Clinics in Surgery

Research Article
Published: 11 Jun, 2021

Radiologic Results of Opening Wedge High Tibial Osteotomy with Granular Hydroxyapatite and Beta-Tricalcium Phosphate Bone Substitute

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Abstract

Background: Opening Wedge High Tibial Osteotomy (OWHTO) is a procedure used mainly for medial osteoarthritis of knee. As open angle gets larger, for mechanical support and facilitation of bony union, autogenous bone, allogenic bone or bone substitute is used. This study aims to analyze the radiographic results of application of granular hydroxyapatite and beta-tricalcium phosphate after OWHTO.

Method: Patients who went through OWHTO surgery between 2015, February to 2019, November were selected. Pre, post-operatives impeller diagram were compared to assess for length and angle correction. Postoperative simple radiograph and computed tomography can were taken 1year after surgery to assess for gap filling, bony union and Hounsfield units score.

Result: Mean correction angle was 13.29°; Mean gap length was 12.98 mm. Every cases how gap filling of more than zone 3. Ten cases which gained zone 3 gap filling gained mean angle correction of 16.14°, mean gap length of 6.97 mm. Eleven cases which gained zone 4 gap filling gained mean angle correction of 13.62°, mean gap length of 12.29 mm. Thirty-six cases which gained zone 5 gap filling gained angle correction of 12.53°, mean gap length of 11.89 mm. Every cases gained bony union and 1 case of superficial wound infection occurred.

Conclusion: Gap filling occurred despite of large amount of correction angle and correction length. And radiographic osteo integrations were observed.

Keywords: Opening wedge high tibial osteotomy; Osteointegration; Bone substitute

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Received Date: *17 May 2021*

Accepted Date: *07 Jun 2021*

Published Date: *11 Jun 2021*

Citation:

Choi ES, Kim KJ, Ahn BH, Kim MB. Radiologic Results of Opening Wedge High Tibial Osteotomy with Granular Hydroxyapatite and Beta-Tricalcium Phosphate Bone Substitute. Clin Surg. 2021; 6: 3209.

Introduction

Open wedge high tibial osteotomy is a useful procedure for osteoarthritis of knee associated varus angulation involving medial component. Usually patients under 65-years old, without ligamentous instability and reserved range of motion is a good candidate for surgery [1]. Alignment correction to reduce medial compartment loading ease the pain of the patient and even expect for chondral regeneration [2]. But medial gap could cause collapse or loss of correction and osteotomy site non union or delayed union can occur depending on the size of osteotomy [3,4]. To solve this problem, autogenous bone, allogenous bone and bone substitute such as hydroxyapatite are in use [5]. These substances are selected regarding osteo conductivity and mechanical strength. After stability of T-shape locking plate increased, structural graft for mechanical strength is no more needed [6]. As a result, bone chip or sponge-form bone substitute which has porosity similar to cancellous bone are used, but it still has poor remodeling and incorporation capability [7,8]. This study uses granular hydroxyapatite and beta-tri calcium phosphate bone substitute (Figure 1, 2), that comprise of multiple pore which is expected to facilitate osteo conduction. To assess for osteo integration, radiograph and Computed tomography can were used.

Materials and Methods

Patients

Patients who went through open wedge high tibial osteotomy surgery between 2015, February to 2019, November were selected. 47 patients out of 52 patients, excluding 5 patients who didn't show up during1 year follow up, were enrolled. Fourteen patients were male and 33 patients were female. Three male patients and 7 female patients went through both knee-surgeries. Mean age was 56.1 years old (45 to 68). Mean BMI was 28.0 (18.9 to 39.4) kg/m^2 Mean operation time was 76.5

Figure 1: Cylindrical structure with multiple pores.

Property	Frabone - II
Diameter	2mm
Type	Granular bone substitute
Composition	Purified and nano- HAp / ß-TCP powder(Ratio 60 : 40)
Channel number	7
Channel Diameter	200㎛
Porosity	>45%

Figure 2: Characters of Frabone.

Age(y)	56.1(45-68)
Female/Male	33/14
Body mass index(kg/m^2)	28.0(18.9-34)
Follow up period(m)	19.3(12-53)
Operation time(min)	76.5(50-140)

Figure 3: Characters of patients.

min (50 to 140). Mean observation period was 19.3 months (12 to 53) (Figure 3).

Surgical procedure and rehabilitation

Pre-operative standing bilateral long-standing radiographs were used to assess for alignment and to see if mechanical axis alignment going through Fujisawa point (point indicates 62.5% of length of proximal tibial plateau measured anteroposterior knee radiography starting from medial edge) [9]. Operation was done by a single surgeon and every procedure was done under epidural or general anesthesia. Patient was placed on a radiolucent table in a supine position. Tourniquet was applied to the thigh. Knee arthroscopy was done to check for intra-articular chondral lesion or meniscus pathology, prior to osteotomy. If needed chondroplasty, microfracture technique, and partial meniscectomy procedures were done for the lesion found during knee arthroscopy. Longitudinal incision was made between medial border of proximal tibia and tibial tuberosity to expose medial surface of tibia. Kirschner-wire was inserted to the point for osteotomy and was checked by C-arm fluoroscopy. Mono planar steotomy were done by oscillating saw and spreader was used to widen the space as planned. Metal block was placed to maintain alignment and locking plate (Ohtofix, Oht Medical, Ilsan, and Republic of Korea) was used for fixation. Frabone (Granular hydroxyapatite and beta-tri calcium phosphate bone substitute) was filled between the osteotomy gap. Suture was done layer by layer and Long leg splint was applied. Range of motion exercise was limited for 1 week with long leg splint applied. Removable splint was applied after 1 week. Continuous passive motion and range of motion exercise began. Toe touch or touchdown with crutch ambulation was allowed until 6 weeks and gradual weight bearing ambulation were allowed. Plate removal was done 1year after

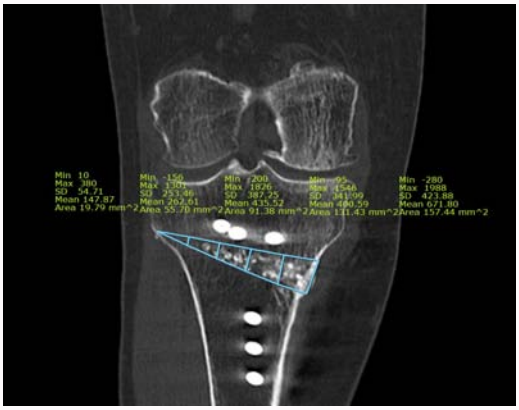

Figure 4: CT images at 1 year follow-up, Coronal view, five zones and each mean Hounsfield unit score.

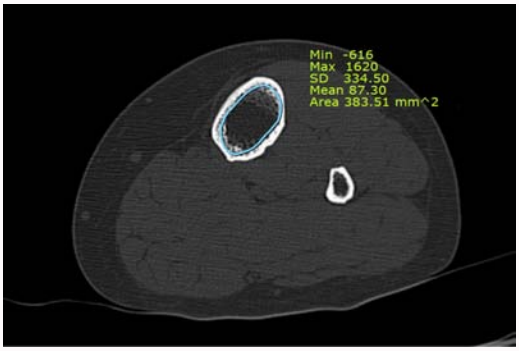

Figure 5.1: CT images at 1years follow-up, Axial view, Region of interest with trabecular bone as much as possible.

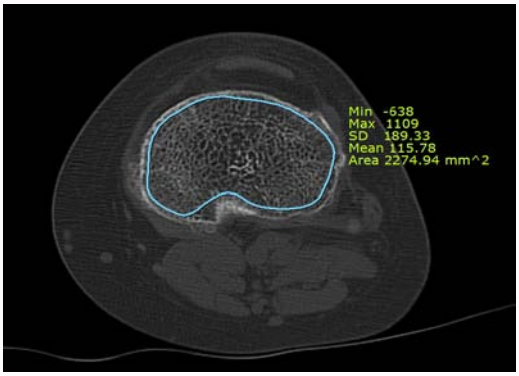

Figure 5.2: CT images at 1years follow-up, Axial view, Region of interest with trabecular bone as much as possible.

the surgery. CT scan was done prior to implant removal and post operative simple radiograph was taken.

Evaluation methods

Postoperative anteroposterior radiograph were used to measure osteotomy angle from hinge and length between medial ends from osteotomy gap. Simple anteroposterior radiograph taken 1 year after osteotomy were used to check which zone were filled, by dividing the length between osteotomy medial end to lateral end by 5. From lateral starts zone 1 and zone 5 (10) to the medial. Similarly, osteotomized gap were divided into 5 zones in a same manner in CT scan. Coronal, axial, sagittal cut in each zone, which were free from metal artifact were chosen. Region of interest value in each selected 3 images for

measured zone were summed up for mean value (Figure 4). Value of unfilled zone was excluded. For comparison proximal and distal axial cut free from plate were chosen and Region of interest were drawn excluding cortical bone and including trabecular bone as much as possible (Figure 5). Zone that were unable to distinguish bone with the substance were classified as grade 1, that were able to distinguish the substance were classified as grade 2, and no sign of osteo integration were classified as grade 3. Region of interest values and grades were evaluated 2 independent orthopedic specialist observers.

Results

Mean correction angle was 13.29°; Mean gap length was 12.98 mm. Every case showed gap filling of at least zone 3. Ten cases which gained zone 3 gap filling gained mean angle correction of 16.14°, mean length correction of 16.97 mm. Eleven cases which gained zone 4 gap filling gained mean angle correction of 13.62°, mean length correction of 12.29 mm. Thirty-six cases which gained zone 5 gap filling gained angle correction of 12.53°, mean length correction of 11.89 mm. Every cases gained bony union and 1 case of superficial wound infection occurred. Mean HU of normal bone was 106.4 (41.6-184.1), zone 1 was 379.2 (44.8-1141.9), zone 2 was 778.45 (46.4-1151.64), zone 3 was 814.37 (121.2-1344.0), zone 4 was 680.2 (74.5-1416.5), zone 5 was 410.98 (214.3-1265.7) (Figure 6). Mean grading for osteo integration for each zone is as followed; zone 1 was 1, zone 2 was 1.12 (1-2), zone 3 was 1.29 (1-3), zone 4 was 2.03 (1-3) zone 5 was 2.43 (2-3). There was no complication of nonunion, delayed union or loss of correction in this study. There was 1 case of superficial infection and warranted additional antibiotics.

Discussion

Open wedge high tibial osteotomy is a useful procedure for osteoarthritis of knee associated varus angulation involving medial component, which is reported to show successful results. However it in evidently results in osteotomy gap. Gap resulting after correction angle less than 10° does not warrant additional gap filling to prevent nonunion or loss of correction [11]. But in case of correction angle more than 10°, obese patients or intraoperative lateral tibia cortex fracture bone grafting is recommended [12]. In this study, 47cases excluding 5cases out of 52 cases, correction angle were more than 10 degree and bony unions were gained in every cases, with no appearance of loss of correction. Currently, autogenous bone, allogenous bone and other bone substitutes are used. Autogenous bone graft were thought to be the gold standard regarding biocompatibility but donor site morbidity with increased operation time can become a setback [13,14]. To use other bone substitutes instead of autogenous bone, the substance should have enough osteo conductivity and bio absorbability to adequately osteo integrate. In this study, similar to previous studies, osteo integration were assessed by HU (Hounsfield Unit) quantitatively and overall integration were assessed by grading [15,16]. Zone 1 which was farthest lateral, had smallest gap, and were impossible to distinguish between normal bones. As the zone progresses less osteo integrations were observed. Meanwhile, Hounsfield unit was unexpectedly lower on zone 4, 5. This is thought to be due to the defects between granular structures. This would be limitation of the study using Hounsfield unit calculation for chip or granule type bone substitute. This study possibly imposes selection bias due to its retrospective nature. Only one surgeon performed every procedure, so reproducibility could be low in this study. There is no comparison group with the substitute group, and observation period is relatively short which warrants further studies.

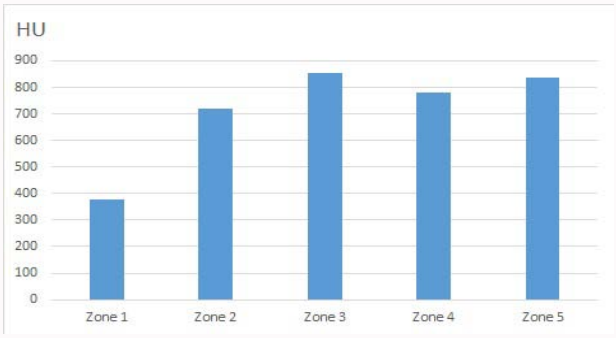

Figure 6: Hounsfield unit trends, Comparison between the zones.

Conclusion

Granular hydroxyapatite and beta-tricalcium phosphate bone substitute (Frabone) could be a reasonably useful substance for filling the gap for osteotomy with high correction angle.

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