Investigation of the Relationship Between Hip and Knee Osteoarthritis and Disordered Spinal and Pelvic Morphology

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Abstract

Introduction

A critical question is the causal relationship between hip or knee osteoarthritis (OA) and disordered spinal and pelvic morphology. The aim of this study is to examine this correlation. Therefore, we studied the effect of total hip or knee arthroplasty (THA/TKA) on truncal parameters to determine the causal relationship between these two situations.

Materials and methods

This is a prospective study of the effect of THA or TKA in patients with hip or knee OA on truncal morphological parameters. Patients with one-sided hip or knee OA who chose to undergo THA or TKA were enrolled and surveyed. A control group (CG) was also surveyed for comparison with the patients. The patients were preoperatively examined for truncal parameters using the Diers Formetric four-D analysis system (surface topography technique) to calculate several truncal parameters in all planes at four months and 12 months postoperatively. Measurable examinations were performed using the Statistical Package for the Social Sciences (SPSS) version 17.00 (SPSS Inc., Chicago), and statistical significance was set at a p-value of <0.05.

Results

The study examined 34 patients who underwent THA, including 19 women and 15 men with a mean age of 67.62 ± 8.28 years. The study also examined 45 patients who underwent TKA, including 34 women and 11 men, with a mean age of 72.42 ± 7.0 years. These patients were also compared with a CG that consisted of 25 normal individuals, including 12 women and 13 men, with a mean age of 69.28 ± 10.11 years.

The results of this study from four months after THA revealed that the lordotic angle, trunk torsion, pelvic inclination, pelvic obliquity, and pelvis rotation were improved to normal levels. At 12 months after THA, only the pelvic obliquity was improved to normal levels. At four months after TKA the lordotic angle, pelvic inclination, and pelvic obliquity were improved to normal levels. However, the fleche cervicale and vertebral rotation were worse. At 12 months after TKA, only the pelvic obliquity was improved to normal levels.

Conclusions

THA and TKA to correct hip and knee OA do not correct the disordered morphology of the trunk in the long term. Thus, hip or knee OA does not seem to be responsible for disordered trunk morphology. However, it cannot be ruled out whether the disturbed morphology is responsible for the appearance of the hip and knee OA.

Categories: Orthopedics

Keywords: osteoarthritis and disordered trunk, total knee arthroplasty, total hip arthroplasty, knee osteoarthritis, hip osteoarthritis

Introduction

It is known from many studies that patients with hip and knee osteoarthritis (OA) have disordered spinal and pelvic morphology [1-7]. A critical question of concern in the orthopedic community is what the relationship is between hip and knee OA and disordered spinal and pelvic morphology. Specifically, it is unknown whether there is a causal relationship between them, which of the two situations precedes the other, and whether one causes the other. These questions have not been answered in recent studies [5,8,9].
The present study attempts to answer these questions by examining the impact of total hip or knee arthroplasty (THA/TKA) in patients with hip or knee OA on truncal morphological parameters. The same groups of patients with hip or knee OA have already been studied and compared with a control group (CG), and disturbed trunk morphologies have been found in both groups of patients preoperatively [1].

Thus, we assumed that if we have improvement of the truncal parameters after THA or TKA in the long term to correct hip or knee OA, then the hip and knee OA could be the cause of changes in the morphology of the spine and pelvis. In the opposite case, if the changes of the truncal parameters are still present after THA and TKA, then this could exclude that OA is responsible for the appearance of the disordered morphology of the trunk. However, it could not be determined whether the disturbed morphology of the trunk is responsible for OA.

Materials And Methods

Study design

This is a prospective study of the effect of THA or TKA in patients with hip or knee OA on truncal morphological parameters. Patients with one-sided hip or knee OA who chose to undergo THA or TKA at Tzaneio General Hospital of Piraeus were enrolled and surveyed. A CG was also surveyed for comparison with the patients. The study was approved by Attikon University General Hospital’s Institutional Review Board (ΕΒΔ390/ 9-9-2014, date of approval 24-9-2014). The principles of the Declaration of Helsinki were applied throughout the study. Informed consent was obtained from all participants.

Inclusion and exclusion criteria

The following inclusion criteria of the CG were applied: (1) without OA in the joints of lower extremities, (2) without neurological deficits in lower extremities, (3) without a history of surgical intervention in the spine or lower extremities, and (4) without other diseases that would affect the alignment of the trunk. The following exclusion criteria of the patients were applied: (1) marked OA in other joints of lower extremities, (2) arthritis secondary to other diseases, e.g., ankylosing spondylitis, rheumatoid arthritis, developmental dysplasia, and trauma, (3) neurological deficits in lower extremities, (4) history of surgical intervention in the spine or lower extremities, and (5) other diseases that would affect the alignment of the trunk.

Data collection

The patients were preoperatively examined for truncal parameters using the Diers Formetric four-D analysis system (surface topography technique) to calculate several truncal parameters in all planes and at four months and 12 months postoperatively. All the calculations were performed using the Statistical Package for the Social Sciences (SPSS) version 17.00 (SPSS Inc., Chicago), and statistical significance was set at a p-value of <0.05.

Results

Control group

The CG comprised of 25 normal individuals with 12 women, 13 men, with a mean age of 69.28 ± 10.11 years (range, 55-86 years). They had a mean weight of 79.40 ± 13.08 kg, a mean height of 165.04 ± 9.46 mm, and a mean body mass index (BMI) of 29.00 ± 3.00 kg/m². The normal values of the CG are for the fleche cervicale (mm; 79.02), fleche lombaire (mm; 39.41), kyphotic angle (°; 56.18), lordotic angle (°; 42.26), sagittal imbalance (°; 4.19), sagittal imbalance (mm; 32.88), coronal imbalance (°; 1.16), coronal imbalance (mm; 8.90), apical deviation root mean square (rms) (mm; 4.94), apical deviation amplitude (mm; 11.40), apical deviation max (mm; 9.20), scoliosis angle (°; 12.96), vertebral rotation rms (°; 9.64), vertebral rotation max (°; 7.80), trunk torsion (°; 4.16), pelvic inclination symmetry line (°; 19.04), pelvic inclination dimples (°; 17.44), pelvic torsion (°; 2.64), pelvic obliquity (°; 0.96), pelvic obliquity (mm; 1.34), and pelvis rotation (°; 2.08).

Patients with THA

A group of 34 patients with 19 women, 15 men, and a mean age of 67.62 ± 8.28 years (range, 47-84 years) was surveyed preoperatively. Of these patients, 15 were surveyed at four and 12 months postoperatively, 14 patients were surveyed only at four months postoperatively, and five patients were surveyed only at 12 months postoperatively. There were 20 patients who underwent an operation for the right hip, and 14 underwent one for the left hip. Four orthopedic surgeons carried out THA. Other characteristics of these patients include a mean weight of 82.32 ± 17.75 kg, a mean height of 165.79 ± 8.80 mm, and a mean BMI of 29.72 ± 4.31 kg/m². Table 1 summarizes the homogeneity of the demographic characteristics between the CG and the patients with THA. No statistically significant differences were noted between the CG and patients with THA.
The parameters of the spine and the pelvis in the patients surveyed preoperatively and at four months after THA are summarized in Tables 2-5. At four months postoperatively, patients presented significantly decreased values compared with the preoperative values, but values improved to normal for the lordotic angle (*; 46.45→44.19, p = 0.006), trunk torsion (*; 8.28→5.03, p = 0.031), pelvic inclination (*; 22.31→19.07, p = 0.030), pelvic obliquity (*; 3.97→2.52, p = 0.018), pelvic obliquity (mm; 5.59→3.77, p = 0.013), and pelvis rotation (*; 3.69→0.72, p = 0.001).

### TABLE 1: Homogeneity of demographic characteristics between the CG and patients with THA

| Characteristics          | CG (n=25)       | Patients (n=34) | p-value |
|--------------------------|-----------------|-----------------|---------|
| Age (years), Mean±SD     | 69.28±10.11     | 67.62±8.28      | 0.540   |
| Gender, male/female n (%)| 13(52%)/12(48%) | 15(44%)/19(56%) | 0.605   |
| Weight (kg), Mean±SD     | 79.40±13.08     | 82.32±17.73     | 0.371   |
| Height (mm), Mean±SD     | 165.04±9.46     | 165.79±8.80     | 0.754   |
| BMI (kg/m²), Mean±SD     | 29.00±3.00      | 29.72±4.31      | 0.482   |
| Operated leg (right/left) n (%) | ---             | 20(58.8%)/14(41.2%) | ---     |

CG: control group, THA: total hip arthroplasty, SD: standard deviation, BMI: body mass index.
| Parameter                                      | Pre-operative | Post-operative |
|-----------------------------------------------|---------------|----------------|
| Fleche cervicale (mm)                         | 92.61         | 93.63          |
| Fleche cervicale (mm) post-op 4               | 28.30         | 19.38          |
| Fleche lombaire (mm)                         | 30.54         | 27.33          |
| Kyphotic angle (°) pre-op                    | 58.30         | 60.83          |
| Kyphotic angle (°) post-op 4                 | 46.45         | 44.19          |
| Lordotic angle (°) pre-op                    | 8.55          | 7.52           |
| Lordotic angle (°) post-op 4                 | 65.12         | 57.11          |
| Sagittal imbalance (°) pre-op                | 28.30         | 30.54          |
| Sagittal imbalance (°) post-op 4             | 1.10          | 1.62           |
| Sagittal imbalance (mm) pre-op               | 1.00          | 1.00           |
| Sagittal imbalance (mm) post-op 4            | 5.99          | 5.31           |
| Coronal imbalance (°) pre-op                 | 13.41         | 11.90          |
| Coronal imbalance (°) post-op 4              | 16.34         | 15.28          |
| Coronal imbalance (mm) pre-op                | 5.14          | 5.14           |
| Coronal imbalance (mm) post-op 4             | 4.88          | 4.88           |
| Apical deviation rms (mm) pre-op              | 11.45         | 11.45          |
| Apical deviation rms (mm) post-op 4          | 4.88          | 4.88           |
| Apical deviation amplitude (mm) pre-op        | 11.28         | 11.28          |
| Apical deviation amplitude (mm) post-op 4     | 11.28         | 11.28          |
| Apical deviation max (mm) pre-op              | 9.59          | 9.59           |
| Apical deviation max (mm) post-op 4          | 12.43         | 12.43          |
| Scoliosis angle (°) pre-op                   | 16.34         | 15.28          |
| Scoliosis angle (°) post-op 4                | 5.14          | 5.14           |
| Vertebral rotation rms (°) pre-op             | 4.88          | 4.88           |
| Vertebral rotation rms (°) post-op 4         | 11.45         | 11.45          |
| Vertebral rotation amplitude (°) pre-op       | 11.28         | 11.28          |
| Vertebral rotation amplitude (°) post-op 4    | 11.28         | 11.28          |
| Vertebral rotation max (°) pre-op             | 9.10          | 9.10           |
| Vertebral rotation max (°) post-op 4          | 8.28          | 8.28           |
| Trunk torsion (°) pre-op                     | 5.03          | 5.03           |
| Trunk torsion (°) post-op 4                  | 28.30         | 27.33          |

**TABLE 2: Comparison of parameters of the spine for patients with THA between preoperative and postoperative four-month values**

THA: total hip arthroplasty, MFU: months follow-up, SD: standard deviation, rms: root mean square, pre-op: preoperative, post-op: postoperative
| Parameter                        | Mean  | SD   | 95% CI Lower | 95% CI Upper | p-value |
|---------------------------------|-------|------|--------------|--------------|---------|
| fleche cervicale (mm)0 - fleche cervicale (mm)4 | -1.03 | 23.80 | -10.08       | 8.03         | 0.818   |
| fleche lombaire (mm)0 - fleche lombaire (mm)4 | -2.25 | 11.44 | -6.60        | 2.11         | 0.299   |
| kyphotic angle (°)0 - kyphotic angle (°)4 | -2.53 | 8.86  | -5.90        | 0.84         | 0.135   |
| lordotic angle (°)0 - lordotic angle (°)4 | 2.26  | 4.08  | 0.71         | 3.81         | 0.006   |
| sagittal imbalance (°)0 - sagittal imbalance (°)4 | 1.03  | 3.84  | -0.43        | 2.49         | 0.161   |
| sagittal imbalance (mm)0 - sagittal imbalance (mm)4 | 8.01  | 29.16 | -3.09        | 19.10        | 0.150   |
| coronal imbalance (°)0 - coronal imbalance (°)4 | -0.52 | 1.50  | -1.09        | 0.05         | 0.074   |
| coronal imbalance (mm)0 - coronal imbalance (mm)4 | -4.44 | 11.81 | -8.93        | 0.05         | 0.053   |
| apical deviation rms (mm)0 - apical deviation rms (mm)4 | 0.68  | 3.67  | -0.72        | 2.08         | 0.328   |
| apical deviation amplitude (mm)0 - apical deviation amplitude (mm)4 | 1.52  | 5.49  | -0.57        | 3.61         | 0.148   |
| apical deviation max (mm)0 - apical deviation max (mm)4 | 1.07  | 5.46  | -1.01        | 3.14         | 0.301   |
| scoliosis angle (°)0 - scoliosis angle (°)4 | 1.07  | 5.96  | -1.20        | 3.34         | 0.342   |
| vertebral rotation rms (°)0 - vertebral rotation rms (°)4 | 0.27  | 2.87  | -0.83        | 1.36         | 0.622   |
| vertebral rotation amplitude (°)0 - vertebral rotation amplitude (°)4 | 0.17  | 4.38  | -1.49        | 1.84         | 0.834   |
| vertebral rotation max (°)0 - vertebral rotation max (°)4 | 0.31  | 4.23  | -1.30        | 1.92         | 0.696   |
| trunk torsion (°)0 - trunk torsion (°)4 | 3.24  | 7.70  | 0.31         | 6.17         | 0.031   |

**TABLE 3: Comparison of parameters of the spine for patients with THA between preoperative and postoperative four-month values**

THA: total hip arthroplasty, MFU: months follow-up, SD: standard deviation, rms: root mean square, CI: confidence interval
### TABLE 4: Comparison of parameters of the pelvis for patients with THA between preoperative and postoperative four-month values

| Parameter                                      | Pre-op | Post-op | Mean差值 | SD差值 | 95% CI | p-value  |
|------------------------------------------------|--------|---------|----------|--------|--------|----------|
| Pelvic inclination symmetry line (°)          | 22.31  | 19.07   | 3.24     | 7.62   | 0.34   | 6.14     | 0.030    |
| Pelvic inclination dimples (°)                | 18.86  | 17.38   | 1.48     | 4.75   | -0.32  | 3.29     | 0.104    |
| Pelvic torsion (°)                             | 3.14   | 2.79    | 0.34     | 1.95   | -0.40  | 1.09     | 0.349    |
| Pelvic obliquity (°)                          | 3.97   | 3.69    | 0.26     | 3.11   | 0.26   | 2.63     | 0.018    |
| Pelvic obliquity (mm)                         | 5.59   | 3.77    | 1.82     | 3.67   | 0.42   | 3.21     | 0.013    |
| Pelvis rotation (°)                           | 3.69   | 0.72    | 2.97     | 4.08   | 1.42   | 4.52     | 0.001    |

THA: total hip arthroplasty, MFU: months follow-up, SD: standard deviation

The parameters of the spine and the pelvis in the patients surveyed both preoperatively and at 12 months after THA are summarized in Tables 6–9. At 12 months postoperatively, patients presented significantly decreased values compared with the preoperative values, and values improved to normal only for pelvic obliquity (°; 4.05→2.35, p = 0.010) and pelvic obliquity (mm; 6.03→3.61, p = 0.009).
| Parameter                                           | Mean   | SD    |
|----------------------------------------------------|--------|-------|
| fleche cervicale (mm) pre-oper                     | 85.38  | 30.39 |
| fleche cervicale (mm) post-oper 12                 | 91.57  | 31.45 |
| fleche lombaire (mm) pre-oper                      | 23.54  | 22.14 |
| fleche lombaire (mm) post-oper 12                  | 28.23  | 24.63 |
| kyphotic angle (°) pre-oper                        | 57.12  | 14.33 |
| kyphotic angle (°) post-oper 12                    | 61.43  | 11.17 |
| lordotic angle (°) pre-oper                        | 47.98  | 11.44 |
| lordotic angle (°) post-oper 12                    | 46.75  | 11.38 |
| sagittal imbalance (°) pre-oper                    | 8.97   | 5.33  |
| sagittal imbalance (°) post-oper 12                | 8.03   | 6.08  |
| sagittal imbalance (mm) pre-oper                   | 69.07  | 42.09 |
| sagittal imbalance (mm) post-oper 12               | 62.58  | 46.81 |
| coronal imbalance (°) pre-oper                     | 1.55   | 1.05  |
| coronal imbalance (°) post-oper 12                 | 1.50   | 1.19  |
| coronal imbalance (mm) pre-oper                    | 11.44  | 7.53  |
| coronal imbalance (mm) post-oper 12                | 10.88  | 8.18  |
| apical deviation rms (mm) pre-oper                 | 6.85   | 4.09  |
| apical deviation rms (mm) post-oper 12             | 6.76   | 2.78  |
| apical deviation amplitude (mm) pre-oper           | 14.50  | 6.19  |
| apical deviation amplitude (mm) post-oper 12       | 15.80  | 7.18  |
| apical deviation max (mm) pre-oper                 | 11.75  | 6.21  |
| apical deviation max (mm) post-oper 12             | 12.35  | 4.98  |
| scoliosis angle (°) pre-oper                       | 16.95  | 7.98  |
| scoliosis angle (°) post-oper 12                   | 17.10  | 7.26  |
| vertebral rotation rms (°) pre-oper                | 5.35   | 2.86  |
| vertebral rotation rms (°) post-oper 12            | 4.79   | 2.23  |
| vertebral rotation amplitude (°) pre-oper          | 12.15  | 4.77  |
| vertebral rotation amplitude (°) post-oper 12      | 12.45  | 4.27  |
| vertebral rotation max (°) pre-oper                | 9.60   | 3.59  |
| vertebral rotation max (°) post-oper 12            | 9.40   | 3.33  |
| trunk torsion (°) pre-oper                         | 7.80   | 6.89  |
| trunk torsion (°) post-oper 12                     | 6.55   | 4.95  |

**TABLE 6: Comparison of parameters of the spine for patients with THA between preoperative and postoperative 12-month values**

THA: total hip arthroplasty, MFU: months follow-up, SD: standard deviation, rms: root mean square, pre-oper: preoperative, post-oper: postoperative
| Parameter                      | Mean  | SD    | 95% CI          | p-value |
|--------------------------------|-------|-------|-----------------|---------|
| fleche cervicale (mm)0 - fleche cervicale (mm)12 | -6.19 | 24.90 | -17.84 to 50.46 | 0.280   |
| fleche lombaire (mm)0 - fleche lombaire (mm)12 | -4.70 | 13.63 | -11.07 to 10.68 | 0.140   |
| kyphotic angle (°)0 - kyphotic angle (°)12          | -4.31 | 10.43 | -9.19 to 50.46  | 0.080   |
| lordotic angle (°)0 - lordotic angle (°)12          | 1.24  | 3.37  | -0.34 to 20.81  | 0.117   |
| sagittal imbalance (°)0 - sagittal imbalance (°)12 | 0.94  | 4.72  | -1.27 to 30.15  | 0.384   |
| sagittal imbalance (mm)0 - sagittal imbalance (mm)12 | 6.49  | 34.12 | -9.48 to 220.46 | 0.406   |
| coronal imbalance (°)0 - coronal imbalance (°)12 | 0.05  | 1.57  | -0.69 to 0.79   | 0.888   |
| coronal imbalance (mm)0 - coronal imbalance (mm)12 | 0.46  | 12.15 | -5.22 to 6.14   | 0.867   |
| apical deviation rms (mm)0 - apical deviation rms (mm)12 | 0.09  | 4.11  | -1.84 to 2.01   | 0.927   |
| apical deviation amplitude (mm)0 - apical deviation amplitude (mm)12 | -1.30 | 6.94  | -4.55 to 1.95   | 0.413   |
| apical deviation max (mm)0 - apical deviation max (mm)12 | -0.60 | 6.24  | -3.52 to 2.32   | 0.672   |
| scoliosis angle (°)0 - scoliosis angle (°)12        | -0.15 | 5.92  | -2.92 to 2.62   | 0.911   |
| vertebral rotation rms (°)0 - vertebral rotation rms (°)12 | 0.56  | 3.01  | -0.85 to 1.96   | 0.419   |
| vertebral rotation amplitude (°)0 - vertebral rotation amplitude (°)12 | -0.30 | 3.85  | -2.10 to 1.50   | 0.732   |
| vertebral rotation max (°)0 - vertebral rotation max (°)12 | 0.20  | 3.69  | -1.53 to 1.93   | 0.811   |
| trunk torsion (°)0 - trunk torsion (°)12            | 1.25  | 6.33  | -1.71 to 4.21   | 0.388   |

**TABLE 7: Comparison of parameters of the spine for patients with THA between preoperative and postoperative 12-month values**

THA: total hip arthroplasty, MFU: months follow-up, SD: standard deviation, rms: root mean square, CI: confidence interval
### TABLE 8: Comparison of parameters of the pelvis for patients with THA between preoperative and postoperative 12-month values

| Parameter                                      | Mean  | SD   |
|-----------------------------------------------|-------|------|
| Pelvic inclination symmetry line (°) pre-oper | 24.90 | 10.79|
| Pelvic inclination symmetry line (°) post-oper| 23.50 | 10.32|
| Pelvic inclination dimples (°) pre-oper       | 21.05 | 6.57 |
| Pelvic inclination dimples (°) post-oper       | 20.65 | 7.26 |
| Pelvic torsion (°) pre-oper                    | 3.55  | 1.67 |
| Pelvic torsion (°) post-oper                   | 3.15  | 2.13 |
| Pelvic obliquity (°) pre-oper                  | 4.05  | 3.35 |
| Pelvic obliquity (°) post-oper                 | 2.35  | 3.48 |
| Pelvic obliquity (mm) pre-oper                 | 6.03  | 5.12 |
| Pelvic obliquity (mm) post-oper                | 3.61  | 4.96 |
| Pelvis rotation (°) pre-oper                   | 3.50  | 4.15 |
| Pelvis rotation (°) post-oper                  | 1.50  | 1.73 |

### TABLE 9: Comparison of parameters of the pelvis for patients with THA between preoperative and postoperative 12-month values

| Parameter                                      | Mean  | SD   |
|-----------------------------------------------|-------|------|
| Pelvic inclination symmetry line (°)0 - pelvic inclination symmetry line (°)12 | 1.40  | 5.67 |
| Pelvic inclination dimples (°)0 - pelvic inclination dimples (°)12            | 0.40  | 4.81 |
| Pelvic torsion (°)0 - pelvic torsion (°)12                                         | 0.40  | 2.28 |
| Pelvic obliquity (°)0 - pelvic obliquity (°)12                                     | 1.70  | 2.64 |
| Pelvic obliquity (mm)0 - pelvic obliquity (mm)12                                  | 2.42  | 3.74 |
| Pelvis rotation (°)0 - pelvis rotation (°)12                                       | 2.00  | 5.01 |

### Patients with TKA

Another group of 45 patients with 34 women, 11 men, and a mean age of 72.42 ± 7.00 years (range, 54-90 years) was surveyed preoperatively. Of these patients, 24 were surveyed at four and 12 months postoperatively, 12 patients were surveyed only at four months postoperatively, and nine patients were surveyed only at 12 months postoperatively. There were 20 patients who underwent an operation for the right knee and 25 for the left knee. Four orthopedic surgeons carried out TKA. Other characteristics of these patients are a mean weight of 79.87 ± 13.79 kg, a mean height of 162.16 ± 5.89 mm, and a mean BMI of 30.36 ± 4.49 kg/m². Table 10 summarizes the homogeneity of the demographic characteristics between the CG and the patients with TKA. No statistically significant differences were noted between the CG and patients with TKA except for gender.
The parameters of the spine and the pelvis in the patients surveyed both preoperatively and four months after TKA are summarized in Tables 11-14. At four months postoperatively, patients presented with significantly decreased values compared with the preoperative values, but values improved to normal for the lordotic angle ($^\circ$; 49.69 → 46.78, $p = 0.002$), pelvic inclination ($^\circ$; 26.50 → 24.35, $p = 0.032$), pelvic obliquity ($^\circ$; 2.78 → 1.86, $p = 0.008$) and pelvic obliquity (mm; 4.02 → 2.47, $p = 0.005$). However, four months postoperatively, patients presented significantly increased values compared with the preoperative values and worse values than normal values for the fleche cervicale (mm; 82.71 → 94.09, $p = 0.004$) and vertebral rotation ($^\circ$; 4.81 → 5.66, $p = 0.046$).
| Parameter                                      | Mean   | SD     |
|-----------------------------------------------|--------|--------|
| fleche cervicale (mm) pre-oper               | 82.71  | 25.52  |
| fleche cervicale (mm) post-op 4              | 94.09  | 28.01  |
| fleche lombaire (mm) pre-oper                | 31.62  | 19.24  |
| fleche lombaire (mm) post-op 4               | 31.15  | 17.70  |
| kyphotic angle (°) pre-op                    | 60.80  | 14.03  |
| kyphotic angle (°) post-op 4                 | 63.89  | 14.04  |
| lordotic angle (°) pre-op                    | 49.69  | 17.41  |
| lordotic angle (°) post-op 4                 | 46.78  | 15.57  |
| sagittal imbalance (*) pre-op                | 7.28   | 5.07   |
| sagittal imbalance (*) post-op 4             | 7.74   | 4.04   |
| sagittal imbalance (mm) pre-op               | 53.24  | 37.61  |
| sagittal imbalance (mm) post-op 4            | 57.59  | 31.97  |
| coronal imbalance (*) pre-op                 | 1.08   | 1.05   |
| coronal imbalance (*) post-op 4              | 1.06   | 1.04   |
| coronal imbalance (mm) pre-op                | 7.87   | 7.13   |
| coronal imbalance (mm) post-op 4             | 7.99   | 6.94   |
| apical deviation rms (mm) pre-op             | 6.69   | 3.67   |
| apical deviation rms (mm) post-op 4          | 6.48   | 3.28   |
| apical deviation amplitude (mm) pre-op       | 13.11  | 5.38   |
| apical deviation amplitude (mm) post-op 4    | 13.17  | 5.13   |
| apical deviation max (mm) pre-op             | 11.19  | 5.38   |
| apical deviation max (mm) post-op 4          | 10.50  | 5.29   |
| scoliosis angle (°) pre-op                   | 16.58  | 5.92   |
| scoliosis angle (°) post-op 4                | 16.83  | 6.20   |
| vertebral rotation rms (°) pre-op            | 4.81   | 2.73   |
| vertebral rotation rms (°) post-op 4         | 5.66   | 3.51   |
| vertebral rotation amplitude (°) pre-op      | 11.67  | 5.34   |
| vertebral rotation amplitude (°) post-op 4   | 11.94  | 4.77   |
| vertebral rotation max (°) pre-op            | 8.94   | 4.36   |
| vertebral rotation max (°) post-op 4         | 10.28  | 4.68   |
| trunk torsion (°) pre-op                     | 7.33   | 6.54   |
| trunk torsion (°) post-op 4                  | 7.75   | 4.78   |

**TABLE 11: Comparison of parameters of the spine for patients with TKA between preoperative and postoperative four-month values**

TKA: total knee arthroplasty, MFU: months follow-up, SD: standard deviation, rms: root mean square, pre-op: preoperative, post-op: postoperative
### TABLE 12: Comparison of parameters of the spine for patients with TKA between preoperative and postoperative four-month values

TKA: total knee arthroplasty, MFU: months follow-up, SD: standard deviation, rms: root mean square, CI: confidence interval
## TABLE 13: Comparison of parameters of the pelvis for patients with TKA between preoperative and postoperative four-month values

| Parameter                        | Pre-op | SD    | Post-op | SD  | p-value | 95% CI  | 95% CI  |
|----------------------------------|--------|-------|---------|-----|---------|---------|---------|
| Pelvic inclination symmetry line | 26.50  | 17.73 | 24.33   | 17.36| 0.032   | 4.13    | 0.032   |
| Pelvic inclination dimples       | 20.83  | 13.00 | 19.44   | 15.07| 0.214   | -0.84   | 3.62    |
| Pelvic torsion                   | 2.89   | 2.35  | 2.72    | 1.72 | 0.657   | -0.59   | 0.92    |
| Pelvic obliquity                 | 2.78   | 2.99  | 1.86    | 2.26 | 0.007   | 0.51    | 2.59    |
| Pelvic obliquity (mm)            | 4.02   | 3.88  | 2.47    | 2.77 | 0.001   | 0.51    | 2.59    |

The parameters of the spine and the pelvis in the patients surveyed both preoperatively and at 12 months after TKA are summarized in Tables 15-18. At 12 months postoperatively, patients presented significantly decreased values compared with the preoperative values, and values improved to normal only for pelvic obliquity (°; 3.58→1.94, p < 0.001) and pelvic obliquity (mm; 4.93→2.59, p = 0.001).
## TABLE 15: Comparison of parameters of the pelvis for patients with TKA between preoperative and postoperative 12-month values

TKA: total knee arthroplasty, MFU: months follow-up, SD: standard deviation, rms: root mean square, pre-oper: preoperative, post-oper: postoperative

| Parameter                                      | Mean  | SD   |
|------------------------------------------------|-------|------|
| fleche cervicale (mm) pre-oper                 | 85.10 | 24.38|
| fleche cervicale (mm) post-oper 12             | 89.61 | 30.00|
| fleche lombaire (mm) pre-oper                  | 31.80 | 16.12|
| fleche lombaire (mm) post-oper 12              | 30.15 | 16.17|
| kyphotic angle (°) pre-oper                    | 62.33 | 12.37|
| kyphotic angle (°) post-oper 12                | 63.60 | 12.00|
| lordotic angle (°) pre-oper                    | 46.94 | 15.09|
| lordotic angle (°) post-oper 12                | 46.48 | 15.05|
| sagittal imbalance (°) pre-oper                | 7.14  | 4.36 |
| sagittal imbalance (°) post-oper 12            | 7.84  | 4.86 |
| sagittal imbalance (mm) pre-oper               | 52.18 | 32.03|
| sagittal imbalance (mm) post-oper 12           | 58.01 | 36.52|
| coronal imbalance (°) pre-oper                 | 1.39  | 1.12 |
| coronal imbalance (°) post-oper 12             | 1.42  | 1.20 |
| coronal imbalance (mm) pre-oper                | 9.91  | 7.37 |
| coronal imbalance (mm) post-oper 12            | 10.44 | 8.48 |
| apical deviation rms (mm) pre-oper             | 6.86  | 3.72 |
| apical deviation rms (mm) post-oper 12         | 5.78  | 2.82 |
| apical deviation amplitude (mm) pre-oper       | 14.30 | 6.34 |
| apical deviation amplitude (mm) post-oper 12   | 12.88 | 4.72 |
| apical deviation max (mm) pre-oper             | 12.42 | 6.29 |
| apical deviation max (mm) post-oper 12         | 10.70 | 4.83 |
| scoliosis angle (°) pre-oper                   | 18.09 | 6.41 |
| scoliosis angle (°) post-oper 12               | 16.30 | 5.77 |
| vertebral rotation rms (°) pre-oper            | 4.88  | 2.46 |
| vertebral rotation rms (°) post-oper 12        | 5.49  | 2.75 |
| vertebral rotation amplitude (°) pre-oper      | 12.36 | 5.06 |
| vertebral rotation amplitude (°) post-oper 12  | 11.64 | 4.36 |
| vertebral rotation max (°) pre-oper            | 9.30  | 3.93 |
| vertebral rotation max (°) post-oper 12        | 9.76  | 4.19 |
| trunk torsion (°) pre-oper                     | 7.09  | 5.89 |
| trunk torsion (°) post-oper 12                 | 7.73  | 6.10 |
| Parameter                                           | Mean  | SD    | 95% CI   | p-value |
|-----------------------------------------------------|-------|-------|----------|---------|
| fleche cervicale (mm)0 - fleche cervicale (mm)12    | -4.51 | 22.84 | -12.61   | 3.59    | 0.265  |
| fleche lombaire (mm)0 - fleche lombaire (mm)12     | 1.65  | 8.38  | -1.32    | 4.62    | 0.267  |
| kyphotic angle (°)0 - kyphotic angle (°)12          | -1.27 | 8.97  | -4.45    | 1.91    | 0.423  |
| lordotic angle (°)0 - lordotic angle (°)12         | 0.47  | 4.85  | -1.25    | 2.19    | 0.584  |
| sagittal imbalance (°)0 - sagittal imbalance (°)12 | -0.70 | 3.22  | 0.44     | 0.221   |
| sagittal imbalance (mm)0 - sagittal imbalance (mm)12 | -5.83 | 25.92 | -15.02   | 3.36    | 0.206  |
| coronal imbalance (°)0 - coronal imbalance (°)12    | -0.03 | 1.55  | 0.52     | 0.911   |
| coronal imbalance (mm)0 - coronal imbalance (mm)12  | -0.53 | 10.25 | -4.17    | 3.10    | 0.767  |
| apical deviation rms (mm)0 - apical deviation rms (mm)12 | 1.09 | 3.35 | -0.10    | 2.27    | 0.091  |
| apical deviation amplitude (mm)0 - apical deviation amplitude (mm)12 | 1.42 | 4.96 | -0.34    | 3.18    | 0.109  |
| apical deviation max (mm)0 - apical deviation max (mm)12 | 1.73 | 5.66 | 0.28     | 3.73    | 0.089  |
| scoliosis angle (°)0 - scoliosis angle (°)12        | 1.79  | 5.42  | -0.13    | 3.71    | 0.067  |
| vertebral rotation rms (°)0 - vertebral rotation rms (°)12 | 0.61 | 3.10 | -1.71    | 0.49    | 0.265  |
| vertebral rotation amplitude (°)0 - vertebral rotation amplitude (°)12 | 0.73 | 5.92 | 0.17    | 2.63    | 0.485  |
| vertebral rotation max (°)0 - vertebral rotation max (°)12 | 0.45 | 4.81 | -2.16    | 1.25    | 0.591  |
| trunk torsion (°)0 - trunk torsion (°)12            | -0.64 | 4.88  | -2.37    | 1.09    | 0.459  |

**TABLE 16: Comparison of parameters of the pelvis for patients with TKA between preoperative and postoperative 12-month values**

TKA: total knee arthroplasty, MFU: months follow-up, SD: standard deviation, rms: root mean square, CI: confidence interval
### Table 17: Comparison of parameters of the pelvis for patients with TKA between preoperative and postoperative 12-month values

| Parameter                              | Pre-op | SD  | Post-op | SD  | Lower | Upper | p-value |
|----------------------------------------|--------|-----|---------|-----|-------|-------|---------|
| Pelvic inclination symmetry line (°)   | 21.18  | 15.63 | 21.09   | 15.35 |       |       | 0.923   |
| Pelvic inclination dimples (°)         | 17.64  | 11.79 | 17.27   | 12.17 |       |       |         |
| Pelvic torsion (°)                     | 2.42   | 2.03  | 2.33    | 1.51  |       |       |         |
| Pelvic obliquity (°)                   | 3.58   | 2.94  | 1.94    | 2.94  |       |       |         |
| Pelvic obliquity (mm)                  | 4.93   | 4.03  | 2.59    | 2.87  |       |       |         |
| Pelvis rotation (°)                    | 3.18   | 4.45  | 2.27    | 3.20  |       |       |         |

TKA: total knee arthroplasty, MFU: months follow-up, SD: standard deviation, CI: confidence interval

### Discussion

We think that the relationships between the hip and knee OA and the disordered morphology of the spine and pelvis, as well as their possible causal relationship, are very interesting topics in orthopedics. We have tried to address this issue in two steps. The first step was to study the trunk morphology in two groups of patients with hip and knee OA and to compare them with a CG. The results of this study showed that the spine and pelvis morphology is actually disturbed in patients with hip and knee OA [1]. The same results were also mentioned in other studies [2-7]. The second step was to study the same groups of patients with hip or knee OA undergoing THA or TKA and to study the effect of these operations on the disturbed morphology of the spine and the pelvis.

Compared to the CG, the patients with hip OA had a greater forward inclination of the spine, increased scoliosis, more vertebral rotation and trunk torsion, and greater obliquity of the pelvis in the frontal plane.
An interesting and unanswered issue in orthopedics is the relationship between the hip and knee OA and the occurrence of disturbed morphology of the trunk, as well as their possible etiological relationship. From this study, it appears that hip and knee OA is not responsible for the disturbed morphology of the trunk. On the other hand, it is still unclear whether the disturbed trunk morphology is responsible for causing the hip and knee OA.

Thus, although THA and TKA operations repaired the hip and knee OA, they could not repair the disturbed morphology of the spine and pelvis in the long run. This means that the hip and knee OA could not be responsible for the disturbed morphology of the spine and the pelvis, but other causes and mechanisms should be responsible for this morphology. These mechanisms apparently persisted postoperatively, resulting in the recurrence of the same problems of trunk morphology at 12 months. A proposed etiological mechanism could be the asymmetric action of the trunk muscles in these patients, which pre-exist and persist postoperatively, resulting in the recurrence of disturbed morphology of the spine and pelvis in patients undergoing THA and TKA. In fact, a similar pathogenetic mechanism has been described in patients with scoliosis [10-12].

From the results of this study, it cannot be ruled out that the disturbed morphology of the spine and pelvis could be responsible for the appearance of hip and knee OA, but further studies are needed to determine if it is truly the cause. There may also be other factors than disordered trunk morphology that continue to exist after THA or TKA and could be responsible for the appearance of hip and knee OA.

Limitations
There were some limitations to this study. The first was that the number of patients was limited. The second was that not all the patients were examined at four and 12 months. The third was that the estimations using the Diers Formetric four-D system were done by only one examiner.

Conclusions
An interesting and unanswered issue in orthopedics is the relationship between the hip and knee OA and the occurrence of disturbed morphology of the trunk, as well as their possible etiological relationship. From this study, it appears that hip and knee OA is not responsible for the disturbed morphology of the trunk. On the other hand, it is still unclear whether the disturbed trunk morphology is responsible for causing the hip and knee OA. Other studies are necessary to provide an answer to this interesting question.
References

1. Kechagias VA, Grivas TB, Papagelopoulos PJ, Kontogeorgakos VA, Vlaris K: Truncal changes in patients suffering severe hip or knee osteoarthritis: a surface topography study. Clin Orthop Surg. 2021, 13:185-95. 10.4055/cios20123

2. Yoshimoto H, Sato S, Masuda T, Kanno T, Shundo M, Hyakumachi T, Yanagibashi Y: Spinopelvic alignment in patients with osteoarthrosis of the hip: a radiographic comparison to patients with low back pain. Spine (Phila Pa 1976). 2005, 30:1630-7. 10.1097/01.brs.0000169446.69758.f2

3. Weng WJ, Wang WJ, Wu MD, Xu ZH, Xu LL, Qiu Y: Characteristics of sagittal spine-pelvis-leg alignment in patients with severe hip osteoarthritis. Eur Spine J. 2015, 24:1228-36. 10.1007/s00586-014-3700-5

4. Weng WJ, Liu F, Zhu YW, Sun MH, Qiu Y, Weng WJ: Sagittal alignment of the spine-pelvis-lower extremity axis in patients with severe knee osteoarthritis: a radiographic study. Bone Joint Res. 2016, 5:198-205. 10.1302/2046-3758.5.2000538

5. Tauchi R, Imagama S, Muramoto A, Tsuboi M, Ishiguro N, Hasagawa Y: Influence of spinal imbalance on knee osteoarthrosis in community-living elderly adults. Nagoya J Med Sci. 2015, 77:329-37.

6. Lee CS, Park SJ, Chung SS, Lee KH: The effect of simulated knee flexion on sagittal spinal alignment: novel interpretation of spinopelvic alignment. Eur Spine J. 2015, 24:1059-65. 10.1007/s00586-013-2661-4

7. Harato K, Nagura T, Matsumoto H, Otani T, Toyama Y, Suda Y: A gait analysis of simulated knee flexion contracture to elucidate knee-spine syndrome. Gait Posture. 2008, 28:687-92. 10.1016/j.gaitpost.2008.05.008

8. Bendaya S, Lazennec JY, Anglin C, Allena R, Sellam N, Thoumie P, Skalli W: Healthy vs. osteoarthritic hips: a comparison of hip, pelvis and femoral parameters and relationships using the EOS® system. Clin Biomech (Bristol, Avon). 2015, 30:192-204. 10.1016/j.clinbiomech.2014.11.010

9. Murata Y, Takahashi K, Yamaga M, Hanaoka E, Moriya H: The knee-spine syndrome. Association between lumbar lordosis and extension of the knee. J Bone Joint Surg Br. 2005, 85:95-9. 10.1302/0301-620x.85b1.13389

10. Grivas TB, Burwell RG, Kechagias V, Maziotti C, Fountas A, Kolovou D, Christodoulou E: Idiopathic and normal lateral lumbar curves: muscle effects interpreted by 12th rib length asymmetry with pathomechanic implications for lumbar idiopathic scoliosis. Scoliosis Spinal Disord. 2016, 11:55. 10.1186/s13013-016-0093-8

11. Kim H, Lee CK, Yeon JS, et al.: Asymmetry of the cross-sectional area of paravertebral and psoas muscle in patients with degenerative scoliosis. Eur Spine J. 2015, 24:1332-8. 10.1007/s00586-013-2740-6

12. Hopf C, Scheidecker M, Steffan K, Bodem F, Eysel P: Gait analysis in idiopathic scoliosis before and after surgery: a comparison of the pre- and postoperative muscle activation pattern. Eur Spine J. 1998, 7:6-11. 10.1007/s00586005019