (19,4%) for autograft and 12 of 64 (18,8%) for TCP graft. The partial union incidence 2 years after surgery of those who underwent surgery by using TCP graft and autograft were 90,6% and 91,7% respectively. Therefore, there is no significant difference of cage subsidence and bony fusion rate between those group which use TCP graft and autograft. Both TCP graft and autograft are grafts of choice for *Anterior cervical discectomy with titanium cage fusion* procedure.¹⁰ The alvolar bone graft in RSCM gives excellent results although some disadvantages such as pain and scar in the donor site, long length of stay for post-operative care, long mobilization time. We advise using TCP graft for alveolar bone grafting due its excellent results and lower the morbidity which will make more benefit for the patient.

CONCLUSION

The TCP graft is still not yet widely used during surgical procedure in Indonesia despite their promising benefits. The use of TCP graft is mainly aims to reduce the morbidity of the patients, shorten the duration of surgery, and limit the cost of medical service. In addition, several researches have shown the similarity of post surgical evaluation results between the use of TCP graft and autograft in various types of surgery. In conclusion, TCP graft can be used as substitution for autograft in particular clinical conditions and surgical methods.

Corresponding author :

Muhammad Iqbal Maulana

muhammadiqbalmaulana@rocketmail.com

REFERENCES

1. Cooney DS, Sacks JM, Brandacher G, Lee WPA. Transplantation Biology and Application to Plastic Surgery. In: Thorne CH, Beasley RW, Aston SI, Bartlett SP, penyunting. Grabb and Smith's plastic surgery, 7th ed. Philadelphia: Lippincott Williams & Wilkins; 2013. h. 57-64.
2. O'Connor AJ, Morrison WA. Tissue Engineering. Dalam: Chang J, Neligan PC, penyunting. Plastic Surger, 3rd ed. Philadelphia: Saunders-Elsevier Health Sciences; 2012. p. 392-393.
3. Ruiter A, Meijer G, Dormaar T, Janssen N, Bilt A, Slootweg P, Bruijn J, Rijn L, Koole R. β -TCP Versus Autologous Bone for Repair of Alveolar Clefts in a Goat Model [internet, cited 2017 Mar 26]. Doi: 10.1597/09-219. Available from: https://www.Research_gate.net/publication/46147095_b-TCP_Versus_Autologous_Bone_for_Repair_of_Alveolar_Clefts_in_a_Goat_Model.
4. Ruiter A, Janssen N, Es R, Frank M, Meijer G, Koole R, Rosenberg T. Micro-structured Beta-Tricalcium Phosphate for Repair of The Alveolar Cleft in Cleft Lip [internet, cited 2017 Mar 26]. Cleft Palate Craniofac J. 2015 May;52(3):336-40. doi: 10.1597/13-260. Epub 2014 Jun 11. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/24919123>.
5. Ru N, Liu SS, Bai Y, Li S, Liu Y, Zhou G. Microarchitecture and Biomechanical Evaluation of Bone Ceramic Grafted Alveolar Defects During Tooth Movement in Rat. Cleft Palate Craniofac J. 2016 Sep 12. [Epub ahead of print]. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/27618613>.
6. Leucht P, Castillo AB, Bellino MJ. Comparison of tricalcium phosphate cement and cancellous autograft as bone void filler in acetabular fractures with marginal impaction [internet, cited 2017 Mar 26]. Injury. 2013 Jul;44(7):969-74. doi: 10.1016/j.injury.2013.04.017. Epub 2013 May 14. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/23684351>.
7. Reichert JC, Wulschleger ME, Cipitria A, Lienau J, Cheng TK, Schütz MA, Duda GN, Nöth U, Eulert J, Hutmacher DW. Custom-made composite scaffolds for segmental defect repair in long bones [internet, cited 2017 Mar 26]. Int Orthop. 2011 Aug;35(8):1229-36. doi: 10.1007/s00264-010-1146-x. Epub 2010 Dec 7. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/21136053>.
8. Delawi D, Krut MC, Huipin Y, Vincken KL, de Bruijn JD, Oner FC, Dhert WJ. Comparing autograft, allograft, and tricalcium phosphate ceramic in a goat instrumented posterolateral fusion model [internet, cited 2017 Mar 26]. Tissue Eng Part C Methods. 2013 Nov;19(11):821-8. doi: 10.1089/ten.TEC.2012.0576. Epub 2013 May 30. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/23521120>.
9. Yamagata T1,2, Naito K2, Arima H2, Yoshimura M3, Ohata K2, Takami T4. A minimum 2-year comparative study of autologous cancellous bone grafting versus beta-tricalcium phosphate in anterior cervical discectomy and fusion using a rectangular titanium stand-alone cage [internet, cited 2017 Mar 26]. Neurosurg Rev. 2016 Jul;39(3):475-82. doi: 10.1007/s10143-016-0714-y. Epub 2016 Apr 21. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/27098659>.
10. Martinkevich P, Rahbek O, Stilling M, Pedersen LK, Gottlieb M, Søballe K, Møller-Madsen B1. Is structural hydroxyapatite tricalcium-phosphate graft or tricortical iliac crest autograft better for calcaneal lengthening osteotomy in childhood? interim results from a randomised, controlled non-inferiority study [internet, cited 2017 Mar 26]. Bone Joint J. 2016 Nov;98-B(11):1554-1562. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/27803234>