EXAMINE THE IMPACT OF TOTAL HIP REPLACEMENT ON SPINE MOBILITY VIA GAIT ANALYSIS

HAIDER MUHI ABOUD ALSAIGH ,Biomedical engineering department ,College of engineering ,Kerbala University ,

Kerbala – Iraq . haideralsaigh7@gmail.com , haider.mohy@uokerbala.edu.iq

ABSTRACT

Total hip replacement (THR) is an elective surgical procedure with the primary indication being pain relief. Secondary to pain relief, but still very important, is a patient's desire to improve his or her physical function and quality of life. The aim of this study was to assess the impaction of the THR on the mobility of the spine. a method has been proposed for assessing the geometry of spine, and study the spine kinematics and their association during walking pre and post THR. Nine healthy men (age 20.44 ± SD 1.01 years, height: mean 178.44 ± SD 6.34 cm, mass: mean 68.55 ± SD 10.4 kg) were studied. The results of control cases were compared with 6 pre THR and 6 post - THR patients (Age: mean 40 ± SD 13.08 years, height: mean 165.7 ± SD 8.693 cm, mass: mean 81.2 ± SD 18.042 kg), four of them before undergoing unilateral total hip replacement surgery, and four other patients after the operation, two of them were examined before and after surgery.

The gait analysis was performed by two-dimensional (2D) motion analysis using two digital video cameras, one placed in the sagittal plane and the other on the frontal plane. Kinematics data were obtained from 2D trajectories of eight passive markers using SkillSpector software (version1.2.4). The digitizing points were exported as txt files that could be imported into Microsoft Excel.

The sagittal vertical axes and spinal angles (thoracic kyphosis, lumbar lordosis, thoracic scoliosis, lumbar scoliosis, horizontal pelvic slop, and vertical spine slope) were measured; this was found to be more correlated with a corotation factor >0.65 and a p-value of 0.05. When comparing these angles for patients pre and post THR with control cases, these angles are near control cases post total hip replacement (p-value < 0.05). So, as a conclusion, functional improvement was found in spinal movement and balance after the operation. It is not uncommon for the mechanics of walking to still not be back to normal after months of recovery. This is because the muscles around the joint need time to heal.

1. Introduction

Humans are distinguished from other animals by their habitual bipedal walking. Walking on two legs freed up the arms and hands for tasks including transporting, tool construction, and tool use, opening the way for continued human development. Thus, bipedalism is seen as a vital early step in human development. Human walking is a complex process that includes the coordination of several joints, muscles, and synapses in order to maintain the stability while moving the center of mass (COM) forward. Walking is a learned ability [1], and the distinctive patterns of adult walking take years to develop. Individuals stamp their own qualities on their walking style throughout the process. Gait recognition software, for example, is based on these distinctive characteristics of a person's gait. On the other hand, minor differences in walking appear to be layered on top of a similar pattern of limb coordination. This underlying pattern seems to influence how a person walks and to be responsible for walking efficiency. Understanding the coordination pattern of the limbs in order to walk is critical. This helps a person with hip osteoarthritis walk normally again after a joint replacement. Regaining one's capacity to walk is critical for physical, psychological, and social rehabilitation.

2. Total Hip Replacement

Total hip replacement (THR): is one of the most common surgical interventions. THR is performed on people who have severe osteoarthritis or osteonecrosis that makes everyday activities difficult. The procedure of removing and replacing the damaged femoral head and acetabulum of the hip joint with an artificial one is known as total hip replacement (THR). THR may be done in a variety of ways, depending on the decision of the orthopaedic surgeon. Different wound regions and post-operative safeguards are required depending on the surgical method [2].

3. Literature Review

Analyses of gait, both kinetic and kinematic, have been conducted quite a few times in connection to the movement of the spine. The analyses that were used in these studies used a variety of approaches to record the participants' gait data. This section gives a brief history of how the field has changed over time.

Leardini et al, 2011, investigated the movement of the multisegmental trunk by striking a balance between the technical limits of the studies and the therapeutic value of the findings. The best spatial matching of four thoracic markers was used to track the thorax segment. Markers on the two acromions were used to determine the distinct bidimensional shoulder line rotations and translations in relation to the thorax. A 5-link-segment model based on four extra skin markers in the anatomical reference frame was used to quantify spine motion. These 14 indicators were measured in 10 healthy people and one clinical case during static upright posture, chair rising-sitting, step up and down walking, elementary flexion and extension, lateral bending, and axial rotation motions of the complete trunk. Most of the measurements had good intra-subject repeatability across ten repetitions, with average standard deviations of less than 1.8° for all plane rotations at the spine and less than 1 mm for shoulder translations. Large motion was seen in all patients but in diverse patterns, suggesting fascinating couplings across the three anatomical planes. Significant subject-specific motion occurs at each of these various trunk segments in all three anatomical planes, in basic workouts, and in everyday motor activities. When this new trunk model is used to evaluate people with disorders, the same patterns and ranges of motion will be seen in abnormal situations [3].

Ranavolo et al., 2013, pointed out that moving the spine is like bending a continuous deformable entity, as it is identifying the minimum number of surface markers that will provide accurate measurement of spinal motion. An approximation was introduced by the common conception of the spine as either a hard body or a series of smaller joints. Possessing this resource would be a plus, as it would provide a method for taking comprehensive measurements of the spine's contour that yields reliable results. Ten healthy volunteers had an optoelectronic spinal column examination performed at the same time as a whole-spine radiography assessment. Polynomial interpolations on the vertebral bodies' centers of mass and on all of the markers were used to measure the degree to which the generated curves were comparable. What has been seen suggests that spine shape may be replicated using a polynomial interpolation of the fifth order. The most accurate curve approximations can be found with ten or nine markers. There is an inaccuracy in the measurement of sagittal angles [4].

Needham, Naemi, et al., 2016, used a 3D cluster technique to quantify the kinematics of the spine. Ten healthy people with no history of musculoskeletal disorders participated in the research. To monitor movement in the thoracic and lumbar spines, 3D marker clusters were implanted across the spinous processes of T3, T8, and L3. Each 3D cluster was comprised of a silicone base plate and three non-collinear reflective marks connected to plastic tubing. A motion capture system was used to record 3D coordinate data at 100 frames per second, as well as two force platforms to gather kinematic data. The regional, three-dimensional mobility of the lumbar and thoracic spines during walking was investigated in this work. The data were standardized, and the time was scaled to span the whole gait cycle [5].

Esbjörnsson, Kiernan, et al., 2021, described and evaluated hip morphology and gait pattern changes one year after complete hip replacement (THR). The effects of postoperative kinematic changes on the femoral, hip, and acetabular joints have been examined. THR was performed on 65 individuals with primary hip osteoarthritis. CT scans and 3-D gait analysis were used to examine patients before and after surgery. Multiple linear regressions were used to explore the relationship between changes in joint architecture and changes in gait pattern after THR. After one year, the participant walked quicker and had fewer trunk bends in all areas of their activities. Following THR, femur and hip kinematics altered in both exterior and interior directions, and a change in hip rotation while walking was related to a change in the femoral neck anteversion in the same direction [6].

Prost et al., 2021, studied spinal connection kinematics and their association during walking in healthy subjects. The data were obtained in a scientific laboratory for motion analysis. Several kinematic measures, including spinal junction motions in three planes and the dynamic sagittal vertical axis, were investigated. During a gait cycle, the angles of the different spinal joints, the pelvis, and the lower limbs were also measured as part of this research [7].

4. Materials and Methods.

4.1 Human Subjects

Participants were needed to go through THR surgery, and normal participants were employed for the experiment. In the end, the outcomes of patients both pre and post –THR were compared to the outcomes of control cases.

4.1.1 Control Group

Nine healthy young males, height (167–188) cm, weight (54–115) kg, BMI (17.83-24.77) and ages (19–20) years .Participants in this research had no history of spine or limb abnormalities. Participants in this research gave informed consent. The participants were directed to proceed at a normal speed along a 6-meter indoor route. Each participant took three walks, the results of which were standardized to the segment of the gait cycle. This stretch went from the first right initial contact to the second right initial contact. Data from three walking trials were collected for each individual, and the averages of these data were calculated to decrease the errors. The mean and standard deviation for each variable were found by adding up the data from each participant's passable walks.

4.1.2 Patients Subjects

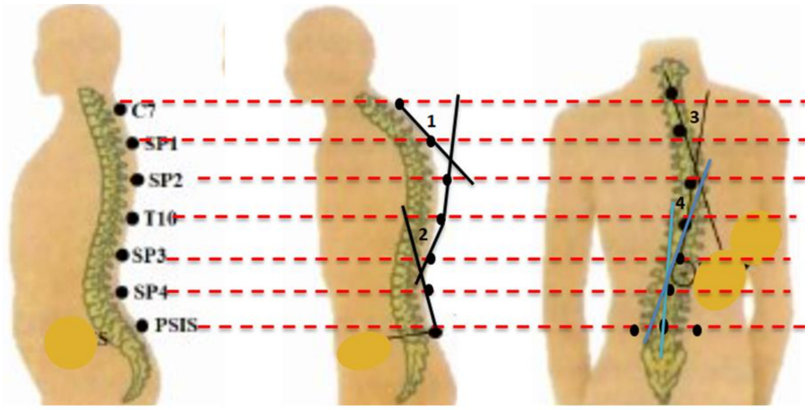
Ten patients were examined, four of them before they underwent unilateral THR surgery and the other four patients were examined after the operation, and two patients were examined before and after the THR. All patients before the operation suffered from painful hips due to Avascular Necrosis or Osteonecrosis.

The ability to walk on a six-meter passageway without using a walking stick; with no evidence of osteoarthritis in other joints of the spine or lower limbs; and no signs of any acute or chronic infections or disorders that might impact the neuromusculoskeletal system were the inclusion criteria.

The participants were told to walk at a normal speed along a 6-meter indoor pathway. Each participant took three walks, with the findings standardized to the segment of the gait cycle. This portion went from the first correct initial contact to the second correct initial contact. To decrease the errors, three walking trials were collected for each individual, and the averages of these data were calculated. The information from each participant's passable walks was combined to get the mean and standard deviation for each variable. This assessment is performed on individuals before THR surgery. The examination is performed after three months to allow the muscles surrounding the bones to return to normal function. To measure the influence of the THR procedure on spine mobility, the findings obtained before and after the operation were compared to the normal subjects' results.

4.2 Marker Placement

The spinous process of the seventh cervical vertebra was decided to be the most useful spinal landmark for the placement of markers [8, 9]. To determine the dynamic angles of the spine joints, eight spherical markers were attached to certain anatomic positions on each person as shown in Figure 1 [7]. Markers were metal suction electrodes used for ECG recording, and they conformed to the following specifications: Bulb Material: Silicon, Diameter of the lead connecting point: 3 mm Cup Nickel plated metal, Material Length: 5 centimeters; Weight: 30 grams. In order to indicate the posterior superior iliac spines on both left and right sides of the PSIS, two markers were utilized. Two markers were positioned on the tenth thoracic vertebra (T10) and the seventh cervical vertebra (C7). In the end, two more markers, designated SP1 and SP2, were added at the same interval and affixed in a straight line. They were given equal amounts of space between themselves and the T10 and C7 markers as shown in Figure 1. The SP3 and SP4 markers were also put between the T10 marker and the PSIS marker at the same distance [7, 10].



a b c

Figure 1: Marker positions, spinal dynamic angle definitions. Looking at (b) there are two angles, angle 1: Dynamic Thoracic kyphosis (dya-TK), Angle 2: Dynamic lumber Lordosis (dya-LL). (c) showing angle 3: Thoracic scoliosis (TS) and angle 4: Lumbar scoliosis[11].

4.3 Gait Measurements

Walking gait measures were taken at a self-selected typical walking speed. It is possible to record joint angles by putting markers on the skin surface in positions that precisely depict the actions of the underlying segments. These markers are captured by two cameras and their positions are converted into motion data by a motion tracking algorithm (Skill Spector). Skill Spector is a program that converts points representing marks captured by a video imaging system into Cartesian coordinates. This program deals with the AVI system only, so you must convert the recorded videos to this system so that we can analyze them later by Skill Spector. Make a two-dimensional measurement with the first camera (60 frames per second) positioned at right angles to the plane of movement in the sagittal plan. Figure 2-a. A second camera (60 frames per second) positioned at right angles to the line of movement in the frontal plane takes two-dimensional measurements Figure 2-b.

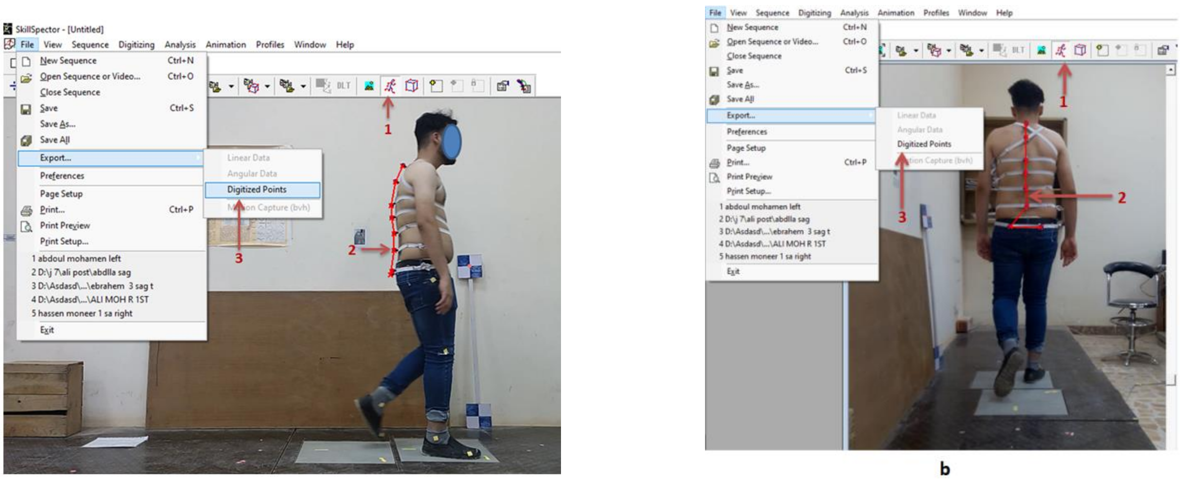


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Figure 2:Markers placement on patient's body, (a) sagittal plane, (b) frontal plane

4.3 Spine Dynamic Angles

1) Lordosis And Kyphosis Dynamic Angles

The mid-sagittal plane angle between the C7SP1 line and the SP2T10 line was designated as the thoracic spine kyphosis dynamic angle. The mid-sagittal plane angle between the T10 SP3 line and the SP4 PSIS line was defined as the lumbar spine lordosis dynamic angle Figure 1.

2) Scoliosis Dynamic Angle

The angle between the C7-SP1 line and the SP2-T10 line in the frontal plane was designated as the thoracic spine scoliosis dynamic angle Figure 1. The angle between the (T10SP3) line and the (SP4PSIS) line in the frontal plane was identified as the lumbar spine scoliosis dynamic angle.

3) horizontal and vertical slope

Horizontal slope determined as the angle between the L PSIS -R PSIS line and the horizontal line in the frontal plane. Vertical slope determined as the angle between theC7-midpoint L PSIS -R PSIS line and the vertical line in the frontal plane.

4) Sagittal Vertical Axis (SVA)

The sagittal vertical axis is determined as the vertical distance between the vertical line that passes through the C7 and the midpoint L PSIS-R PSIS by the sagittal plane.

4.4 Calculation of Segment Angles

The marking method data obtained from the anatomical landmarks can be transformed into absolute cross-sectional angles using the inverse tangent function as shown in Fig. 4-7d, which shows a two-part system in which the thoracic kyphosis region has four anatomical markers, and calculates The absolute angle starting counterclockwise is positive and the right horizontal is 0 degrees. The general equations for the measurement of the absolute angle are:

$$\theta ij = tang\text{-}1((Yj\text{-}Yi) \div (Xj\text{-}Xi)) \qquad (1)$$

From equation (1) can find angle (1) which is consider as dynamic thoracic kyphosis angle see figure 3.

First we must find the angle θ1. In the case of obtaining a negative angle measure, the absolute value is taken.

$\theta 1 = \text{tang-}1((Y1-Y2) \div (X1-X2))$

The angle θ2 measurement is calculated in the same way as before.

$\theta 2 = \text{tang-}1((Y3-Y4) \div (X3-X4))$

$\theta 3 = \theta 1 + \theta 2$ (2)

Angle (1) (day Tk) = $180 - \theta 3$ (3)

Similarly, angles (2, 3, and 4) can be found where these angles represent: lumbar lordosis, thoracic kyphosis, and lumbar lordosis, respectively.

From equation (1) can find angle (5) which is consider as VS angle and find angle (6) which is consider as HS see figure 3.

$V\ S = 90 - \text{tang}^{-1}((Y7-Y1) \div (X7-X1))$

$HS = \text{tang}^{-1}((Y_{RPSIS}-Y_{LPSIS}) \div (X_{RPSIS}-X_{LPSIS}))$

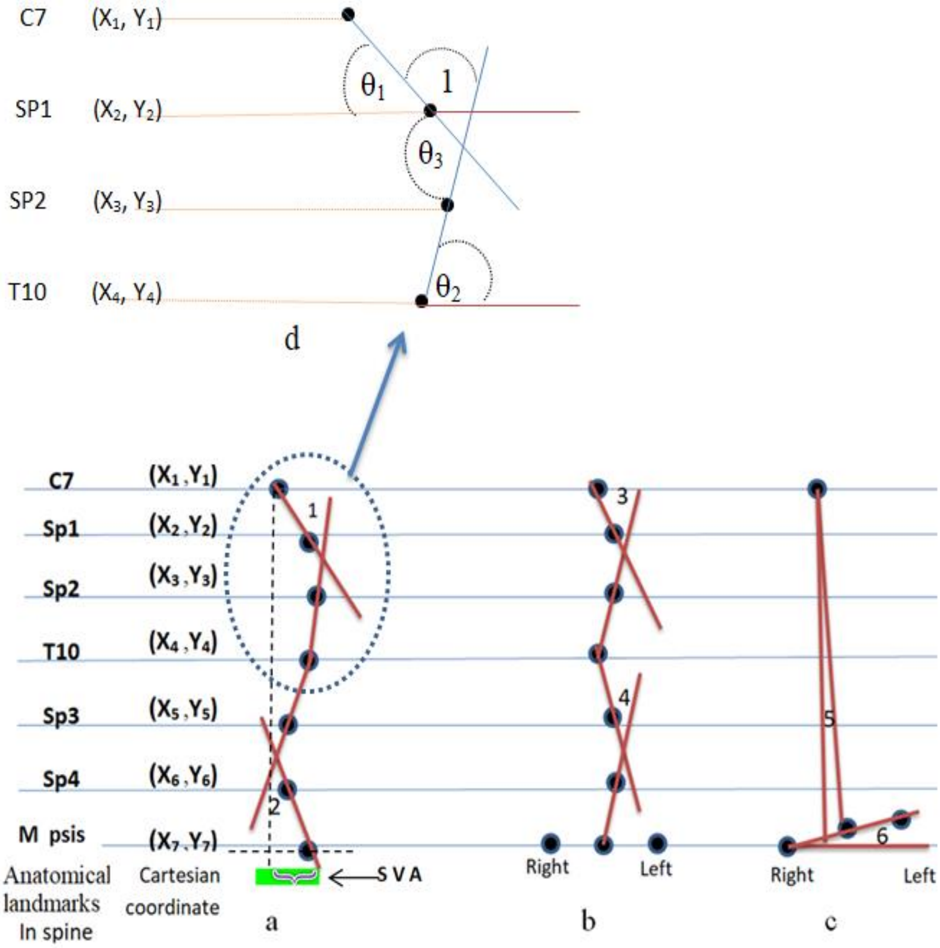

Figure 3: : Spine Angles,
(a) sagittal view show angle 1 (dyn TK), angle 2 (dyn LL)
(b) frontal viwe show angle 3 (T S) , angle 4 (L S)
(c) frontal viwe show angle 5 (H S) , angle 6 (V S)
(d) Joint's absolute angles and Joint's relative angles

4.5 Statistical analysis

Kolmogorov-Smirnov and Shapiro-Wilk test were used to test the normality of the discrete data: demographic, and spine kinematic parameters in contro and pre-THR subjects. Since most discrete data were found to be non-normally distributed and the sample size in the individual subsets was small, nonparametric test were used for all discrete parameters. Spearman correlation was used to found correlation coffering between spine parameters. An independent-samples Wilcoxon signed-rank test was performed to compare the pre-THR group, as well as post THR conditions, to controls. For the pre-THR subgroup analysis, a Kruskal-Wallis test with post-hoc Bonferroni correction for multiple testing was used. Pre- to postoperative analysis was performed.

5. Results

5.1 Patients Pre Operation

Gait analysis was performed for six patients before the THR operation. Spinal angle changes were measured in conjunction with the gait cycle. These patients had different results because of the different nature of their walking. The severe pain in the hip joint was a big reason why the results were so different from what they would have been under CC, as shown in Figures 4 and 5.Table 1 shows the maximum spine parameters at stance face (60% of the gait cycle). The numbers written in bold blue represent the statistical significance by using the Mann-Whitney test. Table 2 shows the maximum spine parameters at 40% of the gait cycle. The numbers written in bold blue represent the statistical significance by using the Mann-Whitney test.

a b

Figure 4:case No1 walking on force plat, (a): sagittal plane, (b): frontal plane

a b

Figure 5 :Case No. 2 walking on force plat , (a): frontal plane, (b): sagittal plane.

Table 1 :Maximum spine parameter at 60% of the gait cycle; color numbers represent significance by using the Wilcoxon signed-rank test. The pre-op color is blue, and the post-op color is red.

Case No	SVA	dya TK**	dya LL**	TS*	LS	HS*	VS	
CC	29.505	30.334	25.481	5.472	9.473	2.255	1.636	
1	21.567	61.302	40.668	8.888	18.473	-1.055	4.588	Pre
2	144.25	33.900	52.931	11.155	22.860	-0.954	4.592	
3	48.482	34.864	38.003	10.785	10.629	2.584	10.10	Pre
	35.783	33.847	27.353	6.161	10.550	3.040	1.938	post
4	67.622	36.882	35.865	11.454	11.134	2.660	8.218	pre
	25.123	32.121	22.094	5.618	9.3166	3.623	2.048	post
5	64.094	42.246	40.870	12.145	16.912	0.289	2.096	Pre
6	144.38	39.334	51.609	5.459	14.946	2.291	2.500	
7	44.079	32.529	30.184	6.142	11.576	5.424	1.580	post
8	50.948	36.617	18.351	5.928	11.398	1.973	2.025	
9	23.229	33.742	19.44	4.934	10.386	3.491	1.675	
10	28.679	29.192	24.728	6.330	11.904	3.594	2.969	

**. Correlation is significant at the 0.05

Table 2 :Maximum spine parameter at 40% of the gait cycle; color numbers represent significance by using Wilcoxon signed-rank test. The pre-op color is blue, and the post-op color is red.

<table>
<tr><th>Case No</th><th>SVA</th><th>dya TK</th><th>dya ** LL</th><th>TS</th><th>LS</th><th>HS</th><th>VS</th><th>60</th></tr>
<tr><td>CC</td><td>24.732</td><td>30.230</td><td>23.296</td><td>5.978</td><td>9.902</td><td>0.596</td><td>2.189</td><td></td></tr>
<tr><td>1</td><td>14.342</td><td>27.753</td><td>36.133</td><td>10.279</td><td>16.820</td><td>-2.289</td><td>5.748</td><td rowspan="2">Pre</td></tr>
<tr><td>2</td><td>143.99</td><td>61.346</td><td>52.701</td><td>7.677</td><td>13.534</td><td>-0.851</td><td>3.679</td></tr>
<tr><td rowspan="2">3</td><td>44.072</td><td>29.529</td><td>27.074</td><td>6.532</td><td>10.406</td><td>2.951</td><td>4.890</td><td>Pre</td></tr>
<tr><td>27.327</td><td>33.185</td><td>25.966</td><td>6.277</td><td>10.981</td><td>2.953</td><td>3.216</td><td>post</td></tr>
<tr><td rowspan="2">4</td><td>67.318</td><td>31.546</td><td>34.153</td><td>6.532</td><td>12.349</td><td>3.908</td><td>4.324</td><td>pre</td></tr>
<tr><td>27.575</td><td>31.460</td><td>22.038</td><td>6.373</td><td>10.064</td><td>3.317</td><td>2.460</td><td>post</td></tr>
<tr><td>5</td><td>56.514</td><td>29.384</td><td>37.442</td><td>11.968</td><td>15.408</td><td>1.670</td><td>2.097</td><td rowspan="2">pre</td></tr>
<tr><td>6</td><td>128.93</td><td>39.283</td><td>50.780</td><td>4.387</td><td>14.844</td><td>3.747</td><td>2.284</td></tr>
<tr><td>7</td><td>44.155</td><td>32.188</td><td>30.457</td><td>6.191</td><td>13.183</td><td>1.775</td><td>1.857</td><td rowspan="4">post</td></tr>
<tr><td>8</td><td>52.969</td><td>36.580</td><td>18.373</td><td>6.600</td><td>11.951</td><td>1.908</td><td>2.041</td></tr>
<tr><td>9</td><td>23.331</td><td>31.333</td><td>19.160</td><td>4.870</td><td>10.461</td><td>3.660</td><td>1.990</td></tr>
<tr><td>10</td><td>27.380</td><td>27.973</td><td>24.636</td><td>5.862</td><td>12.314</td><td>4.651</td><td>3.719</td></tr>
</table>

**. Correlation is significant at the 0.05

Figure 6 depicts the SVA of six cases in comparison to the CC (post-op). From table 1, the maximum SVA through 60% of the gait cycle was 128.93, 67.318, 56.514, 14.342, 143.99, and 44.072 for cases (C1, C2, C3, C4, C5, and C6), respectively. Using the Wilcoxon signed-rank test (WSRT), which was performed to compare the pre-THR group as well as postoperative conditions, there was no statistically significant difference between groups (P-value > 0.05).

From table 2, the maximum SVA through the 40% of the gait cycle was (56.514, 128.93, 67.318, 14.342, 143.99, 44.072, and 27.327) for cases (C1, C2, C3, C4, C5, and C6), respectively. There was no statistically significant difference between the preoperative and postoperative groups using the WSRT (P-value > 0.05).

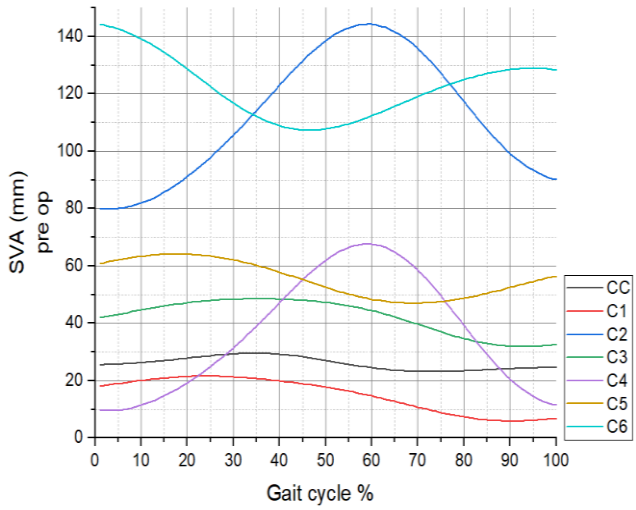

Figure 6: SVA of 6 cases vs the CC (pre op)

Figure 7 shows the dya-TK of six cases vs. the CC (pre op). From table 1, the maximum dya-TK through 60% of the gait cycle were (61.302, 33.9, 34.864, 36.882, 42.246, and 39.334) for cases (C1, C2, C3, C4, C5, and C6), respectively. Using the WSRT, which was performed to compare the pre-THR group as well as postoperative conditions, there was a statistically significant difference between groups (P-value < 0.05). P-value

From table 2, the maximum dya-TK through the 40% of the gait cycle were (27.753, 61.346, 29.529, 31.546, 29.384, and 39.283) for cases (C1, C2, C3, C4, C5, and C6), respectively. WSRT, there was no statistically significant difference between CC and patients (P-value > 0.05).

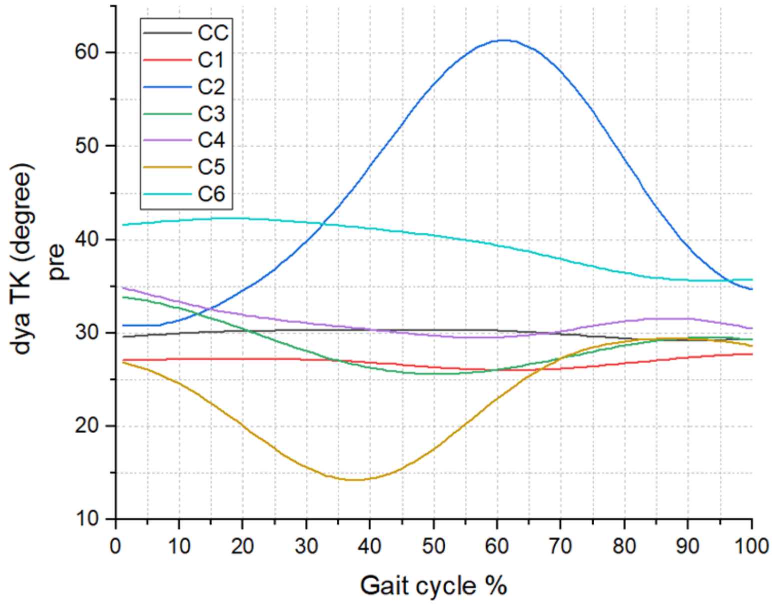

Figure 7:dya-TK of 6 cases vs the CC (pre op)

Figure 8 shows the dya-LL of six cases vs. the CC (pre op). From table 1, the maximum dya-LL through 60% of the gait cycle were (40.668, 51.609, 38.003, 35.865, 40.870, and 52.931) for cases (C1, C2, C3, C4, C5, and C6), respectively. Using the WSRT, there was a statistically significant difference between groups, P-value < 0.05.

From table 2, the maximum dya-LL through the 40% of the gait cycle were (36.133, 52.701, 27.074, 34.153, 37.442, and 50.780) for cases (C1, C2, C3, C4, C5, and C6), respectively. Using the WSRT, there was a statistically significant difference between groups, P-value < 0.05.

Figure 9 shows the TS of 6 cases vs. the CC (pre-op). From table 1, the maximum TS through 60% of the gait cycle was 8.888, 11.155, 10.785, 11.454, 12.145, and 5.459 for cases C1, C2, C3, C4, C5, and C6, respectively. Using the WSRT, there was statistically significant difference between groups (P-value > 0.05).

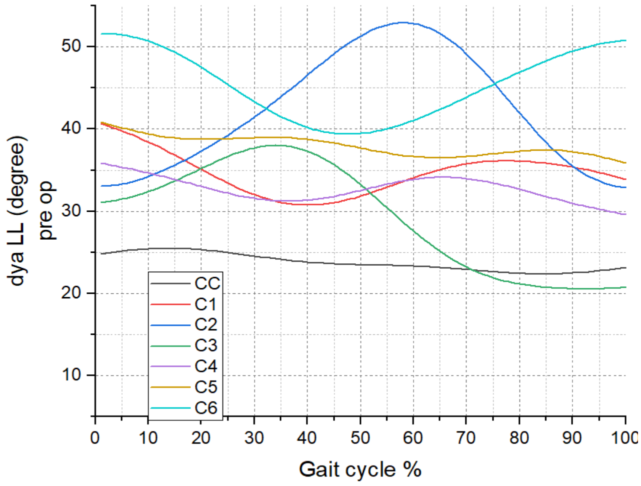

Figure 8: dya-LL of 6 cases vs the CC (pre op)

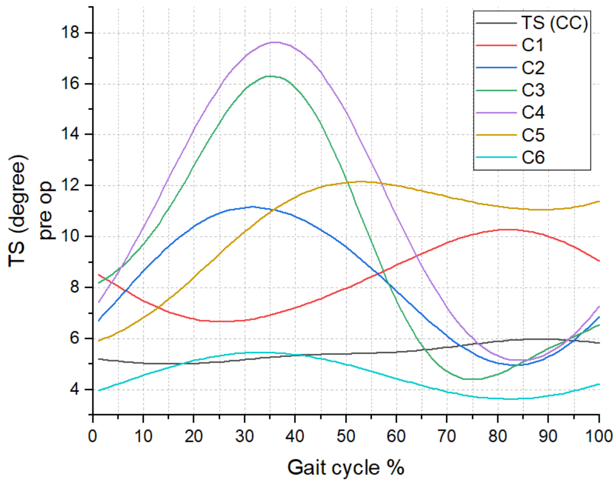

Figure 9: TS of 6 cases vs the CC (pre op)

From table 2, the maximum TS through the 40% of the gait cycle were (10.279, 7.677, 6.532, 6.532, 11.968, and 4.387) for cases (C1, C2, C3, C4, C5, and C6), respectively. WSRT, there was no statistically significant difference between groups (P-value >0.05).

Figure 10 shows the LS of six cases vs. the CC (pre op). From table 1, the maximum LS through 60% of the gait cycle were (18.473, 22.860, 10.629, 11.134, 16.912, and 14.946) for cases (C1, C2, C3, C4, C5, and C6), respectively. Using the WSRT there was no statistically significant difference between groups (P-value > 0.05).

From table 2, the maximum LS through the 40% of the gait cycle were (16.820, 13.534, 10.406, 12.349, 15.408, and 14.844) for cases (C1, C2, C3, C4, C5, and C6), respectively. Using the WSRT, there was no statistically significant difference between groups (P-value > 0.05).

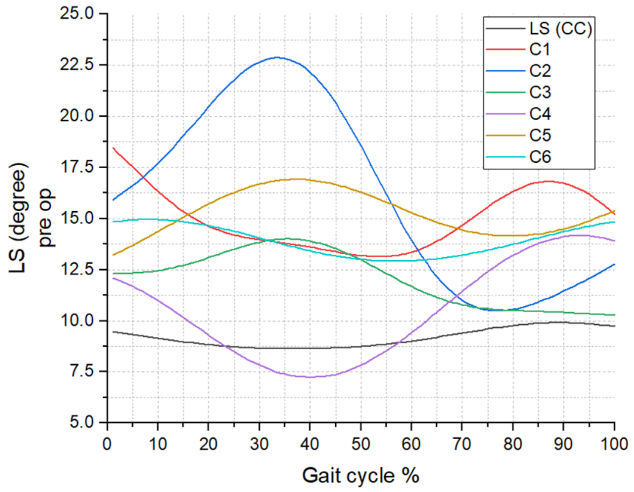

Figure 10: LS of 6 cases vs the CC (pre op)

Figure 11 shows the HS of six cases vs. the CC (pre-op). From table 1, the maximum HS through 60% of the gait cycle were (-1.055, -0.954, 2.584, 2.660, 0.289, and 2.291) for cases (C1, C2, C3, C4, C5, and C6), respectively. Using the WSRT, there was statistically significant difference between groups (P-value < 0.05).

From table 2, the maximum HS through the 40% of the gait cycle were (-2.289, 0.851, 2.951, 3.908, 1.670, and 3.747) for cases (C1, C2, C3, C4, C5, and C6), respectively. Using the WSRT, there was no statistically significant difference between groups (P-value > 0.05).

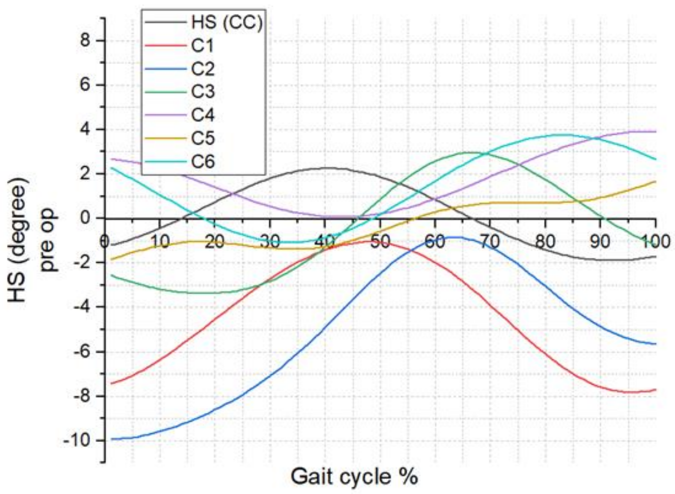

Figure 11: HS of 6 cases vs the CC (pre op)

Figure 12 shows the VS of 6 cases vs. the CC (pre op). From table 1, the maximum VS through 60% of the gait cycle were (4.588, 4.592, 10.10, 8.218.2, 2.096, and 2.500) for cases (C1, C2, C3, C4, C5, and C6), respectively. Using the WSRT, there was statistically significant difference between groups, P-value > 0.05.

From table 2, the maximum VS through the 40% of the gait cycle were (5.748, 3.679, 4.890, 4.324, 2.097, and 2.284) for cases (C1, C2, C3, C4, C5, and C6) respectively. Using the WSRT, there was statistical significance difference between groups (P-value > 0.05).

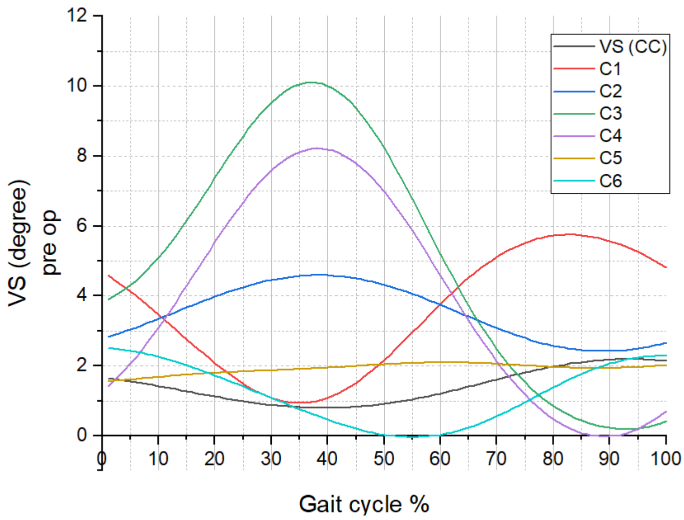

Figure 12VS of 6 cases vs the CC (pre op)

5.2 Patients Post Operation

Gait analysis was performed for six patients after the THR operation. Spinal angles changes were measured in conjunction with the gait cycle. These patients had results slightly near to CC because the severe pain in the hip joint was relieved after THR. Table 1 was shown the maximum spine parameters at stance face (60% of gait cycle). The two stars in the table represent the statistical significance using the Mann-Whitney Test. Table 2 shows the maximum spine parameters at the swing face (40% of the gait cycle).

Figure 13 was shown the SVA of 6 cases vs. the CC (post op). From table 1 maximum SVA through the 60% of the gait cycle were (35.783, 25.123, 44.079, 50.948, 23.229 and 28.679) for cases (C1, C2, C3, C4, C5 and C6) respectively .

From table 2 maximum SVA through the 40% of the gait cycle were (27.327, 27.575, 44.155, 52.969, 23.331 and 27.380) for cases (C1, C2, C3, C4, C5 and C6) respectively.

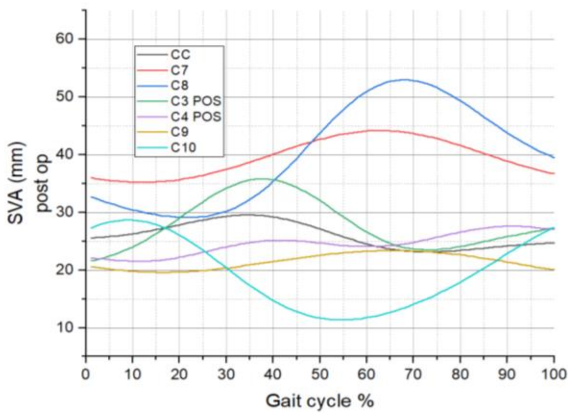

Figure 13:SVA of 6 cases vs the CC (post op)

Figure 14 shows the dya-TK of six cases vs. the CC (post op). From table 1, the maximum dya-TK through 60% of the gait cycle were (33.847, 32.121, 32.529, 36.617, 33.742, and 29.192) for cases (C1, C2, C3, C4, C5, and C6), respectively .

From table 2, the maximum dya-TK through the 40% of the gait cycle were (33.185, 31.460, 32.188, 36.580, 31.333 and 27.973) for cases (C1, C2, C3, C4, C5, and C6), respectively.

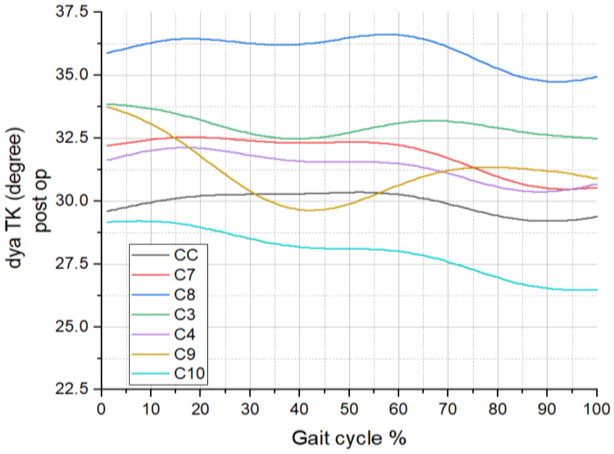

Figure 14:dya-TK of 6 cases vs the CC (post op)

Figure 15 shows the dya-LL of 6 cases vs. the CC (post op). According to table 1, the maximum dya-LL through 60% of the gait cycle for cases C1, C2, C3, C4, C5, and C6 were 27.353, 22.094, 30.184, 18.351, 19.440, and 24.728, respectively.

From table 2, the maximum dya-LL through the 40% of the gait cycle were (25.966, 22.038, 30.457, 18.373, 19.160, and 24.636 for cases C1, C2, C3, C4, C5, and C6, respectively

Figure 16 shows the TS of 6 cases vs. the CC (post -op). From table 1, the maximum TS through 60% of the gait cycle was 6.161, 5.618, 6.142, 5.928, 4.934 and 6.330 for cases C1, C2, C3, C4, C5, and C6, respectively.

From table 2, the maximum TS through the 40% of the gait cycle were (6.277, 6.191, 6.600, 4.870, 5.862 and 6.373) for cases (C1, C2, C3, C4, C5, and C6), respectively.

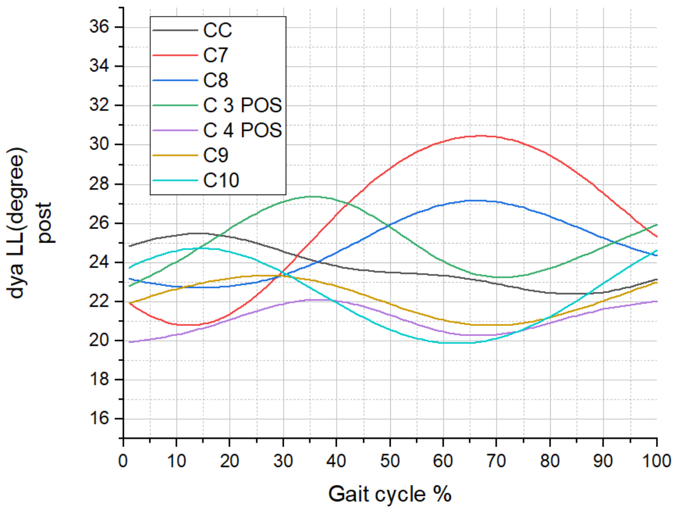

Figure 16:dya-LL of 6 cases vs the CC (post op)

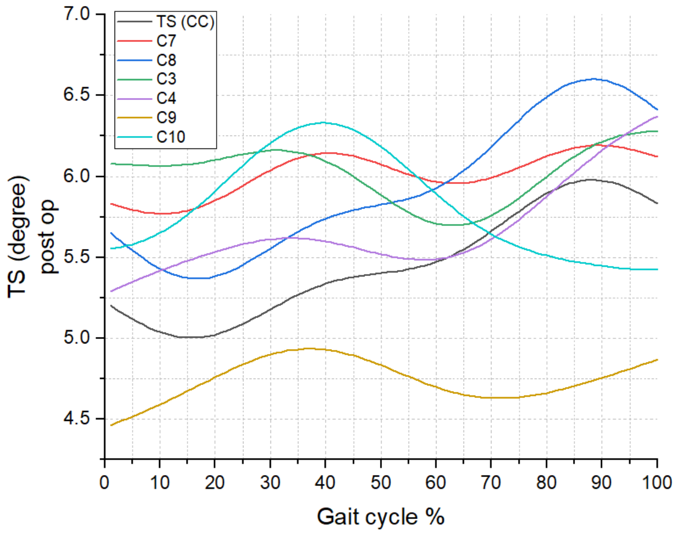

Figure 15: TS of 6 cases vs the CC (post op)

Figure 17 shows the LS of six cases vs. the CC (post op). From table 1, the maximum LS through 60% of the gait cycle were (10.550, 9.3166, 11.576, 11.398, 10.386 and 11.904) for cases (C1, C2, C3, C4, C5, and C6), respectively. From table 2, the maximum LS through the 40% of the gait cycle were (10.981, 10.064, 13.183, 11.951, 12.314 and 10.461) for cases (C1, C2, C3, C4, C5, and C6), respectively.

Figure 18 shows the HS of six cases vs. the CC (post -op). From table 2, the maximum HS through 60% of the gait cycle were 3.040, 3.623, 5.424, 1.973, 3.491 and 3.594) for cases (C1, C2, C3, C4, C5, and C6), respectively .

From table 4-4, the maximum HS through the 40% of the gait cycle were 2.953, 3.317, 1.775, 1.908, 3.660 and 4.651) for cases (C1, C2, C3, C4, C5, and C6), respectively.

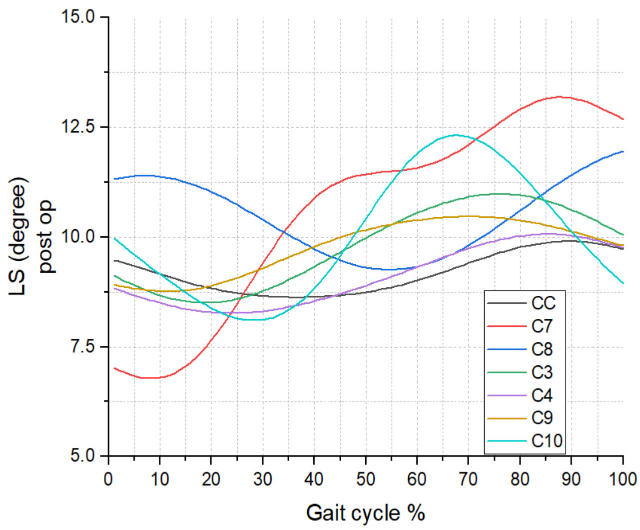

Figure 17: LS of 6 cases vs. the CC (post op)

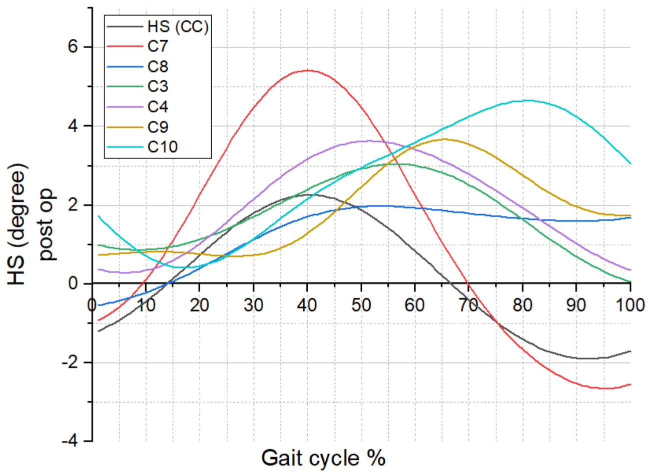

Figure 18: HS of 6 cases vs. the CC (post op)

Figure 20 shows the VS of 6 cases vs. the CC (post op). From table 1, the maximum VS through 60% of the gait cycle were (1.938, 2.048, 1.580, 2.025, 1.675 and 2.969) for cases (C1, C2, C3, C4, C5, and C6), respectively .From table 2, the maximum VS through the 40% of the gait cycle were (3.216, 2.460, 1.857, 2.041, 1.990 and 3.719) for cases (C1, C2, C3, C4, C5, and C6) respectively.

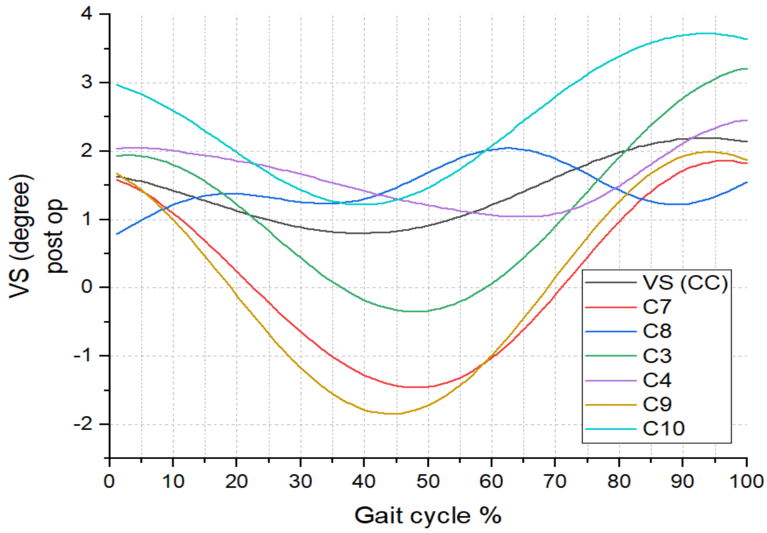

Figure 19: VS of 6 cases vs. the CC (post op)

5.3 Cases Pre and Post THR

For the pre-THR subgroup analysis, a Kruskal-Wallis test with post-hoc Bonferroni correction for multiple testing was used. Pre- to postoperative analysis was performed. There are statistically significant differences between the control group and before and after the operation for all patients p-value <0.05 as shown in Table 3. In this table the compertion doun between cc,pre op and post op,for to cases C3and C4, the sing stare referred to statistically significant between groups. The post-hoc Bonferroni correction told which parameters will effect on the significant.

Table 3 : Kruskal-Wallis test with post-hoc Bonferroni correction for C3 and C4

Kruskal-Wallis Test	SVA*	TK*	LL*	TS*	LS*	HS*	VS*
Case No. 3	ALL	PRE POST	PRE CC	PRE CC	ALL	PRE POST	PRE POST
		POST CC	POST CC	POST CC		PRE CC	PRE CC
Case No. 4	PRE POST	ALL	ALL	ALL	PRE POST	ALL	PRE CC
					PRE CC		PRE POST

Figure 20 was shown the SVA of cases No. 3 and 4 vs. the CC (pre and post op), C3 have statistically significant differences related to defiance between CC, pre op and post-op. C4 have statistically significant differences related to deference between pre op and post-op.

Figure 21 was shown the dya TK of cases No. 3 and 4 vs. the CC (pre and post op). Looking at Table 3 tolled which determinants are being affected and which are statistically significant.

Figure 22 was shown the dya LL of cases No. 3 and 4 vs. the CC (pre and post op). Table 3 tolled which determinants are being affected and which are statistically significant.

Figure 23 was shown the TS of cases No. 3 and 4 vs. the CC (pre and post op). Table 3 tolled which determinants are being affected and which are statistically significant.

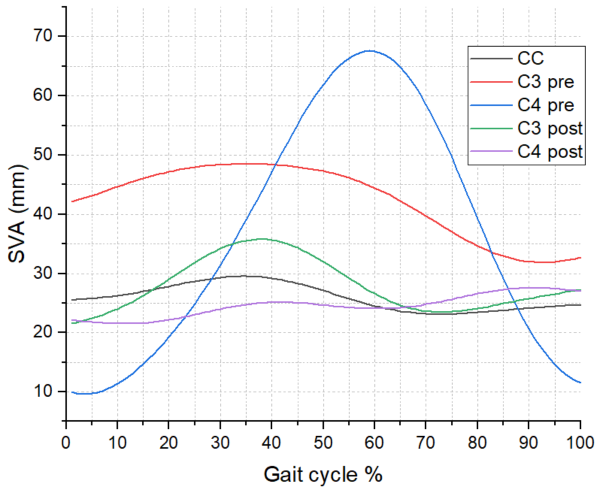

Figure20 : SVA of cases No 3and 4 vs. the CC (pre and post op)

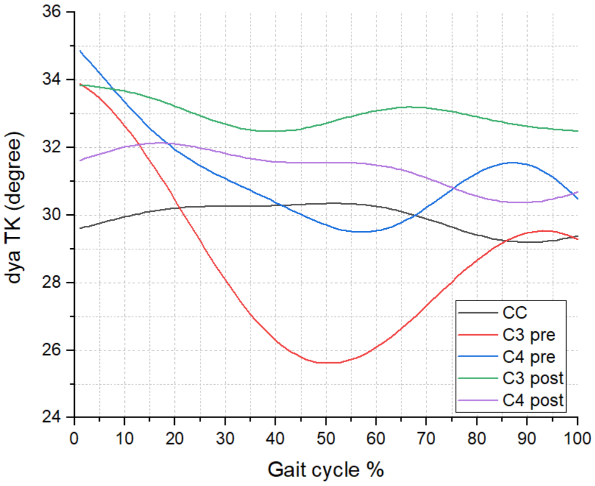

Figure 21: dya TK of cases No 3and 4 vs. the CC (pre and post op)

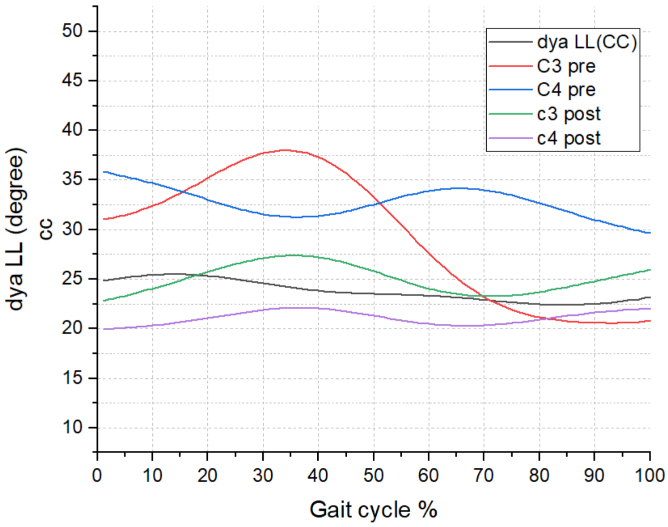

Figure 23: dya LL of cases No 3and 4 vs. the CC (pre and post op)

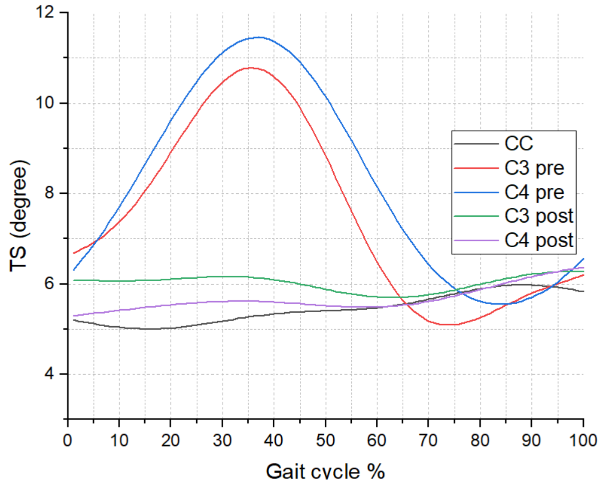

Figure 22 :TS of cases No. 3 and 4 vs. the CC (pre and post op).

Figure 24 was shown the LS of cases No. 3 and 4 vs. the CC (pre and post op). Using the Kruskal-Wallis Test, there was statistical significance difference between CC and C3, P-value < 0.05. Table 2 tolled which determinants are being affected and which are statistically significant These results are the same as those obtained when using C4.

Figure 25 was shown the HS of cases No. 3 and 4 vs. the CC (pre and post op). Using the Kruskal-Wallis Test, there was statistical significance difference between CC and C3, P-value < 0.05. These results are the same as those obtained when analyzing dya TK

Figure 26 was shown the VS of cases No. 3 and 4 vs. the CC (pre and post op). Using the Kruskal-Wallis Test, Table 2 tolled which determinants are being affected and which are statistically significant

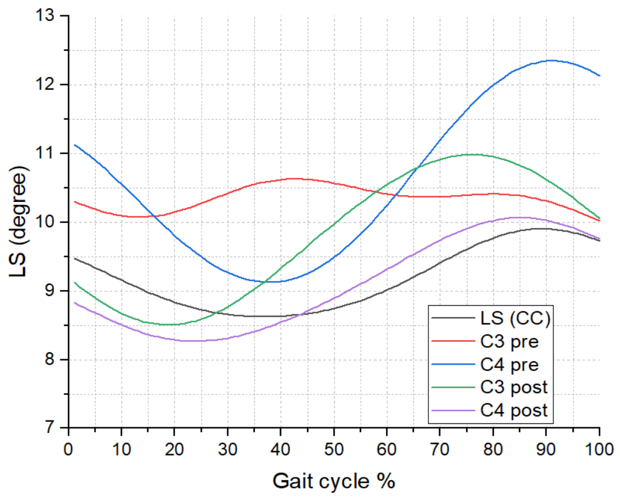

Figure 25: LS of cases No 3and 4 vs. the CC (pre and post op)

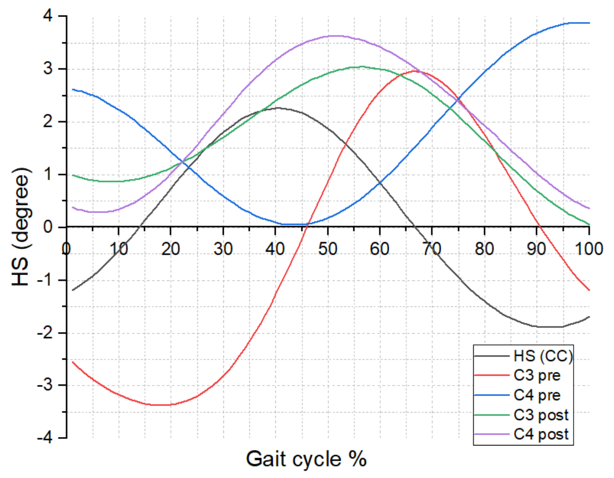

Figure 24:HS of cases No 3and 4 vs. the CC (pre and post op)

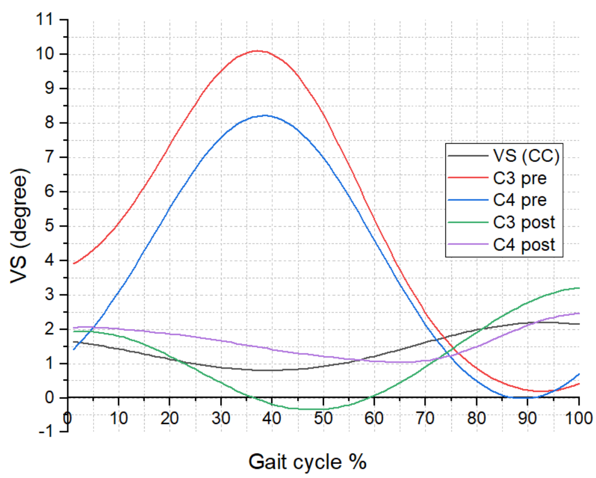

Figure 26: VS of cases No 3and 4 vs. the CC (pre and post op)

6. Discussions

The dya TK have statistically significant in the stance phase as shown in the table 1, the rank of pre op group is higher than post op group. The preoperative dya-TK was larger than cc as shown in Figure 7, but it had the same phase as normal cases. The postoperative dya-TK was nearly to CC as shown in Figure 14. When the patient puts pressure on the affected foot, it caused the patient to bend forward due to pain and felt as if they have lost their balance. After the operation, the dya-TK angle will be closer to normal cases due to the removal of pain, and the patient was able to walk normally after the joint replacement procedure. From WSRT the dya TK angle is higher in pre op than post op table 3 the Kruskal-Wallis Test show that pre op mean dya TK is higher than post op and the last one is closely to the cc as shown in the Figure 21.

The dya-LL was higher and out of phase than normal cases before the operation due to the patient's imbalance during the gait cycle as well as the enlargement of the SVA as shown in Figure 8. By increasing dya-LL, the patient tried to push the spine back in order to increase balance

After the operation, dya-LL was found to improve and approach normal cases as shown in Figure 16. This is due to the disappearance of pain from the joint, and the patient was able to walk comfortably and balance. Tables 1 and 2 show that dya-LL was higher pre-op from CC than post-op, p-value < 0.05, this gives the impression that the operation helped improve the position of the spine as shown in figure 22.

The patient was trying to balance while walking, so the SVA increased due to excessive forward bending. The patient relieved pressure on the affected right side, causing an imbalance during the gait cycle. Increasing the patient's forward curvature was the reason for the body's center of gravity not being centered over the pelvis and the cause of the unbalanced gait cycle. Figure 6 showed that SVA was much higher than in normal cases pre op but at the same phase. The SVA went back to normal pos op, but it was a little bit higher than normal because the patient's spine bent forward more than normal because his muscles were weak as shown in figure 20.

In the frontal plane, the patient tried to lean towards the injured leg, which leads to an increase in the TS angle until about 60% of the GC as shown in Figure 9, at the point where the other foot starts opposite initial contact, this caused the load on the affected foot to be reduced and the angle values approached normal cases. After the operation, this angle approaches the CC, with a small elevation in it as shown in Figure 23. Table 3 shown that TS rank pre op was higher than post op (p-value > 0.05)

The LS angle was high before the operation due to the patient's tilting towards the affected side in the stance phase due to the presence of pain in the hip joint and the imbalance of the gait cycle as shown in Figure 10. After the operation, this angle became within the CC, with a slight decrease in its value at the stance phase and an elevation in the swing phase as the patient attempts to straighten and not sway during the gait cycle as shown in Figure 17.

The HS angle was irregularly tilted and out of phase by 90 degrees from CC as shown in Figure 11. The pelvis was tilted in the opposite direction to the presser foot to reduce the weight on the affected side. After the operation, as shown in Figure 18, it was found that the inclination of the pelvis had decreased, which contributed to an increase in stability while walking.

7. Conclusions

1. A strong correlation ($r \geq 0.6$) exists between almost all spine parameters and a p-value < 0.05 .
2. The most important thing that has come out of this study is a technology that can measure the angles of the spine (thoracic kyphosis, lumbar lordosis, thoracic scoliosis, lumbar scoliosis, horizontal pelvic slop, and vertical spine slope and sagittal vertical axes) quickly and easily for use in clinical settings.
3. When the results of CC and patient before and after THR surgery were compared, it was found that the surgery improved the spine's posture while walking and brought its bend angles closer to normal limits (p-value < 0.05.
4. The clinical implications of changes in spine and pelvic mobility (spinopelvic mobility) that may arise following total hip replacement may be difficult for hip surgeons to manage. The most prominent symptom of these problems is dislocation.
5. The weight of the trunk is balanced by how the spine, pelvis, and hips are set up. Because these joints can move, they can work together to do things like walk.

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