Ganz Osteotomy for Adolescent and Young Adults with Acetabuler Dysplasia.

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Authorship and contribution Declaration:
Each author of this article fulfilled ALL 4 Criteria of Authorship:
1. Conception and design or acquisition of data, or analysis & interpretation of data.
2. Drafting the manuscript or revising it critically for important intellectual content.
3. Final approval of the version for publication.
4. All authors agree to be responsible for all aspects of their research work.

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ABSTRACT

Objective: To determine the functional and radiological outcome of Ganz osteotomy for the treatment of acetabular dysplasia (AD) in adolescent and young adults.

Methods: This descriptive study was conducted in Department of Orthopaedics and Traumatology Altınbas University Medical Faculty Istanbul Turkey from 2nd February 2013 to 2nd January 2022.All adolescent and young adults with acetabular dysplasia(AD) fulfilling the inclusion criteria were operated with Ganz osteotomy(Bernese).Post operative functional results were assesses with Merle d'Aubigne Hip Score and gradded as excellent(score 15-17) good(12-14,average(11-13) and poor(<11).The radiologoical outcome was evaluated in terms of measuring the restoration of Lateral Central-Edge Angle (LCE), Anterior Central-Edge angle (ACE), Acetabuler Index(AI), Lateralized hip sign(LHS) and Shenton-Menard line (SML).

Results: We operated on 19 hips in 18 patients.The mean age was 23.05±2.48 years(range 15 to 32 years). Female patients were 13(72.22%) and male 5(27.22%).Left sided Ganz osteotomy was performed in in 9 (50%) patients, right in 8 (44.44%) and both sides in 1 (5.55%) patient. The average follow up peroid was 3.26±6.8 years. All the patients had excellent functional outcome with Merle d'Aubigne Score improved from pre operative 12.47 ± 1.02 to 17.21 ± 1.03 post operative($P<0.05$) All the radiological parameters were restored with post operative LCE 35.16 ± 9.25°,ACE 32.37 ± 6.49°,AI 9.16 ± 4.26°,LHS10.00 ± 3.11 mm and intact SML in 13(68.42%) hips.($P<0.05$)

Conclusion: Ganz osteotomy is an effective technique for the surgical treatment of acetabular dysplasia in adolescents and young adults as shown by excellent functional and radiological outcome in our series.

Keywords: Acetabular Dysplasia, Acetabuler Index, Bernese osteotomy, Ganz osteotomy, Merle d'Aubigne Hip Score.

This article may be cited as: Ince Y, Caniklioglu M. Ganz Osteotomy for adolescent and young adults with acetabular dysplasia .J Pak Orthop Assoc 2022;34(2):79-86.

INTRODUCTION

Acetabular Dysplasia (AD) is a developmental failure of the acetabulum with a structural malformation of the acetabular rim accompanied by insufficient coverage of the femoral head leading to an unstable hip joint and deformations of the femoral head.[1] Untreated or residual forms of developmental dysplasia of the hip (DDH), Leg-Calve-Perthes disease and several neurological diseases can lead to AD and secondary osteoarthritis in early adulthood.[2,3] The mainstay of AD treatment has been focused on providing a functional and painless hip joint with a wide range of motion (ROM). Although total hip arthroplasty has served as the ideal treatment of choice in the middle-aged and elderly population of AD, prosthesis in young and active patients is controversial due to short prosthetic lifespan and the need for revision surgeries. Hence pelvic osteotomy had been proposed as the ideal management tool in young, active patients with well-preserved acetabular cartilage and mild to moderate levels of degenerative change in order to prevent secondary osteoarthrosis and possibly reversing the existing damage.[4-6] Dating back to the work of Konig in the 1890 several

osteotomy methods have been proposed and osteotomy techniques have evolved and become widespread during the historical process.[7] In 1988 Reinhold Ganz, a Swiss Orthopedic surgeon described the Ganz (Bernese) periacetabular osteotomy, considering the limitations of the prior osteotomy methods, the Ganz osteotomy has become the mainstay of surgical treatment for the reorientation of the mature dysplastic acetabulum.[8] Although it is a technically advanced technique with a longer learning curve the technique allows the implementation of all osteotomies in the same session through a single incision and providing a better outcome. In addition, labral pathologies can easily be evaluated and treated by hip arthroscopy or arthrotomy during the procedure, with preservation of and the posterior column of hemipelvis. With minimal internal fixation of the osteotomy, the patient does not require an additional outside splint and is mobilized in the early postoperative period.Vaginal delivery is also possible in young female patients of childbearing age by virtue of maintained pelvis dimensions.Moreover Ganz osteotomy does not pose a restriction to total hip arthroplasty rather strengthens the hip and acetabulum anatomically for prosthetic surgery.[9-11]

The objective of our study was to determine the functional and radiological outcome of Ganz osteotomy for the treatment of acetabular dysplasia (AD) in adolescent and young adults.

METHODS

We conducted this descriptive study in Department of Orthopaedics and Traumatology Altınbas University Medical Faculty Istanbul Turkey from 2nd February 2013 to 2nd January 2022.All adolescent and adults patients of AD with Tonnis grade[12] 0,1 and 2 and with an acceptable femoro-acetabular fit on the preoperative abduction/internal rotation radiographs were included.All patients treated elsewhere and revisions were excluded.The study was approved by the Institutional Review Board.Informed written consent was obtained from all study participants or their parentss.Detailed history and clinical examination was undertaken. Relevant investigations were obtained.The preoperative functional outcome was assessed with Merle d'Aubigne Hip Score[13] This score was calculated by taking into account pain,mobility and ability to walk with minimum of 0(worst) to maximum 6(best) score for each component.The score was summed up and interpretated as excellent (15-17) good (12-14,average (11-13) and poor (<11). The radiological measurements included Lateral Central-Edge Angle (LCE) of Wiberg calculated on Xray pelvis AP view.(Normal 25° to 40°)[14] Anterior Central-Edge Angle (ACE) or Vertical Center Anterior (VCA) angle measured on false profile view hip radiograph. (normal 20° to 45°).[15] Acetabuler Index(AI) was measured on AP pelvis radiograph.(normal 3° to 13°).[16] Lateralized hip sign(LHS) indicated lateral subluxation of femoral head measured on AP radiographs(normal<10mm).[17] Continuity or interruption of the Shenton Menard Line (SML) was assessed on xray pelvis AP view.[18]

Surgical technique

Prior to Ganz osteotomy the surgical team carried out detailed cadaveric studies and the details of osteotomy procedures, neighboring structures, features of the surgical area and possible complications.The patient was positioned supine on a radiolucent table. The involved extremity was prepared and draped in a free manner in order to provide positioning during the surgery and better visibility of the iliac crest and femur. The osteotomy instruments were custom-designed and fabricated specifically for this type of surgery(Figure I) A modified Smith-Petersen incision was performed for the superficial dissection on the extended hip in order to provide a safe approach and efficient exposure (Figure II). By continuing the dissection in this plan the adipose tissue lying between the Sartorius and Tensor Fascia Lata muscles was reached. The fascia of the Tensor Fascia Lata located lateral to the main branch of the Femoral cutaneous nerve was split apart and the muscle was pulled in the lateral direction with a Langenbeck retractor. By a longitudinal incision on the base of this compartment through the space provided the Rectus Femoris muscle and its reflective part were reached.

The anterior superior iliac spine (ASIS) was displaced by a V-type osteotomy and the origins of Tensor Fascia Lata and Sartorius muscles were moved medially along with the inguinal ligament. The origin of the External Oblique muscle was removed and separated from its attachment to the iliac crest subperiosteally. The dissection was continued in the subperiosteal direction up to the linea terminal on the inner surface of the iliac wing. Intra-pelvic dissection was continued by separating the origin of the iliac muscle from its attachment, along the interspinous crest. This process was continued until the origin of the Rectus Femoris muscle and the reflective head are visible.

In the meantime flexing the hip to 40 degrees prior to the surgical division of the reflected head of

the Rectus Femoris muscle would loosen the medial soft tissues and expand the field. The direct head was separated from the anterior inferior iliac spine (AIIS) and the reflected head was pulled medially with the help of a Langenbeck retractor. The capsular part of the iliac muscle was separated from the capsule until the Psoas tendon becomes visible. Following the medial direction of the Psoas muscle tendon with the aid of a Hohmann retractor and to preserve the femoral nerves and vessels the medial border of the dissection was reached.

Subsequently the anteroinferior part of the capsule was exposed by the distal separation of the capsule and the iliocapsular muscle and the medial retraction of the muscle was done. Surgical scissors with wide and curved tips were advanced to the ischium in contact with the capsule in the posterior direction along with the capsule. The ischium was palpated through this space avoiding the insertion of any instrument into this area in an attempt to secure the Sciatic nerve and the Medial Circumflex artery. Thus keeping the instruments in contact with the capsule while continuing the dissection process was highly recommended.The periosteum was cut along the anterior face of the acetabulum in order to open the inner wall of the pelvis and reach the ischial spine. The flexion and adduction of the leg were recommended to overcome the soft tissue tension while retracting the area with an elevator to expose the sacroiliac ligament. By creating a subperiosteal tunnel in this area and extending a pelvic retractor from this tunnel to the greater sciatic foramen muscles and the Sciatic nerve are protected during supra- and retro-acetabular osteotomies of the ilium.Following the soft tissue dissections the pubis, ischium and ilium were ready for osteotomy procedures.Periacetabular osteotomy was performed in five stages while keeping the hip at 45 degrees of flexion (Figure III).The initial incomplete ischium osteotomy was performed under fluoroscopy guidance with a 15 mm fork-tipped osteotome angled 30 degrees. The osteotome is advanced slowly through a created notch and an incision is made at a depth of 20-25 mm. During this incision, the direction of the osteotome was gradually changed and directed towards the posterosuperior, meticulously securing the sciatic nerve.The second osteotomy was the pubic osteotomy performed while the hip was flexed with a mild adduction angle. With the help of a 15mm osteotome the osteotomy was started medial to the iliopubic eminence and completed at an angle of 45 degrees to the midline.

Subsequent supra- and retroacetabular osteotomies were performed in two stages. First, a 4 cm vertical osteotomy is made starting below the osteotomized ASIS towards the terminal line of the pelvis extending 1.5 cm distance to the terminal line**.** The incision was extended towards the ischiatic spine with a rotating angle of 110-120 degrees. The crucial part herein was leaving the 1 cm of bone column intact and it was recommended to determine the osteotomy line prior to the incision by marking the bone with a 10 mm osteotome in order to reduce the margin of error.

Following a 4 cm vertical incision with a motor cutter 15 mm straight osteotomes were used in the area widened with the help of retractors. With a 15-20 mm diameter beveled osteotomes the osteotomy was extended towards the ischium from the inner side of the ilium while the joint was kept at slight abduction and flexion. A controlled fracture was done with a Schanz nail (placed in ASIS supraacetabularly) and laminar spreader (inserted in the osteotomy line) with meticulous manipulation without reaching the joint or foramen.The acetabular fragment was released with the help of a Schanz nail, laminar spreader and angled osteotomes. The view of the dissected released fragments is shown in Figure IV on cadaveric samples.

The free fragment with the acetabular joint face was medialized in order to compensate for the lateralization tendency of the joint. When adequate and optimal correction was achieved the position was fixed with 2 K-wires and an intraoperative pelvic AP radiograph was taken. The degree of correction, comparison of the contralateral hip, the Shenton's line, and the position of the femoral head were evaluated in an attempt to evaluate the presence of an overcorrection.When the correction was completed and the final shape of the joint was given fixation was provided with two or preferably three 4.5 and 6-8 cm cortical screws. Two screws were placed from the iliac crest to the free fragment and one screw from the fragment to the sacroiliac joint in the AP plan direction (Figure V).

During wound closure the capsule was repaired with absorbable suture. The direct and reflected heads of the Rectus muscle was re-attached transosseously with a non-absorbable suture. After the fascia was closed, ASIS was fixed with a 2.7 mm cortical screw. A closed-suction surgical drain was placed and the skin was closed.

Immediate postoperative evaluation of the patient was done in operating room in order to evaluate the sciatic, femoral and obturator nerves

with 'foot lift', 'knee extension', and 'leg adduction' movements respectively.

Supervised standard physical theraphy was started for each patient.Follow up visits were scheduled at 2 weeks,4 weeks and 6 weeks initially and then every 4th week for 3 years.Final functional and radiological outcome was assessed at 3 years and compared with pre operative.

The data was analysed with SPSS version 23.Qualitative data was represented as frequency and percentages.Quantative data was represented as mean±SD. The preoperative and post operative Merle d'Aubigne Hip Score and various radiological parameters were compared and *P* value was calculated with paired sample-t test. *P* value <0.05 was considered significant The data was represented in table where necessary.

Fig. I: Custom-made Ganz osteotomy İnstruments.

From left to right: Straight osteotomes ranging between 10-15 mm, concave 30°-angled osteotome, wide and reverse-angles retractors.

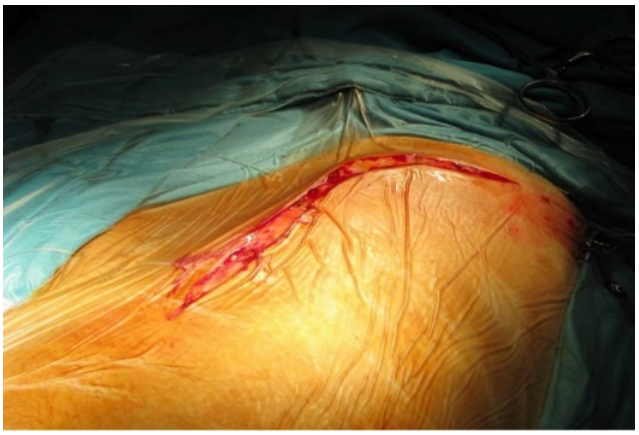

Fig. II: Modified Smith-Petersen incision for Ganz Osteotomy

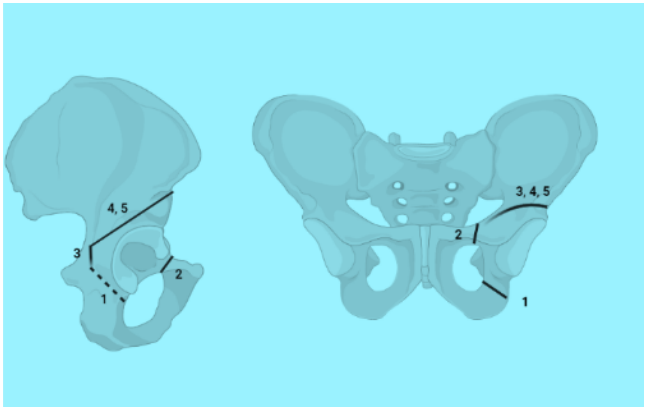

Fig. III: Five stages ofGanz periacetabular osteotomy cuts.
Left: Lateral pelvis view. 1. Ischium cut; 2) Pubis cut; 3) Retroacetabular cut; 4, 5) Supracetabuler cuts.
Right: 1) Ischium cut; 2) Pubis cut; 3, 4, 5) Supra- and retroacetabuler cuts.

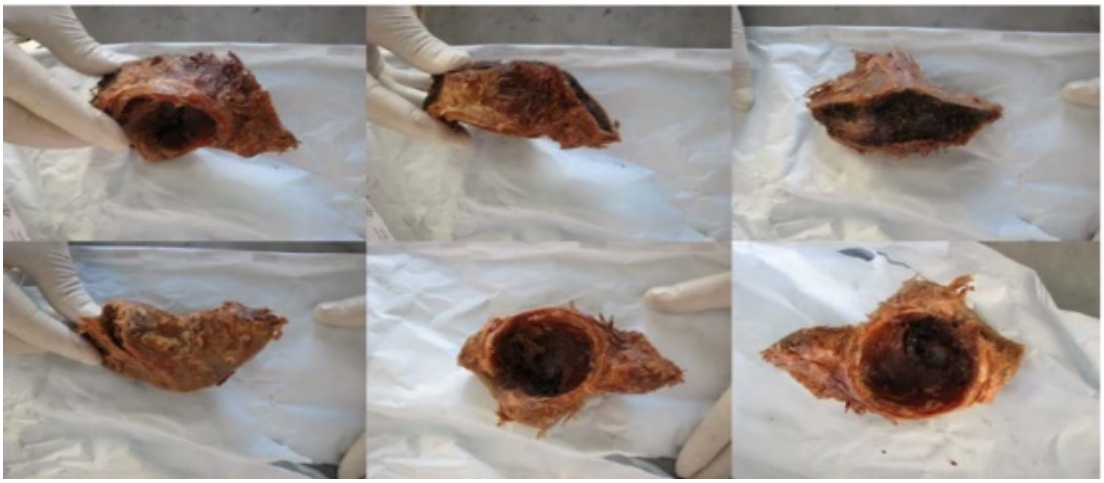

Fig. IV: Dissected free fragment samples obtained from cadaveric samples (special series of Dr.Yener Ince.)

Fig. V: Radiographs showing fixed fragment with the fixation screw. **a)** Bilateral acetabuler displasia in a 17 year-old female **b)** Condition of the hip joint on the second year follow-up visit **c)** Anterior coverage following the surgery

RESULTS

In this study we performed Ganz osteotomy in 19 hips(18 patients).The mean age was 23.05±2.48 years(range 15 to 32 years) Female patients were 13(72.22%) and male 5(27.22%).Left sided Ganz osteotomy was performed in in 9 (50%) patients, right in 8 (44.44%) and both sides in 1 (5.55%) patient. The average follow up peroid was 3.26±6.8 years. Excellent functional outcome was documented in all patients as indicated by a statastically significant improvement(P<0.05) of Merle d'Aubigne Score (pre operative 12.47 ± 1.02 versus 17.21 ± 1.03 post operative) as shown in table I. All the radiological parameters were improved signaficantly(P<0.05) improved after Ganz osteotomy and normal anatomical parameters were achieved (Table II).

Table I: Comparision of pre operative and postoperative Merle d'Aubigne Score.

Merle d'Aubigné Score	Preoperative	Postoperative	*P* value
Pain	3.11 ± 0.74	5.68 ± 0.58	**<0.001**
Mobility	5.18 ±0.94	7.24±1.01	**0.001**
Ability to walk	4.32 ± 0.58	5.63 ± 0.50	**<0.001**
Total	12.47 ± 1.02	17.21 ± 1.03	**<0.001**

Table II: Comparision of pre operative and postoperative radiological variables.

Radiological Variable	Preoperative	Postoperative	*P* value
Lateral Central-Edge Angle (LCE)	5.00° ± 7.20° (-18° to 17°)	35.16° ± 9.25° (22°to 54°)	<0.001
Anterior Central-Edge Angle (ACE)	4.11° ± 4.59° (-6° to 13°)	32.37 ± 6.49° (21° to 48°)	<0.001
Acetabuler Index(AI)	29.37° ± 7.32° (19° to 48°)	9.16° ± 4.26° (4°-21°)	<0.001
Lateralized Hip Sign(LHS)	18.37 ± 4.07 mm (9 to 26)	10.00 ± 3.11mm (3 to 16)	<0.001
Shenton Menard Line(SML)			
Broken	15 (78.94%)	6 (31.57%)	0.004
Intact	4 (21.05%)	13 (68.42%)	

One of our patients developed a femoral neck fracture which was fixed with cannulated screws and union was achieved. One patient required femoral varus osteotomy to ensure joint compliance. The final follow-up results of both the patients were recorded as excellent according to the Merle d'Aubign hip score.In our serious 4(22.22%).

In our series 4(22.22%) patients with suspected labrum defect with MRI evidence underwent arthroscopic evaluation and the diagnosis was confirmed in 2(11.11%) and patients were treated with partial labrectomy and labroplasty. The final follow-up evaluation results were recorded as excellent and good. Clinical improvement in one patient was found to be inadequate and the patient underwent total hip replacement surgery. No additional problem was encountered during the surgery and the previous Ganz osteotomy did not pose a technical obstacle for total hip replacement. Other major complications like nonunion of osteotomy, loss of correction, vascular injury, or nerve injury were not noted in our series.

DISCUSSION

In our study the mean age was 23.05±2.48 years (range 15 to 32 years). Due to several constraints in terms of correct indication of Ganz osteotomy the mean age of presentation in different series are variable and it is presumed that the increased age limits the success of this procedure contrary to the satisfactory results recorded in earlier ages. Matheney[19] included a heterogeneous population of patients in terms of age ranging from 9-54 years in his study. Alcobia Diaz[20] reported 10-year follow-up results of their 26 patients with a mean age of 39.8 (range 15-49) years at the time of the surgery.On the other hand Guindani[21] presented a younger series of 51 patients with a mean age of 14 (range 10-18 years) years with a follow-up period of 3 years.Guindani indications of Ganz-type osteotomy were slipped capital femoral epiphysis, femoroacetabular impingement, osteonecrosis of the femoral head, multiple hereditary exostoses, and pigmented villonodular synovitis which usually require relatively earlier intervention compared to the cases with AD.Siebenrock**[22]** listed advanced arthrosis of the hip, preoperative incompatibility and excessive correction as well as increase patient age among the main reasons limiting the success of Ganz osteotomy.

A review of 40 studies of 4070 hips with a mean age of 29 years similar to the mean age of our study group, Ali**[23]** reported good to excellent outcome in 82% of the cases.Ali demonstratedthat ACE correction was in the range of 10**°** to 51**°** and LCE correction was 15**°** to 44.6**°** which are comparable to our data of 21**°** to 48**°** and 22**°**to 54**°** respectively. This relatively wide range in our data might be due to our patient selection criteria and the presence of younger individuals amongst our cases.It is worth mentioning that in his 20-year survivorship study patients treated with this procedure Siebenrock**[24]** reported that Ganz's original series had a mean age of 29.3 years.

Thawrani and colleague**[25]** performed 83 Ganz osteotomies in 76 patients with mean age 15.6±2.4 years.At two years follow up LCE angle improved from pre operative -0.14 degrees to 35.5 degrees,VCE angle -5.13 degrees to 31.3 degrees and femoral head extrusion from 38.4% to 7.7%(P <0.0001).These authors concluded that Ganz osteotomy is an effective technique to corrrect acetabular dysplasia in adolescent patients.The rate of major complications however, are associated with prolonged surgery and femoral varus osteotomy.Other authors **[26,27]** also reported excellent functional and radiological outcome with Ganz osteotomy but they utilized Harris hip score for asssessing post operative functional outcome in their series while we used Merle d'Aubigne hip Score.

We did not performed femoral varus osteotomy in our series.Novais**[28]** studied the data of 128 hips and concluded that sever hip dysplasia had a higher risk for undercorrection as evident by inadequate LCEA post operative.Novais advocated concomittant femoral osteotomy alongwith Ganz osteotomy if femoral head coverage is not adequate per operatively.

Our study had few limitations.First the design of our study was descriptive.Second our sampole size was small.We therefore recommend further studies to verify the results of Ganz osteotomy in adolescent and youung patients with acetabulum dysplasia.

CONCLUSION

Ganz osteotomy is an effective technique for the surgical treatment of acetabular dysplasia in adolescents and young adults as shown by excellent functional and radiological outcome in our series.Ideal patient selection criteria and detailed understanding of the technique are however,mandatory to achieve satisfactory functional outcomes following Ganz osteotomy through a single incision.

Conflict of Interest: None
Grants/Funding: None

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