

Summary

Understanding patient variability in gait biomechanics and its relationship to clinical factors is important for targeted and personalized treatment options for patients with knee osteoarthritis (OA). This study examined natural clusters in gait kinematics among patients with end-stage knee OA awaiting joint replacement surgery and to compare clinical, demographic and anthropometric metrics among resulting clusters. Clusters appeared to correspond to gait severity with post-clustering significance on clinically relevant characteristics.

Introduction

Knee OA progressively impacts gait with disease progression, but specific impacts vary among individuals [1], potentially implicating clinically significant differences among identifiable subgroups. Informing patient subgroups requires robust population samples, which has been enabled by newer, efficient technologies that can be used in clinic settings such as markerless motion capture. We examined if clinically relevant clusters of patients with end stage knee OA can be defined based on gait kinematic data during the perioperative arthroplasty period using in-clinic markerless motion capture, and, secondly, examined differences in clinical and patient characteristics among clusters pre-operatively.

Methods

Overground walking gait kinematics from clinic visits (n=145) from patients with end stage knee OA receiving joint replacement were captured in an orthopaedic clinic hallway using a markerless motion capture system (10 x Sony RX0II cameras; Thieia markerless; Visual 3D). Principal component analysis was used to extract key features from knee flexion/extension and abduction/adduction angles during walking. Flexion/extension principal components (PCs) 1-4 and abduction PCs 1-3 and gait speed were included in clustering due to their previously established relevance to OA outcomes [2,3]. Variables were assessed using a Tukey fence, normalized and dimensionally reduced. Hierarchical clustering was employed and assessed using silhouette score and weighted sum of squares. A k-way ANOVA and Tukey’s honest significant difference test were employed to examine inter-cluster differences in kinematics. Anthropometrics, demographics and clinical patient reported outcome measures

(PROMs) for single pre-operative patient datapoints (closest to surgery, n=77) were evaluated individually.

Results and Discussion

Optimal clustering (n=3 clusters, Figure 1) organized based on gait severity, with significant sagittal and frontal plane knee angle differences among clusters. Cluster 1 had the most asymptomatic knee flexion/extension angles, and were the most adducted during stance phase. Cluster 3 had the most severe knee OA gait patterns based on sagittal plane angles.

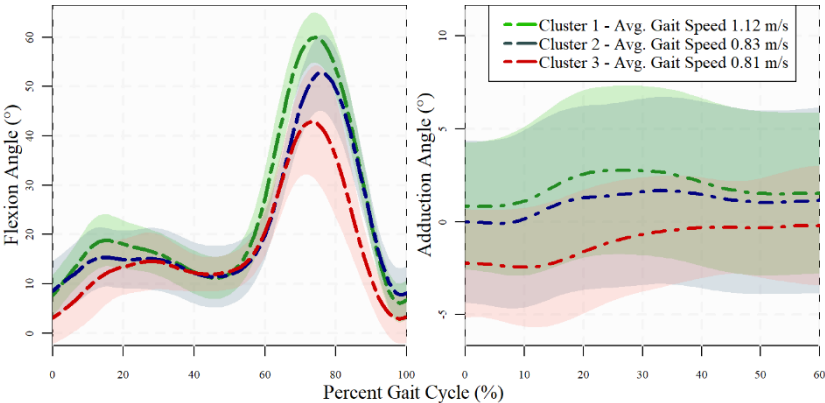


Figure 1: Cluster-specific Sagittal and Frontal Mean (SD) Knee Angles during Walking.

Post-clustering analysis identified significant pre-operative differences between clusters, primarily between clusters 1-2, with cluster 2 having consistently less favorable clinical responses, higher BMI and worse OA radiographic grading, and cluster 1 less severe, consistent with gait findings.

Conclusions

Patients with end stage knee OA naturally clustered into groups based on gait function, with differences between these clusters indicating clinical differences that could have implications for treatment decisions and screening. Further research will more data will refine clusters and link clusters to joint morphometric data to understand how surgical approaches could target cluster-specific functional deficits.

References

[1] Collins et al. (2021) *Arthritis Care Res*, **73(9)**, 1354–1362
 [2] Young-Shand et al. (2020). *JBJS OA*, **5(2)**: E00038.
 [3] Young-Shand et al. (2023). *JBJS OA*, **41(2)**: 335–344.

Table 1: Cluster-specific Pre-operative Outcomes (+/- for PROMs indicates scale direction for a more favorable response)

	Sex (M/F)	Age	BMI (kg/m ²)	Pain Catastrophizing (/12, -)	OKS Pain (/28, +)	OKS Functional (/20, +)	EQ5D (/1, +)	PHQ8 (/24, -)	UCLA (/10, +)	KL (/4, -)
Cluster 1	23, 30	67 (13)	31.5 (6.2)	4.0 (4.3)	15.0 (5.3)	12.6 (3.0)	0.76 (0.17)	3.0 (5.0)	4.0 (3.0)	3 (1)
Cluster 2	6, 13	67 (12)	38.1 (11.5)	6.0 (4.3)	11.0 (4.5)	10.1 (3.2)	0.64 (0.37)	5.0 (8.0)	3.0 (0.3)	4 (0)
Cluster 3	1, 4	71 (19)	34.7 (4.2)	5.5 (4.3)	11.0 (10.3)	10.0 (2.9)	0.64 (0.30)	1.5 (6.0)	3.5 (1.3)	4 (0)
p	0.44	0.38	<0.01	0.03	0.06	<0.001	<0.01	<0.01	<0.01	<0.001
Tukey HSD			2>1			1>2	1>2	2>1	1>2	2,3>1