

COMPARATIVE GAIT ANALYSIS: GAIT PARAMETERS IN PRE- AND POST-OPERATIVE DEVELOPMENTAL DYSPLASIA OF THE HIP

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ABSTRACT

Objectives: To compare the pre-and post-operative gait patterns in developmental dysplasia of the hip (DDH) undergoing corrective surgery.

Materials and Methods: This prospective observational study was conducted at the Department of Anatomy in collaboration with the Department of Orthopedic and Traumatology, Khyber Teaching Hospital Peshawar, and Pakistan Institute of Prosthetics and Orthotics (PIPOS) laboratory, Hayatabad Peshawar from March 2018 to March 2019. Patients were examined clinically and radiologically, and pre-operative gait analyses were done. Three months postoperatively, the second gait analysis was repeated. Data was analyzed through SPSS-23 using one-way ANOVA.

Results: The mean age of study participants was 6 years. Clinically all patients were positive for trendelenberg test, limping of lower limb and lower limb discrepancy. Radiologically there was no significant correlation between age and Tonnis (Chi square test). The range of motion for each joint; hip, ankle and knee was calculated for deviation from standard of 50, 30 and 70 degree for each joint respectively. The results were tabulated as flexion and dorsiflexion (+), extension and plantar flexion (-) from the standard. Post-operatively the hip joint showed hyperextension deviation 24.83 ± 6.84 while the knee joint and ankle joints demonstrated flexion/plantar deviation of 5.85 ± 68.57 and 22.89 ± 42.52 respectively. In this study, there is negative correlation between gait parameters and range of motion (p -value=0.003).

Conclusion: In the pre and post operative comparison in gait parameters there were three parameters post trunk, post valgus/varus and post stance are significant P value is less than 0.05.

Key words: Dysplastic hip, Gait analysis, Range of motion

INTRODUCTION

The term developmental dysplasia of hip (DDH) has replaced congenital dislocation of hip as it describes the full range of abnormalities including dislocation, subluxation and malalignment of the infant hip¹. The rate of incidence is from 1 to 20 in every 1000 births depending upon some cultural differences but average risk at birth calculated is 6.6/ 1000 live birth². Screening by ultrasonography

increases the incidence at birth. Pre maturity, breech presentation and oligohydramnios are considered major risk factors in a local study³. The earlier the diagnosis the more conservative the treatment and the better chances to have a normal hip joint⁴.

Radiologically Tonnis classification is used for DDH after walking age⁵. Recently IHDR classification system proposed for DDH in children whose ossific nucleus not yet ossified^{6,7}. All newborns with risk factors should be screened for DDH by neonatal hip screening physical examination and ultrasonography, if indicated. As DDH is a painless condition and because of lack of screening program, most cases

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in our set up are diagnosed late. These neglected cases require complex reconstructive procedure with possible complications as well^{8,9}.

Effective gait depends on a number of biomechanical factors controlled by central nervous system to make gait energy efficient. Pathological conditions like DDH may negatively affect the gait biomechanics and energy expenditure¹⁰.

Three-dimensional gait analysis showed that children with untreated DDH walk with shorter step and slowly as compared to normal. These children also showed decreased maximum hip flexion and extension during walking¹¹. Peak hip flexion joint force is also reduced in these patients^{11,12}. Patients undergoing total hip replacement secondary to DDH have shown to have statistically significant reduced hip abductor length and moment arm¹³.

Neglected DDH cases are most of the time treated with open reduction and femoral or pelvic osteotomies. Beyond 3 years of age both osteotomies are needed¹⁴. Hip ROM and radiological features are most of the time used to assess the outcome of DDH surgery in neglected cases^{8,14}. Remodeling potential of hip is greatly reduced after 2 years, relocation of DDH in neglected case does not guaranty a normal hip at long term follow up. That's is why we are reporting results of operated neglected DDH cases by a more objective parameter of 2D gait analysis.

MATERIALS AND METHODS

This prospective observational study was conducted in the Anatomy department of Khyber medical college and orthopedic department of Khyber Teaching Hospital Peshawar Pakistan. The laboratory work was conducted in PIPOS gait lab Hayatabad in collaboration of KMU. The time period of the study was one year from March 2018 to February 2019. The total number of 20 dysplastic hip patients were included in the study. All DDH patients of age 6 years were included in the study. Exclusion criteria for the study was syndromic patients, already operated and neuromuscular disorders patients. The research proposal was approved by Graduate Study Committee(GSC) dated 25/3/2018, then reviewed and approved by advanced study and research board under notification DIR/KMU-ASRB/AC/000534. The research proposal was then cleared by Ethical committee of KMC and informed consent from all

patients were taken. After consent patients were examined clinically for hip range of motion (ROM), lower limb discrepancy (LLD), and gait abnormality.

Hip Flexion, abduction, adduction, Internal Rotation (IR) and External Rotation (ER) were recorded clinically. Hip flexion contracture was excluded by Thomas test. LLD was assessed by Galaezzi test. Visual gait assessment was done by making the child walk in OPD and examination of gait in frontal and sagittal plane. Specific Trendelenburg gait is performed after visual gait analysis²². In the radiological assessment X-ray of the hip joint was taken in anterior posterior and lateral views. Next, we graded patients as per Tonnis classification on AP pelvis view by drawing H line and P lines. Shelton line is drawn to differentiate between Tonnis 1 and Tonnis 2 grading. In radiological assessment we looked at dislocation, subluxation and acetabula dysplasia.

The third step is pre-operative gait analysis where the patients were taken to PIPOS gait lab. Active markers were placed on different anatomical joints. Then the subject was allowed to walk on the carpet in front of high-resolution cameras on 10-meter path way in advance gait lab. These markers were captured by the cameras throughout gait cycle. The patients were synchronized with computer system which automatically calculate data and give us the result with the help of Simi Aktysis software. (Camera (approx 100fps), objective 4-11mm focal length, tripod, LED markers (5 pieces), adhesive rings, camera cable (10m), laptop for recording and camera

In sagittal gait analysis 5 markers were placed on the fore foot, under the ankle joint and on the knee joint, trochanter and shoulder. Recording with values for dorsal and plantar flexion at the ankle, extension and flexion at the knee and hip and upper body angle to the horizontal were produced with standard reference values for every phase. In the frontal plane, markers placed anteriorly on the ankle joint, the origin of the patella ligament, on both the left and right anterior superior iliac crests and in line with the height of the T6 vertebrae allowed measurement of valgus and varus movement at the knee, lateral hip tilt, and deviations of the upper-body from the midline. The software provided data of all phases of gait from the initial contact, loading response, mid stance, push off and swing phase. These patients then had a surgical plan according to their

clinical, radiological and gait analysis. Then plaster of Paris (POP) cast was given for 6 to 8 weeks to these patients. After removal of spica the patient was encouraged to do exercises and these exercises are range of motion exercises and gait training exercises in the physiotherapy department of KTH. These exercises are needed to mobilize the stiff hip and achieve hip of flexion, abduction and rotation. When the patients were fully mobilized then post op gait analysis was done.

RESULTS

This prospective observational study was designed to observe the pre and post operative correlation in DDH patients by gait analysis. The total number of patients included in this study was 20. The majority of patients (60%) were from Peshawar whereas the rest were from areas extending up to Buner. The age of the participants was around 6 years. In total of 20 patient’s majority of them were female 17 (85%). In clinical history details of clinical finding were taken. All patients were positive for Trendelenburg test, limping of lower limb and lower limb discrepancy (LLD). Tonnis grading done showed that majority of the patients was severely affected and were in Grade 4 out of these 8 (73%) were females. Though there was no significant correlation between age and Tonnis, or gender with Tonnis (Chi square test) majority of the patients of older age group had grade 4 Tonnis.

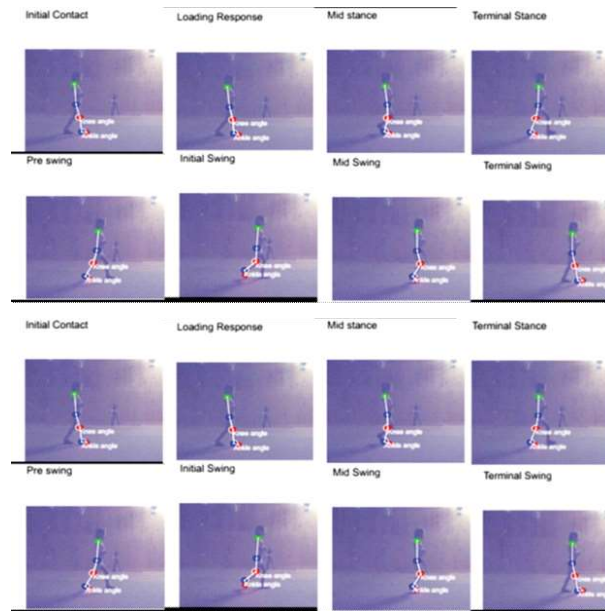


Fig 1 & 2: Preoperative and post-operative changes identified in gait parameters for Tonnis 4.

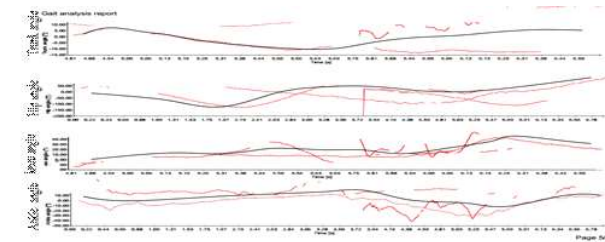


Fig. Pre operative Tonnis 4

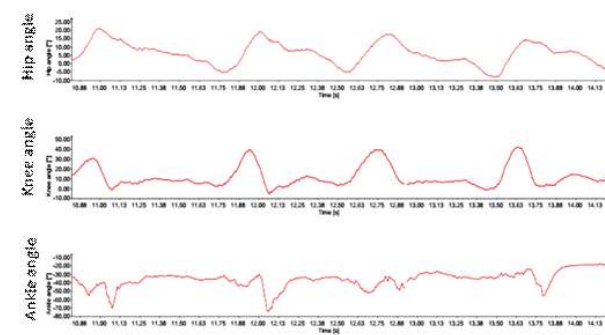


Fig. Post operative Tonnis 4

Gait Parameters:

A representative image of the angles in sagittal view for each phase of the gait cycle is shown in figure 1. Each of the main four angles for the lower limb: trunk, hip, knee and ankle are plotted for each

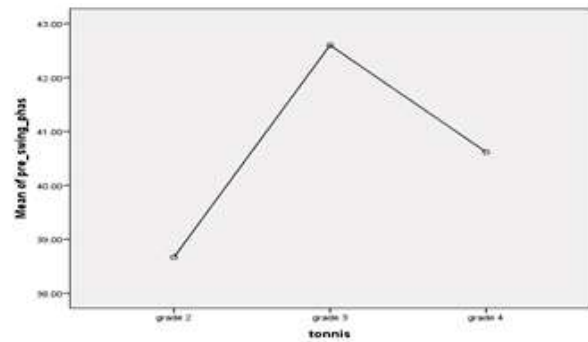


Fig. p>0.05, One-way ANOV, Post hoc Tukey Means plot for swing phase

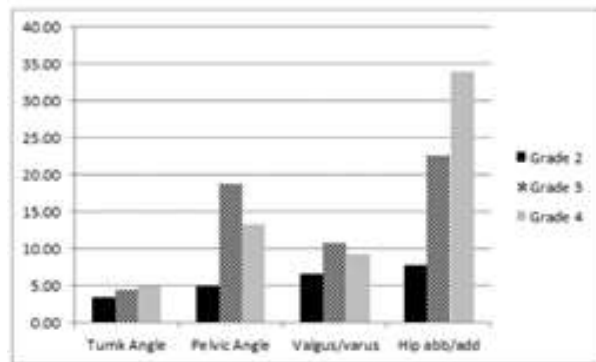


Fig 3.

of the three groups according to Tonnis classification. The variations for each angle vary greatly between individuals and throughout the Tonnis groups but severity in Group 4 Tonnis is increased. The range of motion for each joint; hip, ankle and knee was calculated for deviation from standard of 50, 30 and 70 degree for each joint respectively. The results were tabulated as flexion and dorsiflexion (+), extension and plantar flexion (-) from the standard. Post-operatively the hip joint showed hyperextension deviation 24.83 ± 6.84 while the knee joint and ankle joints demonstrated flexion/plantar deviation of 5.85 ± 68.57 and 22.89 ± 42.52 respectively. In this study, there is negative correlation between gait parameters and range of motion (p -value=0.003).

Post operative Tonnis 4

The means duration of both groups 2 and 4 were $\sim 61.3 \pm 6.6$ and ± 6.9 respectively for the stance phase and the reverse for the swing phase. There is no statistical significance of comparison of swing and stances phases with the Tonnis groups ($P > 0.05$, One-way ANOV, Post Hoc Tukeys). The angle deviation in swing and stance phase for pre-op was 2.67 ± 15.85 and 5.17 ± 14.34 respectively while for post op cases it was 8.82 ± 9.72 and 3.48 ± 12.86 , respectively.

Thus, a difference of 11.49 and 1.69 was noted post operatively in stance and swing phases.

Angle Parameters:

The angle parameters were recorded on frontal view for trunk angle, pelvic angle, valgus/varus and hip adduction/abduction for maximum and minimum values. The mean range of deviation for trunk was a tilt towards the contralateral side (positive value, 4.6 ± 4.5). The pelvic showed a contralateral lowering (positive value, 13.7 ± 24.5). The hip showed an adducted prominently (positive values, 9.4 ± 6.1) and the knee showed a valgus deformity (positive value, 26.6 ± 62.3). The detailed cadences are demonstrated in Figure 3.

DISCUSSION

The present study was aimed to assess the changes in the gait parameters after correction of DDH. For this purpose the gait pattern of DDH patients were compared pre and post operatively. The changes were made by analyzing the gait pattern. The results show great correlation with gait parameters and

range of motion. The variables included in the study were pre swing, trunk and pelvic angles. DDH is a painless condition with no apparent abnormality in lower limb before a child starts walking at the ages of 1 to 2 years¹⁵. Once they start walking limping is the first indication of something wrong. In countries with well-developed screening programs for DDH especially in high risk patients, diagnosis is usually made within first few weeks of life and the condition is usually treated conservatively¹⁶. In our study the mean age of the patients was approximately 6 years mainly due to a lack of appropriate screenings program and lack of awareness of early correction of DDH. Thus, all of them were recruited for open reduction. Studies have shown that open reduction with femoral and pelvic osteotomies is most appropriate for such an age group with acceptable results^{8,14}. A study conducted by Agnieszka, et al stated a similar ratio with predominantly girls affected with DDH¹⁰. In our study patients less than 8 years of age were included which develop altered biomechanics and gait pattern. DDH correction before 18 months of age with soft tissue release results in no abnormality.

Gait parameters shows that DDH patients walk slower and this reduction in walking speed was mainly because of short step length¹². Romano et al reported that the affected limb in DDH patients had longer double step length¹⁷, but in our study the double step length in all patients were the same. In a study by Marangoz et al the patients performed gait pattern at a fixed speed¹⁸, but in our study the patients walk was not at fixed speed and thus there is great variation in the step length, and cadence parameters i.e. stance swing and double step length. This difference may be because of patients age difference between two studies. Angle parameters correction was more obvious in Tonnis 2 DDH than in 4, which is associated with more complication as well¹⁹. Studies applied shoe lifts and shoe rockers in adult patients with DDH to improve the walking pattern which changed the gait parameters and so this may be a conservative management for a child going to school till surgery is planned¹⁶. The first compensatory mechanism was pelvic drop with leaning of trunk on the shorter side and subject had more flexion of knee on the longer side to equalize the functional limb length. The fore foot rocker for easier walking acted as a propelling motion as in a normal foot¹⁶. In pre and post operative comparison

there were three parameters which are significant and these are stance valgus/varus of knee and trunk tilt. The mean difference of post operative trunk tilt is -26.4 ± 45.53 . The SD of valgus/varus is 10.35 and post stance phase 30.08 so this difference is significant.

CONCLUSION

After surgical Correction of DDH marked improvement in gait parameters was recorded. Radiological grade does not determine gait parameters improvement postoperatively. Ankle and knee joint Rom showed significant improvement.

LIMITATION

Our study has limited no of patients with shorter follow up. More over control groups are needed to draw a definitive conclusion

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