Supplementary Material:

This PDF file includes:

Figures S1 to S11

Tables S1 to S5

Measurements on the skyline view
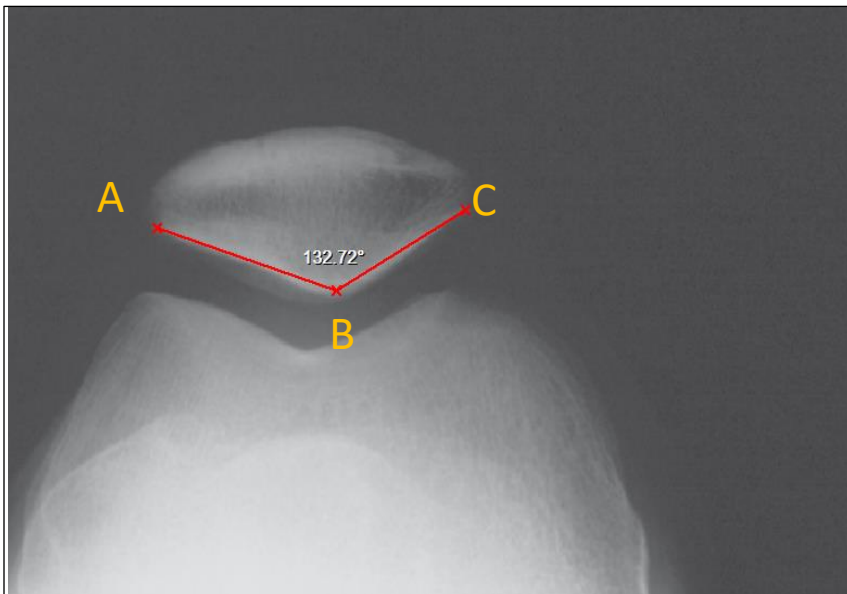
1. Patellar angle

Figure S1. patellar angle

This is the angle between the medial and lateral facets of the patella with the point of the patellar central ridge as the zenith (angle ABC in Figure S1).

Method - A straight line is drawn joining the most lateral point on the lateral facet of the patella to the patellar central ridge. Another straight line is drawn from the most medial point on the medial facet of the patella to the patellar central ridge. The patellar angle is the angle formed where the two lines meet at the patellar central ridge [1].
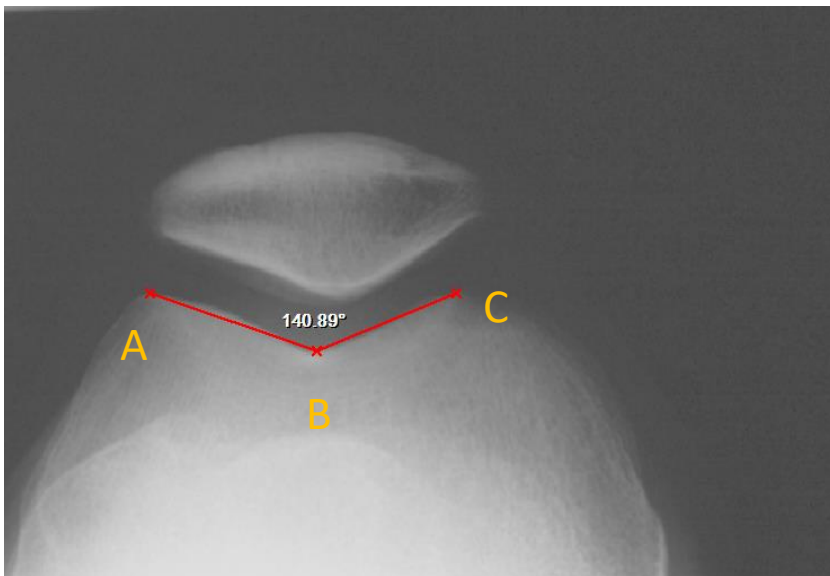
2. Sulcus angle

Figure S2. Sulcus angle

This is the angle between the medial and lateral condyles of the femur with the lowest trochlear point as the zenith (angle ABC in Figure S2).

Method - A straight line is drawn along the medial and lateral condyles of the femur, from the highest point to the lowest point on the trochlea. The sulcus angle is the angle between the medial and lateral condyles of the femur with the lowest trochlear point as the zenith (angle ABC in Figure S2) [1, 2].

3. Patellar thickness

This is the widest vertical height of the patella (Figure).

Method - A transparent ruler placed perpendicular to the horizontal margin of the screen is used to identify the landmarks. As the ruler is moved across from the lateral to the medial part of the patella, perpendicular to the lowest margin of the radiograph, the widest vertical distance gives the maximum patellar thickness [1].
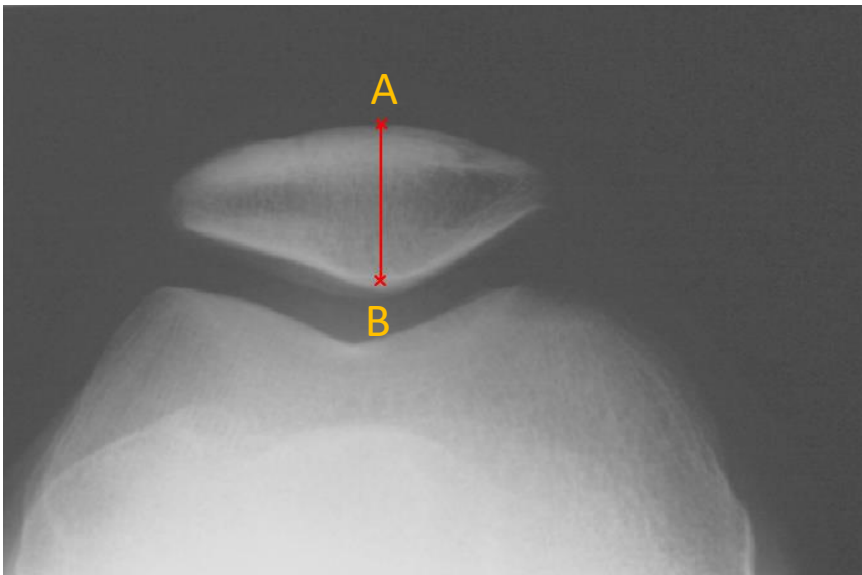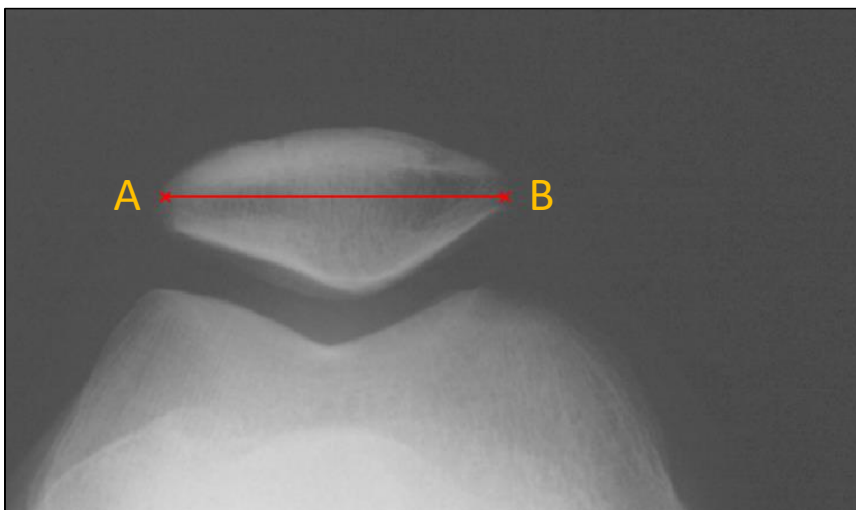

Figure S3. Patellar thickness

4. Patellar width

This is the widest horizontal distance between the most medial (A) and lateral (B) points of the patella as shown in Figure S4.

Method - A transparent ruler is placed horizontally, perpendicular to the vertical margin of the screen and moved from the bottom of the patella to its top and parallel to the lower border of the radiograph. The widest horizontal distance is identified and measured [1].

5. Condylar width

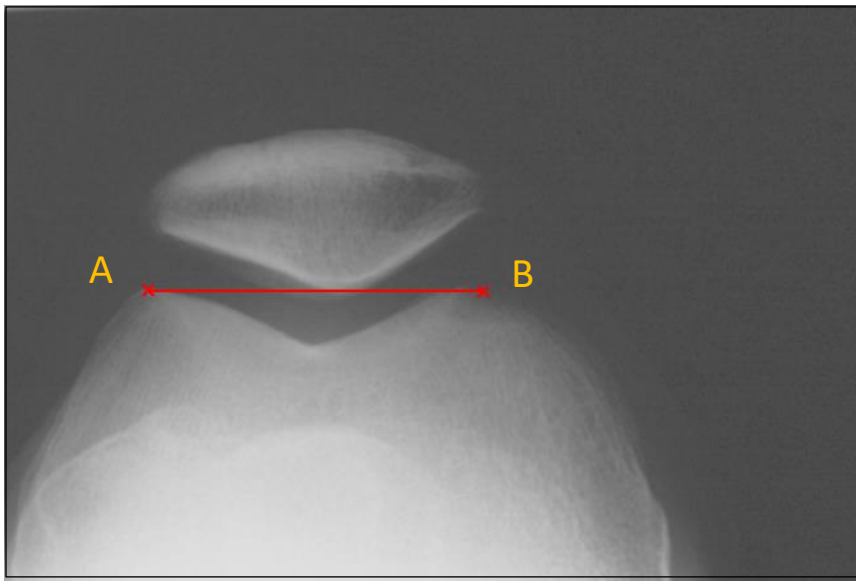
Figure S5. Condylar width

Condylar width is the width between the prominences of the medial and lateral femoral condyles (Figure S5)

Method - The highest points as shown in Figure S5 of the medial (A) and lateral (B) condyles of the femur are selected and a straight line is drawn joining them and parallel to the lowest margin of the radiograph. This length (AB) is the condylar width [1].

6. Condylar angle
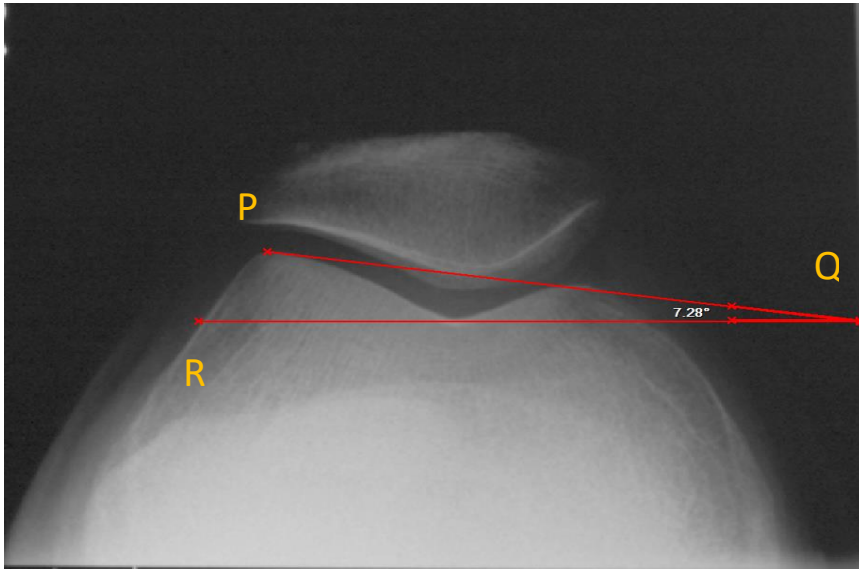
Figure S6. Condylar angle

Condylar angle denotes the slope of the femoral condyles.

Method - A line is drawn along the highest point of the medial and lateral condyles of the femur (Line PQ in Figure S6). A second line (RQ) is drawn horizontally, perpendicular to the vertical margin of the screen, along the condyles passing through the lowest trochlear point and parallel to the lower margin of the radiograph. The angle formed by the intersection of the lines (angle PQR) is the condylar angle.

7. Intercondylar width and medial and lateral condylar height
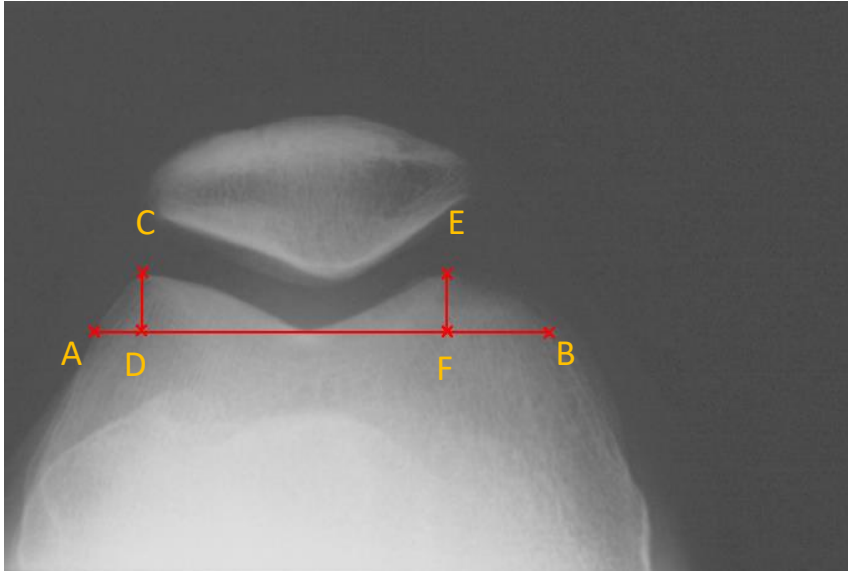
Figure S7. Intercondylar width and Lateral condylar height

Method - A horizontal line is drawn across the medial and lateral femoral condyles passing through the lowest trochlear point and parallel to the lower margin of the radiograph, perpendicular to the horizontal margin of the screen (Line AB in Figure S7). Two vertical lines are drawn from the highest points in the medial and lateral femoral condyles which intersect the horizontal line AB at right angles (D and F). The distance between D and F gives the intercondylar width. The vertical lines CD and EF represent the heights of the medial and lateral femoral condyles.

Measurements on the Postero-anterior view (TFJ)

8. Condylar plateau angle
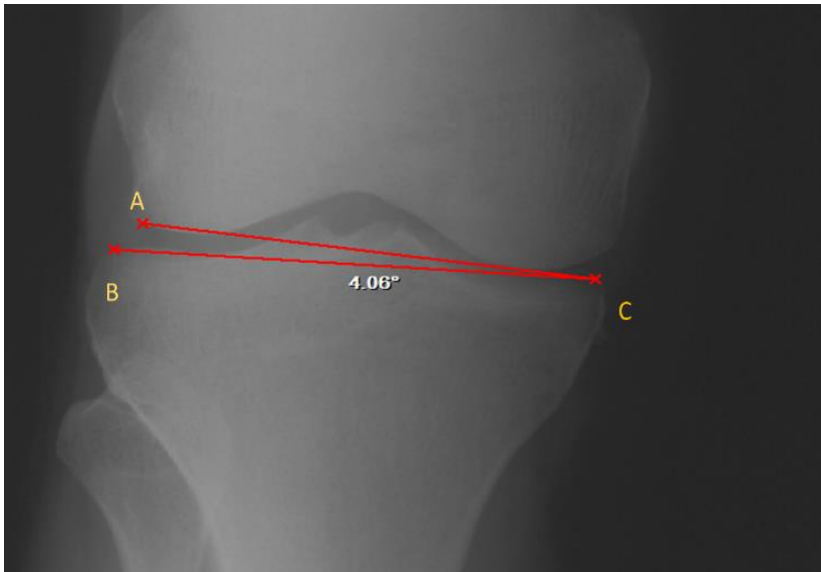
Figure S8. Condylar plateau angle

The CPA (condylar plateau angle) is the angle between the bony outline of the tibia and femur respectively, at the knee joint.

Method - A straight line is drawn along the two lowest points of the medial and lateral distal femoral condyles and along the highest points of the medial and lateral proximal tibial plateaus as shown in Figure . The angle formed where these two lines meet (ACB) is the Condylar plateau angle [3].

9. Distal femoral tilt
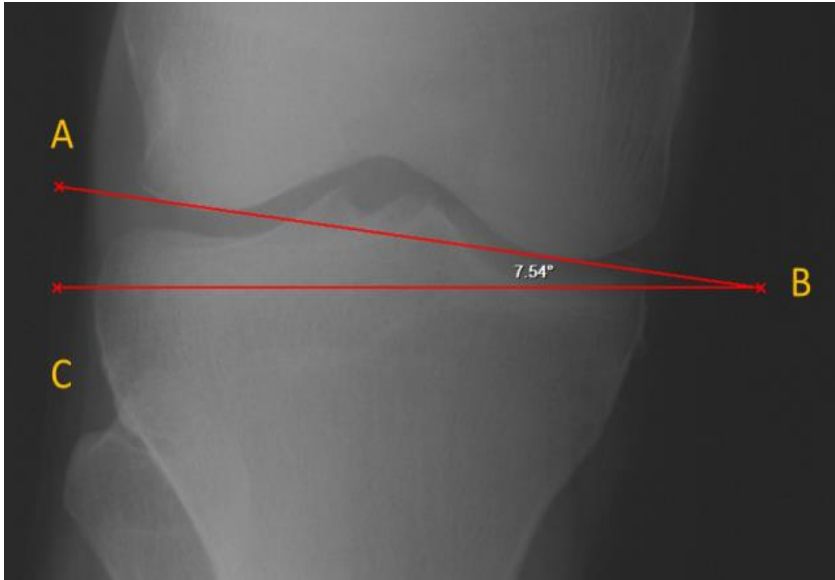
Figure S9. Distal femoral tilt

Distal femoral tilt denotes the tilt of the distal femur.

Method - A straight line (AB in Figure S9) is drawn along the lowest points of the medial and lateral distal femoral condyles. A horizontal line parallel to the lowest margin of the radiograph drawn and brought up from below till it meets point B. The angle formed where these two lines meet is the distal femoral tilt angle (angle ABC in Figure S9).

10. Proximal tibial tilt
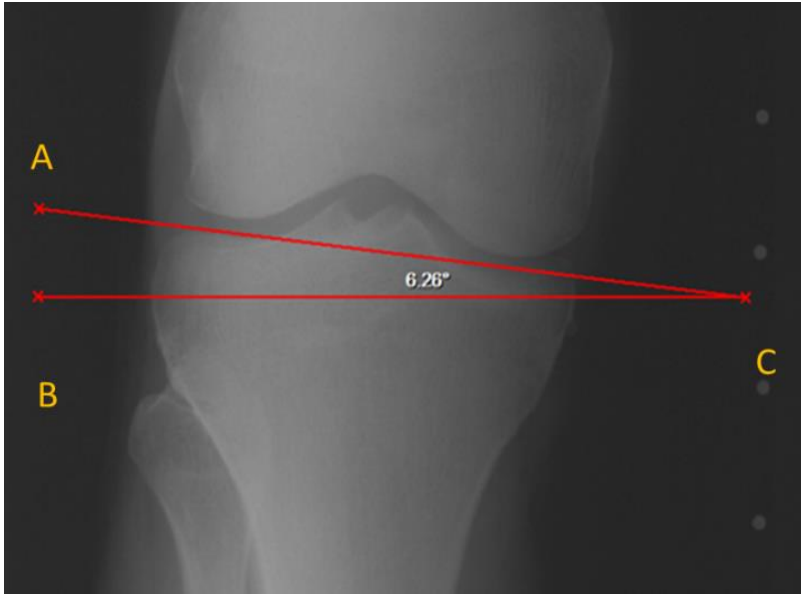
Figure S10. Proximal tibial tilt

Proximal tibial tilt denotes the tilt of the proximal tibia.

Method - A straight line (AC in Figure) is drawn along the highest points of the medial and lateral plateaus of the proximal tibia. A horizontal line parallel to the lowest margin of the radiograph is drawn, touching the lower end of the first line. The angle formed where these two lines meet gives the proximal tibial tilt angle (ACB in Figure).

If the angle opens laterally it denotes a medial tilt of the tibia and if it opens medially it denotes a lateral tilt
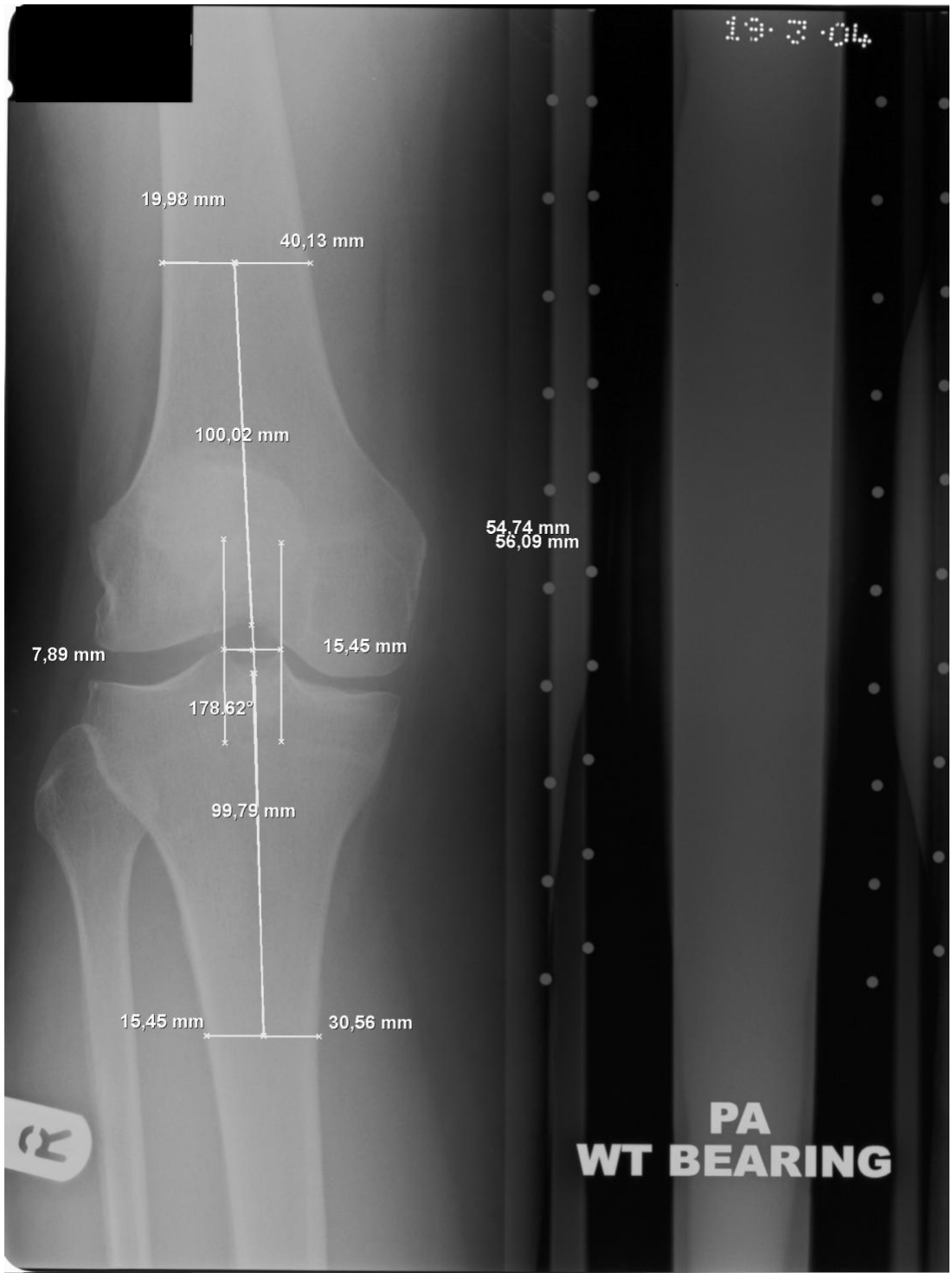
Figure S11. Illustration of method for measuring radiographic frontal plane knee alignment

Supplementary table S1. Association between patellofemoral joint measurements and age

Measurements	β-coef (95%CI)	*P* value	β-coef adjusted (95%CI)*	*P* value
Sulcus angle[1]	0.04 (-0.02, 0.1)	0.20	0.03 (-0.04, 0.1)	0.40
Patellar angle[1]	0.11 (0.04, 0.2)	<0.001[2]	0.10 (0.01, 0.2)	0.03
Condylar angle[1]	0.004 (-0.04, 0.03)	1	0.01 (-0.04, 0.3)	1
Patellar width[1]	0.12 (0.04, 0.2)	<0.001[2]	0.02 (-0.04, 0.1)	1
Patellar thickness[1]	0.1 (0.03, 0.1)	<0.001[2]	0.01 (0.04, 0.3)	< 0.001[2]
Condylar height medial[1]	0.05 (0.01, 0.1)	0.03	0.1 (-0.002, 0.10)	0.10
Condylar height lateral[1]	0.01 (-0.02, 0.03)	1	-0.01 (-0.4, 01)	1
Condylar width[1]	0.2 (0.1, 0.23)	<0.001[2]	0.1 (-0.01, 0.1)	0.11
Inter Condylar width[1]	0.13 (0.1, 0.2)	<0.001[2]	0.1 (0.003, 0.1)	0.12

*-adjusted for , gender, weight, height [1] All angles measured in degrees, and all distances in millimetres [2] significant after Bonferroni correction

Supplementary table S2. Association between patellofemoral joint measurements and gender

*-adjusted for , gender, weight, height [1] All angles measured in degrees, and all distances in millimetres [2] significant after Bonferroni

Measurements	β-coef (95%CI)	*P* value	β-coef adjusted (95%CI)*	*P* value
Sulcus angle[1]	-0.9 (-2, 0.14)	1	-0.5 (-2.0, 1.1)	0.5
Patellar angle[1]	-1.6 (-2.9, -0.33)	< 0.001[2]	-1.85 (-2.65, -1.05)	0.03
Condylar angle[1]	0.05 (-0.52, 0.63)	0.9	1 (-1.6, 3.6)	1
Patellar width[1]	-5 (-6.21, -3.92)	< 0.001[2]	-2.5 (-4, -0.93)	< 0.001[2]
Patellar thickness[1]	-2.43 (-2.95, -1.91)	< 0.001[2]	-0.52 (-1.2, 0.2)	0.14
Condylar height medial[1]	-0.84 (-1.6, -0.001)	0.05	-0.2 (-1.4, 1.01)	0.1
Condylar height medial[1]	0.75 (-1.18, -0.3)	< 0.001[2]	-0.41 (-1.0, 0.2)	0.2
Condylar width[1]	-8.3 (-9.31, -6.95)	< 0.001[2]	-5.1 (-6.74, -3.43)	< 0.001[2]
Inter Condylar width[1]	-6.2 (-7.1, -5.4)	< 0.001[2]	-3.33 (-4.5, -2.15)	< 0.001[2]

correction

Supplementary table S3. Association between patellofemoral joint measurements and weight

Measurements	β-coef (95%CI)	*P* value	β-coef adjusted (95%CI)*	*P* value
Sulcus angle[1]	0.02 (-0.01, 0.05)	0.2	0.02 (-0.02, 0.06)	1
Patellar angle[1]	0.05 (0.01, 0.1)	0.01	0.04 (-0.004, 0.1)	0.1
Condylar angle[1]	-0.01 (-0.03, 0.10)	0.45	-0.01 (-0.03, 0.01)	0.4
Patellar width[1]	0.12 (0.1, 0.15)	< 0.001[2]	0.05 (0.01, 0.1)	< 0.001[2]
Patellar thickness[1]	0.05 (0.03, 0.1)	< 0.001[2]	0.003 (-0.02, 0.02)	1
Condylar height medial[1]	0.02 (-0.003, 0.01)	0.1	0.02 (-0.02, 0.05)	0.3
Condylar height lateral[1]	0.01 (-0.01, 0.2)	0.32	-0.02 (-0.03, 0.002)	0.1
Condylar width[1]	0.2 (0.14, 0.22)	< 0.001[2]	0.1 (0.01, 0.10)	0.01
Inter Condylar width[1]	0.14 (0.1, 0.17)	< 0.001[2]	0.1 (0.02, 1)	< 0.001[2]

*-adjusted for , gender, weight, height [1] All angles measured in degrees, and all distances in millimetres [2] significant after Bonferroni correction

Supplementary table S4. Association between patellofemoral joint measurements and height

*-adjusted for age, gender and height; ¹ All angles measured in degrees, and all distances in millimetres; ² significant
after Bonferroni correction

*-adjusted for age, gender and height; [1] All angles measured in degrees, and all distances in millimetres; [2] significant after Bonferroni correction

Measurements	β-coef (95%CI)	*P* value	β-coef adjusted (95%CI)*	*P* value
Sulcus angle[1]	0.04 (-0.01, 0.1)	0.14	0.05 (-0.01, 0.1)	0.1
Patellar angle[1]	0.1 (0.01, 0.16)	0.03	0.04 (-0.03, 0.11)	0.23
Condylar angle[1]	-0.002 (-0.04, 0.03)	0.9	0.01 (-0.04, 0.1)	1
Patellar width[1]	0.3 (0.24, 0.36)	< 0.001[2]	0.4 (0.3, 0.42)	< 0.001[2]
Patellar thickness[1]	0.16 (0.13, 0.2)	< 0.001[2]	0.2 (0.13, 0.25)	< 0.001[2]
Condylar height medial[1]	0.4 (-0.004, 0.1)	0.1	0.01 (-0.07, 0.1)	0.1
Condylar height lateral[1]	0.05 (0.02, 0.1)	< 0.001[2]	0.04 (0.01, 0.1)	0.2
Condylar width[1]	0.42 (0.36, 0.48)	< 0.001[2]	0.1 (0.05, 0.24)	< 0.001[2]
Inter condylar width[1]	0.34 (0.29, 0.39)	< 0.001[2]	0.2 (0.10, 0.24)	< 0.001[2]

Supplementary table S5. Association of tibiofemoral joint measurements and participant characteristics

	β-coef (95%CI)	P value	β-coef adjusted (95%CI)*	P value
Age				
Condylar plateau angle[1]	-0.01 (-0.03, -002)	0.01	-0.02 (-0.03, -0.004)	0.01
Distal femoral tilt[1]	-0.03 (-0.05, -0.01)	< 0.001[2]	-0.03 (-0.05, -0.01)	< 0.001[2]
Proximal tibial tilt[1]	0.004 (-0.01, 0.01)	1	0.002 (-0.01, 0.02)	1
Varus alignment[1]	0.002 (-0.00, 0.004)	0.08	0.001 (-0.0007, 0.003)	0.22
Valgus alignment[1]	-0.002 (-0.003, -0.0001)	0.04	-0.002 (-0.004, -0.0005)	0.01
Gender (Female)				
Condylar plateau angle[1]	0.12 (-0.10, 0.32)	0.24	-0.24 (-0.52, 0.05)	0.10
Distal femoral tilt[1]	-0.10 (-0.40, 0.23)	1	-0.4 (-0.8, 0.06)	1
Proximal tibial tilt[1]	-0.13 (-0.37, 0.10)	0.30	-0.2 (-0.5, 0.12)	0.40
Varus alignment[1]	-0.05 (-0.08, -0.01)	< 0.001[2]	-0.03 (-0.08, 0.01)	0.15
Valgus alignment[1]	-0.01 (-0.04, 0.02)	0.32	-0.04 (-0.08, 0.005)	0.08
Weight				
Condylar plateau[1]	-0.01 (-0.01, -0.0001)	0.04	-0.004 (-0.012, 0.003)	0.01
Distal femoral tilt[1]	-0.01 (-0.02, 0.001)	0.01	-0.01 (-0.02, -0.003)	0.20
Proximal tibial tilt[1]	0.003 (-0.003, 0.01)	0.31	0.004 (-0.01, 0.01)	0.51
Varus alignment[1]	0.001 (0.00, 0.02)	< 0.001[2]	0.002 (0.0002, 0.003)	0.02
Valgus alignment[1]	0.0005 (-0.0004, 0.002)	0.28	0.0003 (-0.0008, 0.002)	0.61
Height				
Condylar plateau[1]	-0.01 (-0.02, -0.001)	0.04	-0.01 (-0.03, -0.001)	0.01
Distal femoral tilt[1]	-0.01 (-0.03, 0.003)	0.12	-0.01 (-0.21, 0.003)	0.20
Proximal tibial tilt[1]	0.003 (-0.01, 0.01)	1	-0.01 (-0.03, 0.01)	0.45
Varus alignment[1]	0.00 (-0.0009, 0.002)	0.51	-0.0005 (-0.002, 0.001)	0.59
Valgus alignment[1]	0.0002 (-0.001, 0.002)	0.67	-0.001 (-0.003, 0.0009)	0.31

*-adjusted for age, gender and height; [1] All angles measured in degrees, and all distances in millimetres; [2] significant after Bonferroni correction

References

1.   Yang B, Tan H, Yang L, Dai G, Guo B. Correlating anatomy and congruence of the patellofemoral joint with cartilage lesions. Orthopedics. 2009;32:20.

2.   Hunter DJ, Zhang YQ, Niu JB, Felson DT, Kwoh K, Newman A, et al. Patella malalignment, pain and patellofemoral progression: the Health ABC Study. Osteoarthritis Cartilage. 2007;15:1120–7.

3.   Cooke D, Scudamore A, Li J, Wyss U, Bryant T, Costigan P. Axial lower-limb alignment: comparison of knee geometry in normal volunteers and osteoarthritis patients. Osteoarthritis Cartilage. 1997;5:39–47.