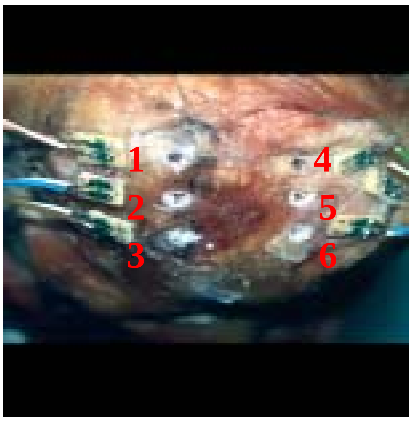
RESULTS.

RESULTS.

EXPLANATION.

THE PATELLA.



1 SE	4 SI
2 ME	5 MI
3 IE	6 II

(Position Of The Strain Gauge On The Patella).

1 SE = Superior External **(Lateral).**
2 ME = Medium External **(Lateral).**
3 IE = Inferior External **(Lateral).**

4 SI = Superior Internal **(Medial).**
5 MI = Medium Internal **(Medial).**
6 II = Inferior Internal **(Medial).**

Note:-

- Stress **(+)** ➜ **Tension.**
- Stress **(-)** ➜ **Compression.**

- **FAV** ■ **Femoral Anteversion.**
- **FRV** ■ **Femoral Retroversion.**

- **Each Graphic** ■ **3 Cycle.**

As we have explained previously, the values are given in the unit of microdeformations, being the negatively values a few signs of ***Compression*** and the positives of traction **(** ***Tension*** **).**

Table 1: Galga 1= Strain Gauge 1: Microdeformations between Cycles and Torsion.

	Cycle 1	Cycle 2	Cycle 3
Torsion :			
-30	-75.23 (130.70)	-84.46 (126.66)	-75.58 (122.27)
-15	-75.79 (154.90)	-67.71 (144.87)	-70.17 (129.68)
0	-72.60 (99.05)	-47.48 (93.47)	-39.10 (101.49)
15	-20.04 (143.60)	-14.71 (150.47)	-5.81 (155.74)
30	-31.96 (137.23)	-33.79 (141.10)	-34.29 (139.62)

Table 2: Galga 1= Strain Gauge 1: Microdeformations between Cycles and Phases.

	Cycle 1	Cycle 2	Cycle 3
Phase :			
1	-3.57 (73.38)	-7.57 (90.24)	-2.83 (88.74)
2	-131.70 (158.95)	-130.97(166.49)	-126.13(167.47)
3	-14.53(99.56)	-10.53(105.22)	-13.50(111.27)
4	-0.40(80.50)	-0.63 (89.14)	2.67 (87.78)
5	-66.83 (111.50)	-53.10 (109.46)	-49.40 (111.38)
6	-159.70 (175.60)	-150.93 (185.39)	-149.57 (189.37)
7	-47.07 (140.10)	-31.47 103.35)	-13.80 (62.03)
8	-24.33 (120.17)	-11.83 (104.96)	-7.37 (102.48)

Table 3: Galga 1= Strain Gauge 1: Microdeformations between Torsions and Phases.

Torsion

	-30	-15	0	15	30
Phase :					
1	-24.72 (43.72)	-21.28 (89.59)	-14.22(48.53)	-117.44(219.07)	8.33(113.23)
2	-176.44(127.00)	-159.33(138.82)	-86.22(117.69)	-117.44(219.07)	-108.56(187.45)
3	-26.39(36.74)	-29.28(86.55)	-27.94(60.61)	31.67(122.40)	-12.33(165.16)
4	-20.83(23.21)	-10.61(47.62)	-1.61(37.83)	32.72(118.67)	3.06(133.14)
5	-83.00(68.79)	-68.00(88.65)	-70.11(90.74)	-25.61(147.34)	-35.50(133.59)
6	-216.50(225.48)	-209.39(238.24)	-100.06(118.14)	-106.38(147.27)	-134.78(125.85)
7	-58.44(114.06)	-60.00(176.14)	-31.00(73.35)	4.00(76.62)	-8.44(20.90)
8	-21.06(25.80)	-11.89 (44.94)	-93.33(146.53)	32.28(130.38)	21.00(100.71)

Table 4: Galga 1 = Strain Gauge 1: Analyses Results.

	p-value
Cycle effect	0.584
Phase effect	< 0.001
Torsion effect	< 0.001
Interactions:	
Phase/Cycle	1
Phase/Torsion	0.468
Cycle/Torsion	0.971

Table 5: Galga 1 = Strain Gauge 1: Cycle Effect.

	p-value
Cycle 1 vs. Cycle 2	0.840
Cycle 1 vs. Cycle 3	0.554
Cycle 2 vs. Cycle 3	0.883

Table 6: Galga 1 = Strain Gauge 1: Phase Effect.

	p-value						
	Phase 2	**Phase 3**	**Phase 4**	**Phase 5**	**Phase 6**	**Phase 7**	**Phase 8**
Phase 1	< 0.001	0.998	1.0	0.017	< 0.001	0.630	0.995
Phase 2	---	< 0.001	< 0.001	< 0.001	0.812	< 0.001	< 0.001
Phase 3	---	---	0.991	0.115	< 0.001	0.952	< 0.001
Phase 4	---	---	---	0.009	< 0.001	0.508	0.982
Phase 5	---	---	---	---	< 0.001	0.745	0.148
Phase 6	---	---	---	---	---	< 0.001	< 0.001
Phase 7	---	---	---	---	---	---	0.971

Table 7: Galga 1 = Strain Gauge 1: Torsion Effect.

	p-value			
	Torsion –15	**Torsion 0**	**Torsion 15**	**Torsion 30**
Torsion -30	0.979	0.262	< 0.001	0.003
Torsion -15	---	0.602	< 0.001	0.023
Torsion 0	---	---	0.015	0.522
Torsion 15	---	---	---	0.516

Figure 1: Strain Gauge 1 : Torsion vs. Cycle

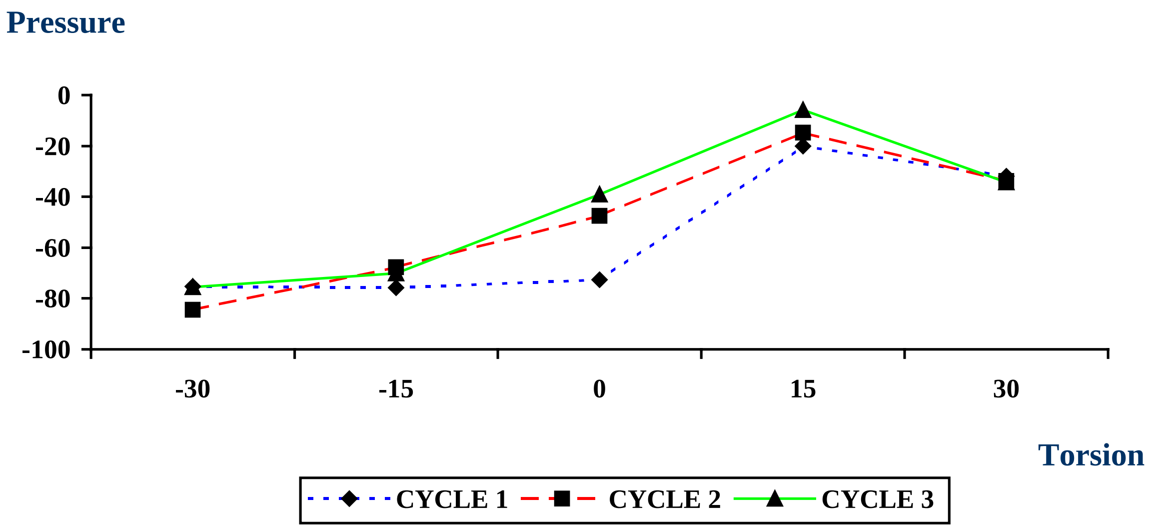


Figure 2: Strain Gauge 1 : Cycle vs. Phase

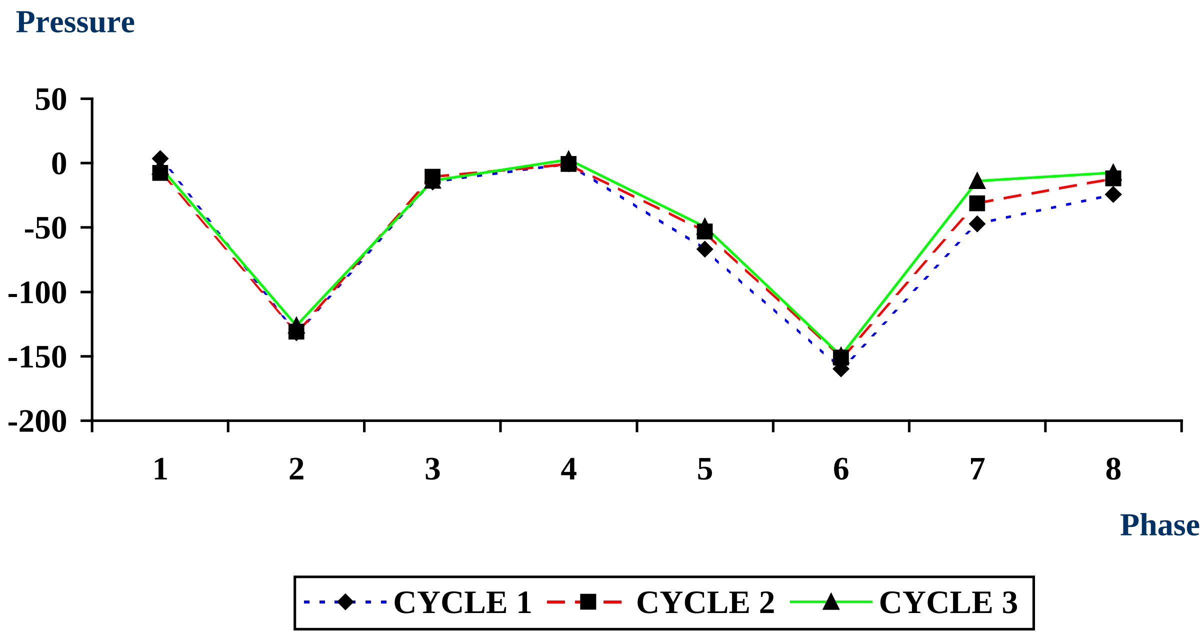
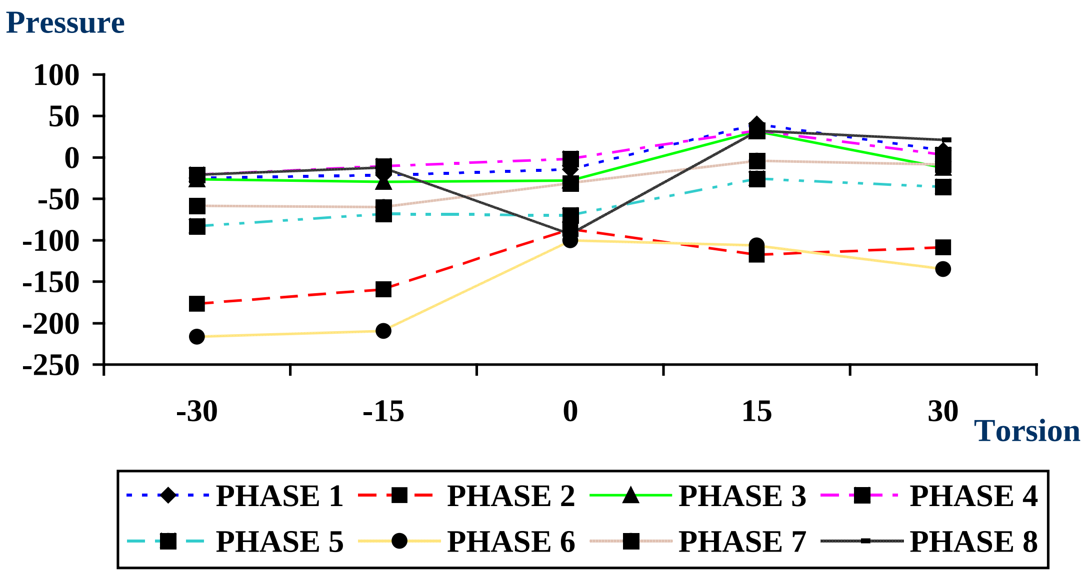


Figure 3: Strain Gauge 1 : Torsion vs. Phase



Strain Gauge (1) :

None of the interactions between two variables Phase/Cycle, Phase/Torsion and Cycle/Torsion has reached statistical significance (p = 1, 0.468 and 0,971 Respectively). **(Table 4).**

Cycle Effect: Differences have not been observed in the Microdeformations between the different cycles (p=0.584) behaving of form seemed so much in every torsion like in every phase. **(Figure 1 and Figure 2). (Table 4 and Table 5).**

Phase Effect: An effect has been observed phase (p < 0,001). **(Figure 2 and Figure 3).** In the phases 2 and 6 it is where lower values of Microdeformations are observed, presented significant differences with the rest of the phases. **(Table 4 and Table 6).**

Torsion Effect: An effect has been observed torsion (p < 0,001) **(Figure 1 and Figure 3).** When to the bone (Knee) one applies torsion of $+15^0$ and $+30^0$ it is when in general are observed values significantly higher than the rest of torsion. **(Table 4 and Table 7).**

Table 8: Galga 2 = Strain Gauge 2: Microdeformations between Cycles and Torsions.

Torsion :	Cycle 1	Cycle 2	Cycle 3
-30	-49.23 (79.31)	-49.35 (79.22)	-42.77 (78.08)
-15	-53.17 (84.89)	-45.50 (82.02)	-35.92 (89.89)
0	-5.06 (68.30)	-11.08 (70.44)	-10.29 (60.82)
15	-55.83 (96.46)	-46.13 (92.54)	-43.44 (91.85)
30	-57.44 (89.31)	-53.44 (87.98)	-50.29 (87.93)

Table 9: Galga 2 = Strain Gauge 2: Microdeformations between Cycles and Phases.

Phase :	Cycle 1	Cycle 2	Cycle 3
1	-12.20(19.82)	-7.37 (32.98)	-8.57 (29.72)
2	-108.20 (77.75)	-99.23(79.59)	-100.87(71.03)
3	-11.23(34.51)	5.33(26.85)	1.87(24.42)
4	-4.60(18.43)	3.20 (22.29)	2.67 (17.51)
5	-76.97 (67.37)	-70.37 (72.44)	-69.67 (63.70)
6	-148.00(183.55)	-149.83 (131.85)	-148.07 (126.62)
7	3.70 (38.80)	11.10 (24.86)	12.87 (31.31)
8	4.53 (48.27)	13.83 (24.61)	17.43 (33.50)

Table 10: Galga 2 = Strain Gauge 2: Microdeformations between Torsions and Phases.

	Torsion				
Phase :	**-30**	**-15**	**0**	**15**	**30**
1	-8.50 (16.65)	-27.56 (39.75)	6.72 (24.36)	4.06(15.45)	-21.61(19.78)
2	-116.44(57.13)	-142.67(86.39)	-20.17(57.79)	-110.44(58.22)	-124.11(51.92)
3	-5.00(14.39)	4.06(23.29)	-5.78(49.71)	-0.61(35.10)	0.61(5.00)
4	-8.44(17.61)	-0.67(21.78)	10.89(30.85)	2.39(5.39)	-2.06(6.29)
5	-90.06(61.94)	-78.94(65.88)	-10.72(49.07)	-95.83(64.53)	-86.11(61.17)
6	-158.33(111.28)	-129.78(120.41)	-59.00(138.12)	-193.83(125.29)	-202.22(119.12)
7	2.22(17.65)	11.06(32.53)	28.61(32.91)	0.50(46.33)	3.72(14.60)
8	7.94(10.89)	5.61 (37.50)	38.06(32.61)	6.06(59.06)	2.00(8.91)

Table 11: Galga 2= Strain Gauge 2: Analyses Results.

	p-value
Cycle effect	0.206
Phase effect	< 0.001
Torsion effect	< 0.001
Interactions:	
Phase/Cycle	1
Phase/Torsion	< 0.001
Cycle/Torsion	0.664

Table 12: Galga 2 = Strain Gauge 2: Cycle Effect.

	p-value
Cycle 1 vs. Cycle 2	0.278
Cycle 1 vs. Cycle 3	0.267
Cycle 2 vs. Cycle 3	< 0.001

Table 13: Galga 2 = Strain Gauge 2: Phase Effect.

	p-value						
	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Phase 1	< 0.001	0.973	0.923	< 0.001	< 0.001	0.276	0.132
Phase 2	---	< 0.001	< 0.001	0.004	< 0.001	< 0.001	< 0.001
Phase 3	---	---	1.0	< 0.001	< 0.001	0.889	0.709
Phase 4	---	---	---	< 0.001	< 0.001	0.956	0.836
Phase 5	---	---	---	---	< 0.001	< 0.001	< 0.001
Phase 6	---	---	---	---	---	< 0.001	< 0.001
Phase 7	---	---	---	---	---	---	1.0

Table 14: Galga 2 = Strain Gauge 2: Torsion Effect.

	p-value			
	Torsion –15	Torsion 0	Torsion 15	Torsion 30
Torsion -30	0.997	< 0.001	0.999	0.829
Torsion -15	---	< 0.001	0.979	0.623
Torsion 0	---	---	< 0.001	< 0.001
Torsion 15	---	---	---	0.920

Figure 4: Strain Gauge 2 : Torsion vs. Cycle

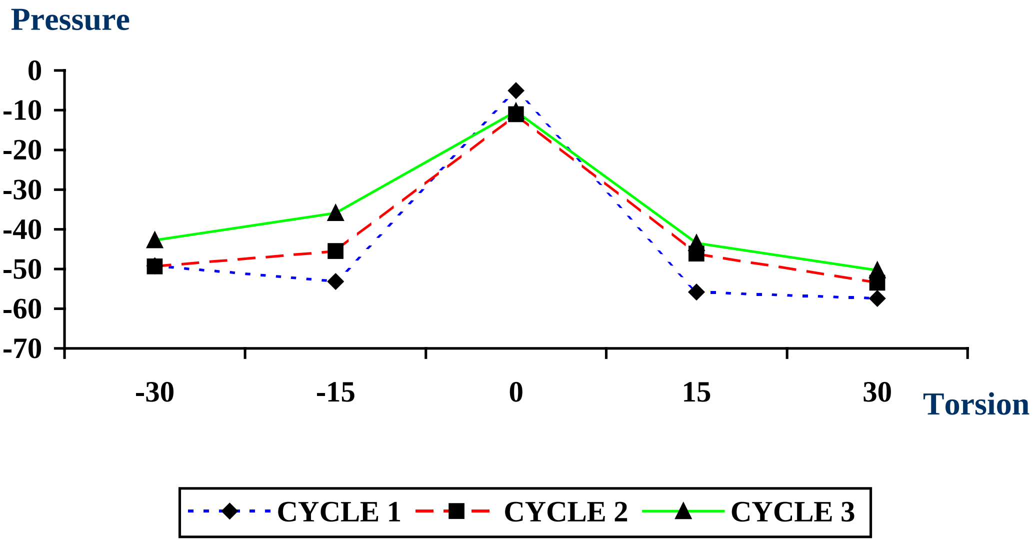


Figure 5: Strain Gauge 2 : Cycle vs. Phase

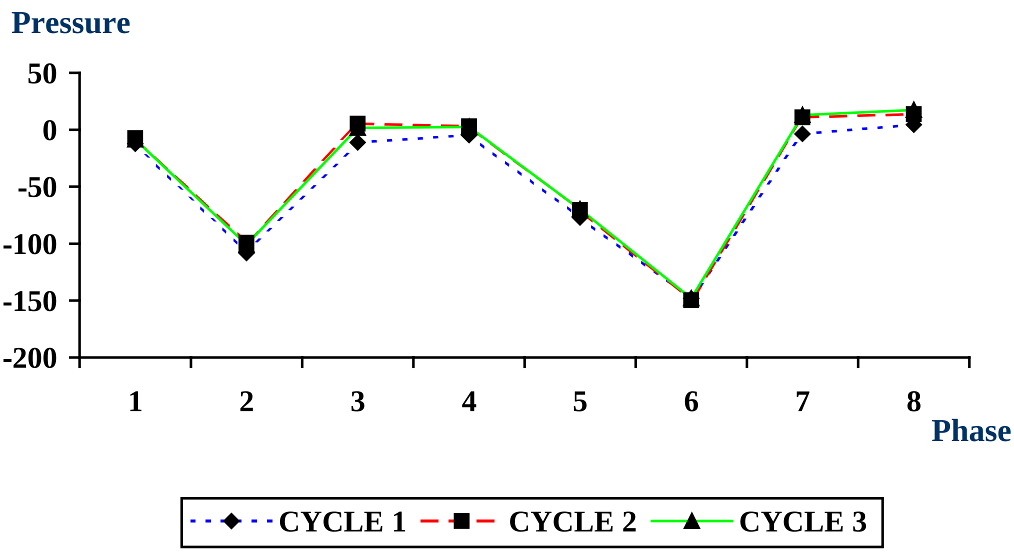
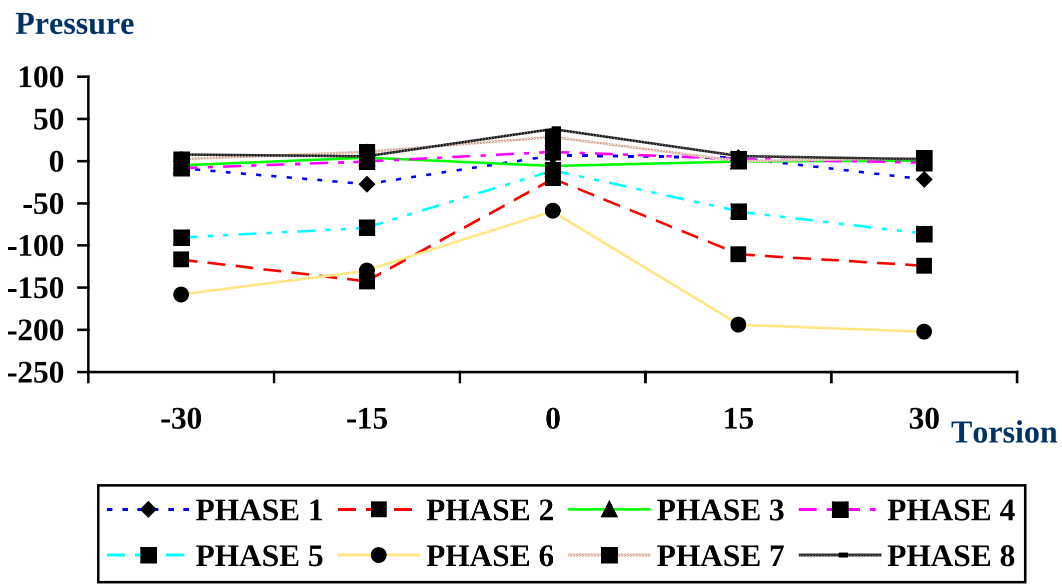


Figure 6: Strain Gauge 2 : Torsion vs. Phase



Strain Gauge (2) :

The interactions between Phase/Cycle and Cycle/Torsion did not reach statistical significance (p = 1, and 0,664 Respectively) **(Table 11).**

Nevertheless a significant interaction has been situated between Phase/Torsion (p < 0,001) **(Table 11).** Basically the Phases it 3 and 4 is not modified by the torsion, whereas the phases 2, 5 and 6 show less deformations in the torsion 0^0. **(Figure 6).**

Cycle Effect: Differences have not been observed in the Microdeformations between the different cycles (p=0.206) **(Figure 4 and Figure 5) (Table 11 and Table 12).**

Phase Effect: An effect has been observed phase (p < 0,001). **(Figure 5 and Figure 6)**. In the phases 2 and 6 it is where lower values of Microdeformations are observed, presented significant differences with the rest of the phases. **(Table 11 and Table 13).**

Torsion Effect: An effect has been observed torsion (p < 0,001) **(Figure 4 and Figure 6).** When to the knee it applies one to her torsion of 0^0 is when in general are observed values significantly higher than the rest of torsion. **(Table 11 and Table 14).**

Table 15: Galga 3 = Strain Gauge 3: Microdeformations between Cycles and Torsions.

Torsion :	Cycle 1	Cycle 2	Cycle 3
-30	-44.73 (54.31)	-46.60 (64.86)	-46.73 (54.56)
-15	-55.02 (66.79)	-111.85 (160.59)	-107.83 (166.35)
0	-44.94 (75.89)	-44.50 (72.33)	-57.88 (71.06)
15	-89.52 (159.51)	-138.46 (232.85)	-137.96 (233.66)
30	-75.02 (159.66)	-131.46 (233.27)	-133.08 (232.42)

Table 16: Galga 3 = Strain Gauge 3: Microdeformations between Cycles and Phases.

Phase :	Cycle 1	Cycle 2	Cycle 3
1	-24.83(24.54)	-86.57 (158.01)	-83.03 (158.44)
2	-165.27 (73.55)	-201.33(147.38)	-204.53(144.28)
3	-27.47(48.91)	-74.63(175.12)	-77.70(175.46)
4	-20.57(13.86)	-74.43 (172.68)	-77.67 (17.11)
5	-16.33 (38.90)	-107.80 (164.43)	-109.40 (163.57)
6	-86.37 (167.98)	-93.73 (182.98)	-93.87 (183.55)
7	-47.00 (159.69)	-49.57 (181.00)	-59.37 (179.21)
8	-61.93 (162.31)	-68.53 (175.87)	-68.00 (177.20)

Table 17: Galga 3 = Strain Gauge 3: Microdeformations between Torsions and Phases.

			Torsion		
Phase :	-30	-15	0	15	30
1	-44.56 (32.77)	-69.89 (83.51)	-30.61 (31.12)	-83.61(200.53)	-95.39(195.94)
2	-171.67(32.17)	-199.17(107.41)	-94.78(74.94)	-253.83(158.94)	-232.44(154.13)
3	-18.28(3.32)	-62.11(150.34)	-49.94(70.46)	-93.72(199.53)	-75.61(202.25)
4	-24.50(6.11)	-68.78(147.74)	-20.50(17.85)	-92.33(196.51)	-81.67(199.79)
5	-59.56(15.07)	-105.33(134.23)	-66.67(66.68)	-123.72(185.59)	-108.94(191.03)
6	-28.22(41.36)	-99.33(146.00)	-93.00(140.99)	-124.56(235.34)	-111.50(242.09)
7	4.56(45.43)	-47.17(149.39)	-18.39(20.19)	-103.00(243.73)	-95.89(246.43)
8	-25.94(13.34)	-80.78 (156.61)	-18.94(17.54)	-101.06(244.79)	-104.06(243.46)

Table 18: Galga 3 = Strain Gauge 3: Analyses Results.

	p-value
Cycle effect	< 0.001
Phase effect	< 0.001
Torsion effect	< 0.001
Interactions:	
Phase/Cycle	0.955
Phase/Torsion	0.974
Cycle/Torsion	0.398

Table 19: Galga 3 = Strain Gauge 3: Cycle Effect.

	p-value
Cycle 1 vs. Cycle 2	0.003
Cycle 1 vs. Cycle 3	0.001
Cycle 2 vs. Cycle 3	0.975

Table 20 : Galga 3 = Strain Gauge 3: Phase Effect

	p-value						
	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Phase 1	< 0.001	1.0	1.0	0.672	0.732	0.994	1.0
Phase 2	---	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Phase 3	---	---	1.0	0.467	0.532	1.0	1.0
Phase 4	---	---	---	0.372	0.432	1.0	1.0
Phase 5	---	---	---	---	1.0	0.192	0.725
Phase 6	---	---	---	---	---	0.234	0.781
Phase 7	---	---	---	---	---	---	0.988

Table 21: Galga 3 = Strain Gauge 3: Torsion Effect.

	p-value			
	Torsion –15	Torsion 0	Torsion 15	Torsion 30
Torsion -30	0.004	0.999	< 0.001	< 0.001
Torsion -15	---	0.009	0.126	0.446
Torsion 0	---	---	< 0.001	< 0.001
Torsion 15	---	---	---	0.960

Figure 7: Strain Gauge 3 : Torsion vs. Cycle

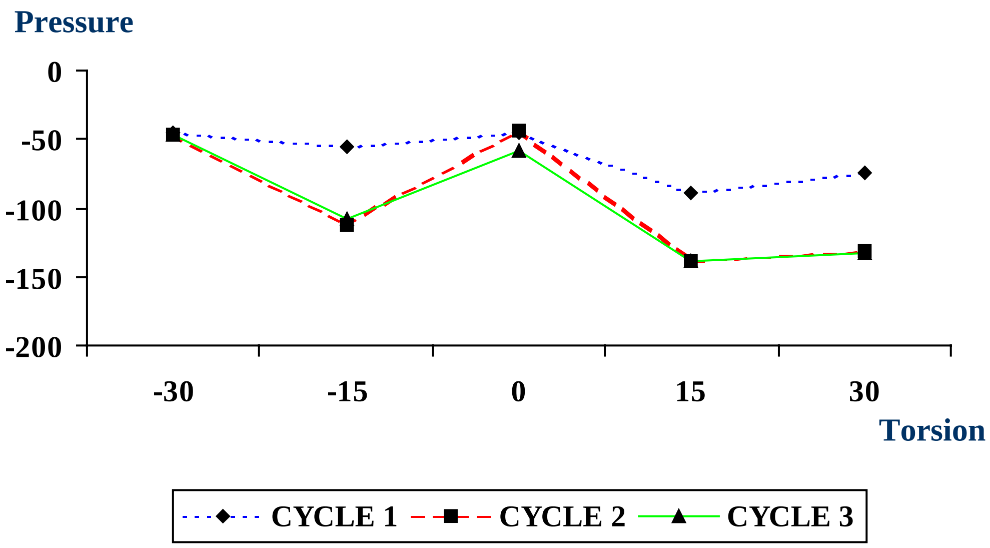


Figure 8: Strain Gauge 3 : Cycle vs. Phase

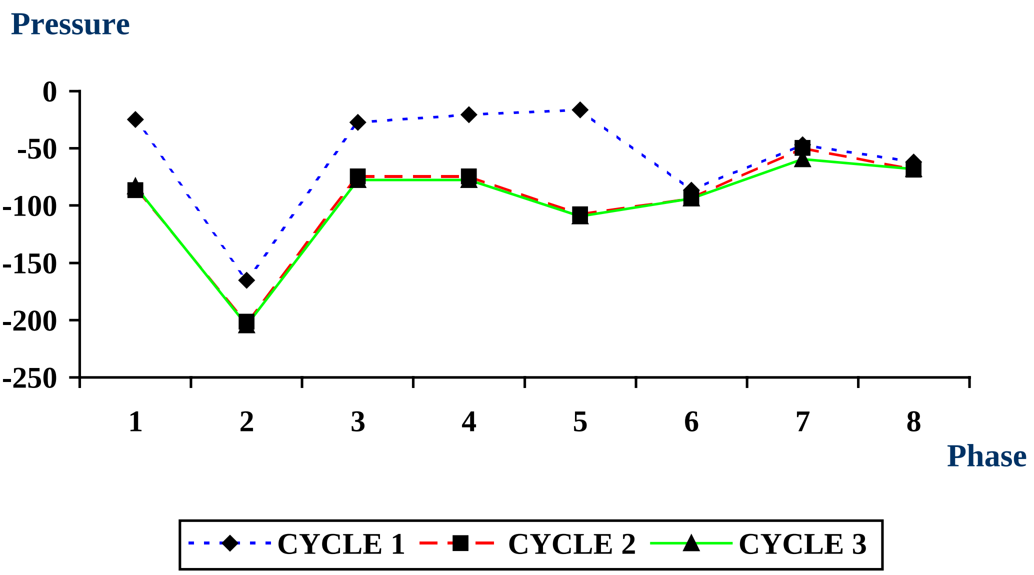
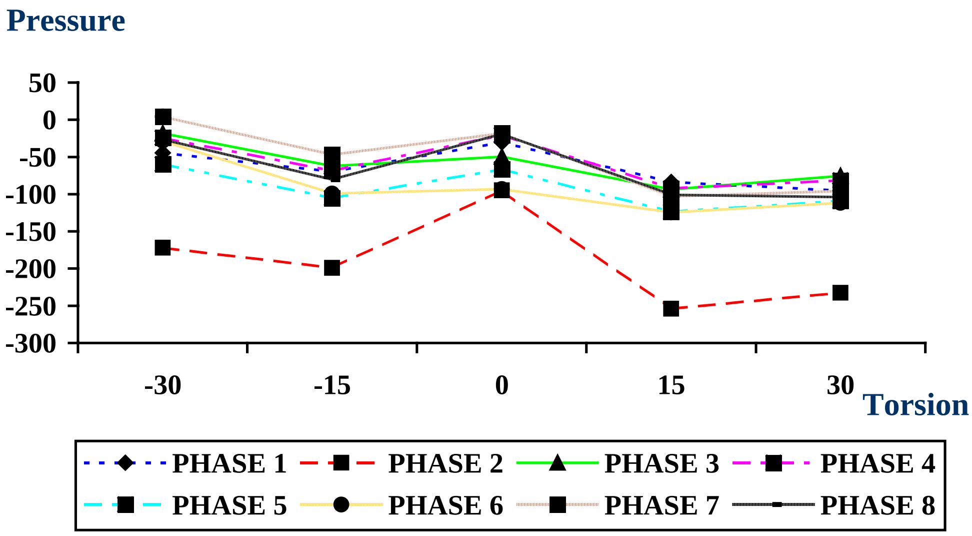


Figure 9: Strain Gauge 3 : Torsion vs. Phase



Strain Gauge (3) :

None of the interactions Phase/Cycle, Phase/Torsion and Cycle/Torsion reached statistical significance (p = 0.995, 0.974 and 0.398 Respectively) **(Table 18).**

Cycle Effect: An effect has been observed cycle ($p < 0.001$) **(Figure 7 and Figure 8).** The cycle one presents significantly major values that the rest of the cycles **(Table 18 and Table 19).**

Phase Effect: An effect has been observed phase ($p < 0{,}001$). **(Figures 8 and Figures 9).** In the phase 2 it is where lower values of Microdeformations are observed, presented significant differences with the rest of the phases. **(Table 18 and Table 20).**

Torsion Effect: An effect has been observed twist ($p < 0{,}001$) **(Figure 7 and Figure 9).** In the torsion -30^0 and 0^0 it is where in general are observed values significantly higher than the rest of torsion. **(Table 18 and Table 21).**

Table 22: Galga 4 = Strain Gauge 4: Microdeformations between Cycles and Torsions.

	Cycle 1	Cycle 2	Cycle 3
Torsion :			
-30	-56.10 (77.16)	-58.96 (77.71)	-59.67 (78.73)
-15	-54.98 (75.20)	-54.75 (71.39)	-59.06 (77.05)
0	-24.58 (67.60)	-25.67 (67.29)	-21.04 (60.30)
15	-49.54 (79.90)	-43.60 (80.80)	-39.31 (82.76)
30	-69.51 (88.11)	-73.25 (93.27)	-68.63 (92.08)

Table 23: Galga 4 = Strain Gauge 4: Microdeformations between Cycles and Phases.

	Cycle 1	Cycle 2	Cycle 3
Phase :			
1	-14.37(22.12)	-24.40 (32.78)	-20.10 (31.73)
2	-119.97 (86.13)	-111.17(87.20)	-124.37(84.73)
3	-17.33(45.92)	-19.37(61.63)	-17.27(61.97)
4	-9.90(29.00)	-12.63 (46.73)	-5.30 (46.28)
5	-129.97 (87.16)	-131.57 (83.43)	-119.73 (88.79)
6	-110.53 (86.71)	-107.13 (84.78)	-103.03 (84.96)
7	-0.63 (26.26)	1.53 (27.13)	-0.23 (26.94)
8	-6.87 (22.20)	-5.23 (24.31)	-6.30 (23.46)

Table 24: Galga 4 = Strain Gauge 4: Microdeformations between Torsions and Phases.

			Torsion		
	-30	-15	0	15	30
Phase :					
1	-21.33 (27.49)	-28.56 (30.04)	-14.00 (23.20)	-7.06(28.78)	-27.17(33.18)
2	-144.28(88.62)	-122.56(88.01)	-81.89(98.85)	-108.22(58.32)	-135.56(81.86)
3	-13.72(20.00)	-12.67(20.85)	-15.72(33.90)	1.56(19.94)	-49.39(112.91)
4	-13.83(21.09)	-13.17(21.86)	-13.50(28.83)	0.61(21.15)	-33.50(73.14)
5	-141.78(91.44)	-146.33(82.45)	-68.17(71.43)	-140.50(99.31)	-139.18(58.54)
6	-108.44(62.30)	-106.22(65.28)	-48.44(67.56)	-109.50(95.68)	-161.89(93.60)
7	-10.11(7.86)	-6.72(5.70)	-18.67(42.13)	6.89(25.91)	-7.61(22.31)
8	-12.44(13.91)	-13.89 (18.53)	5.94(26.81)	3.00(20.51)	-13.28(23.39)

Table 25: Galga 4 = Strain Gauge 4: Analyses Results.

	p-value
Cycle effect	0.929
Phase effect	< 0.001
Torsion effect	< 0.001
Interactions:	
Phase/Cycle	0.999
Phase/Torsion	0.026
Cycle/Torsion	0.994

Table 26: Galga 4 = Strain Gauge 4: Cycle Effect.

	p-value
Cycle 1 vs. Cycle 2	0.997
Cycle 1 vs. Cycle 3	0.960
Cycle 2 vs. Cycle 3	0.935

Table 27: Galga 4 = Strain Gauge 4: Phase Effect.

	p-value						
	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Phase 1	< 0.001	1.0	0.900	< 0.001	< 0.001	0.202	0.692
Phase 2	---	< 0.001	< 0.001	0.963	0.831	< 0.001	< 0.001
Phase 3	---	---	0.958	< 0.001	< 0.001	0.304	0.814
Phase 4	---	---	---	< 0.001	< 0.001	0.934	1.0
Phase 5	---	---	---	---	0.188	< 0.001	< 0.001
Phase 6	---	---	---	---	---	< 0.001	< 0.001
Phase 7	---	---	---	---	---	---	0.993

Table 28: Galga 4 = Strain Gauge 4: Torsion Effect.

	p-value			
	Torsion –15	Torsion 0	Torsion 15	Torsion 30
Torsion -30	**0.989**	< 0.001	0.168	0.299
Torsion -15	---	< 0.001	0.307	0.163
Torsion 0	---	---	0.011	< 0.001
Torsion 15	---	---	---	< 0.001

Figure 10: Strain Gauge 4 : Torsion vs. Cycle

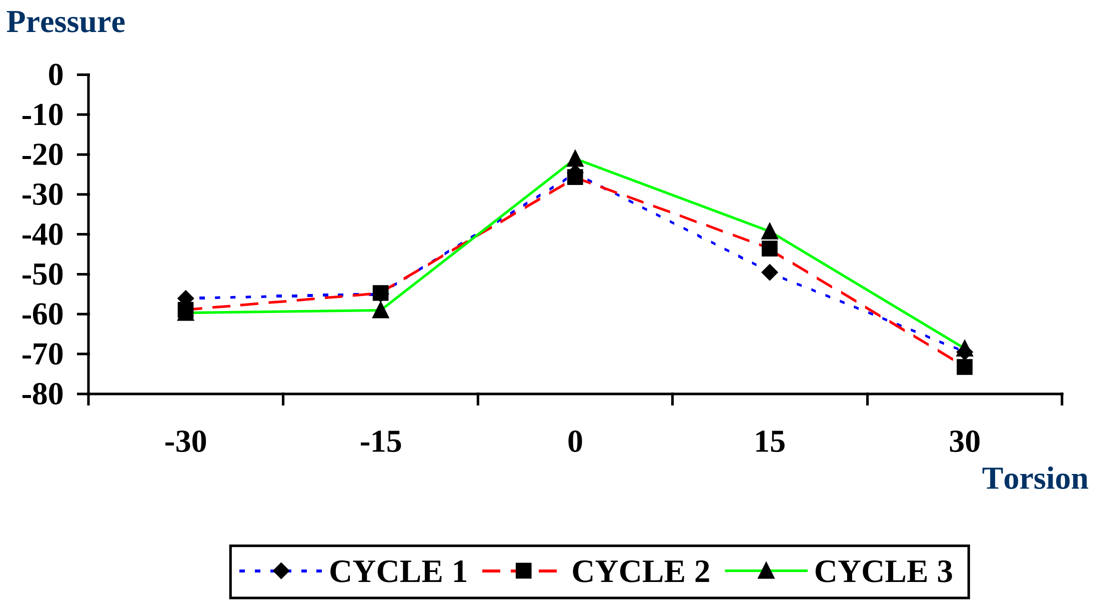


Figure 11: Strain Gauge 4 : Cycle vs. Phase

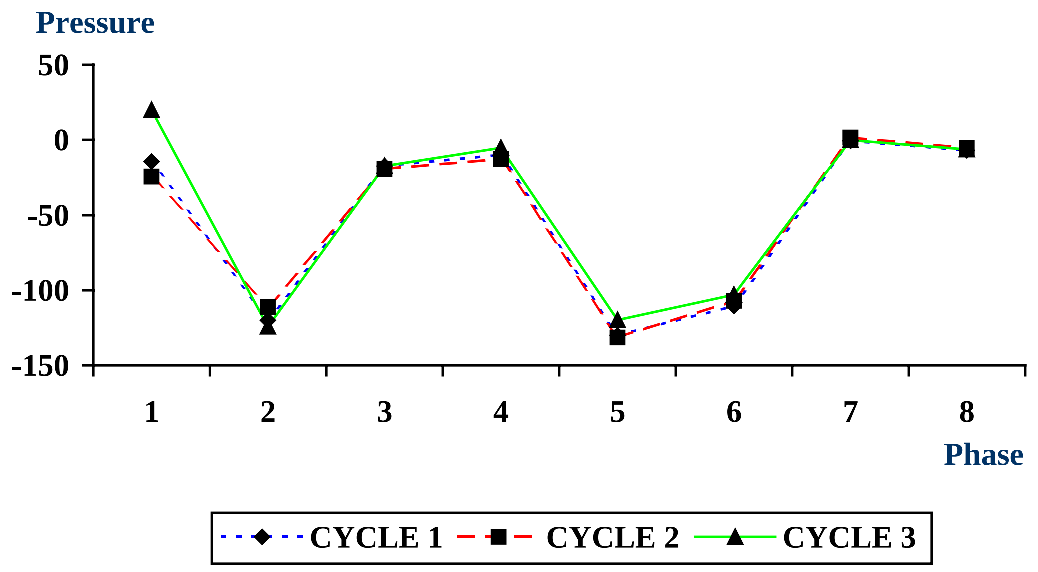
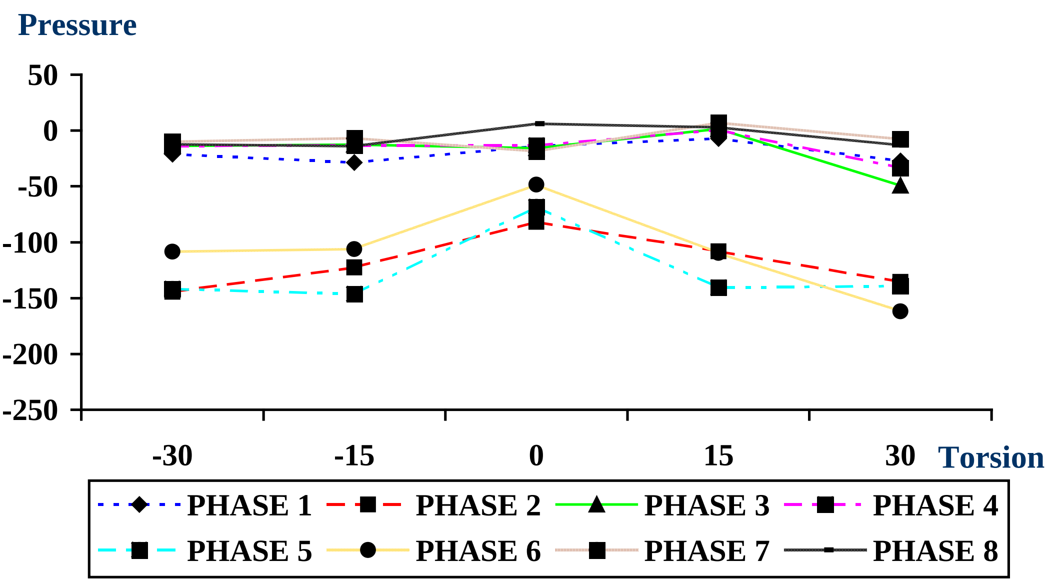


Figure 12: Strain Gauge 4 : Torsion vs. Phase



Strain Gauge (4) :

The interactions between Phase/Cycle and Cycle/Torsion did not reach statistical significanc (p = 0.999, and 0.994 Respectively) **(Table 25).**

Nevertheless a significant interaction has been situated between Phase/Torsion (p = 0,026) **(Table 25).** Basically in the Phases 2, 5 and 6 a decrease is observed in the torsion of 0^0 that does not happen in the rest of the phases. **(Figure 12).**

Cycle Effect: An effect has not been observed cycle (p < 0.929) **(Figure 10 and Figure 11**) and **(Table 25 and Table 26).**

Phase Effect: An effect has been observed phase (p < 0,001). **(Figure 11 and Figure 12**). In the phase 2, 5 and 6 it is where lower values of Microdeformations are observed, presented significant differences with the rest of the phases. **(Table 25 and Table 27).**

Torsion Effect: An effect has been observed torsion (p < 0,001) **(Figure 10 and Figure 12).** In the torsion 0^0 it is where in general are observed values significantly higher than the rest of torsion. **(Table 25 and Table 28).**

Table 29: Galga 5 = Strain Gauge 5: Microdeformations between Cycles and Torsions.

	Cycle 1	Cycle 2	Cycle 3
Torsion :			
-30	-19.42 (51.74)	-22.98 (51.97)	-21.94 (50.25)
-15	-8.81 (54.04)	-13.38 (57.40)	-12.92 (56.03)
0	-24.29 (60.95)	-12.35 (57.11)	-10.90 (55.03)
15	-28.67 (59.44)	-22.60 (70.49)	-18.33 (72.94)
30	-12.04 (68.03)	-15.29 (72.96)	-12.46 (71.11)

Table 30: Galga 5 = Strain Gauge 5: Microdeformations between Cycles and Phases.

	Cycle 1	Cycle 2	Cycle 3
Phase :			
1	-13.27(22.60)	-21.37 (33.78)	-16.53 (28.83)
2	-110.73 (50.74)	-105.80(65.42)	-106.67(64.67)
3	-8.80(27.86)	-5.50(27.99)	-2.73(28.54)
4	-8.57(15.74)	-6.83 (16.64)	-3.33 (19.60)
5	-11.45 (53.19)	-13.33 (54.06)	-4.20 (54.46)
6	10.37 (100.32)	14.70 (106.54)	9.93 (103.69)
7	3.90 (17.55)	6.53 (17.56)	7.13 (16.66)
8	-10.60 (30.32)	-7.07 (25.41)	-6.07 (22.37)

Table 31: Galga 5 = Strain Gauge 5: Microdeformations between Torsions and Phases.

	-30	-15	0	15	30
Phase :					
1	-25.56 (23.66)	-19.44 (37.72)	-11.06(18.68)	-24.67(18.05)	-4.56(34.86)
2	-119.22(50.81)	-103.28(62.08)	-51.06(52.47)	-145.94(29.39)	-119.17(59.62)
3	-6.50(12.61)	4.28(22.36)	-20.44(50.73)	-10.83(12.86)	5.11(14.05)
4	-11.06(13.77)	-4.50(19.81)	4.94(18.61)	-16.94(15.75)	-3.67(10.52)
5	-10.72(42.92)	-6.17(50.30)	-3.11(50.43)	-14.56(65.00)	-13.88(61.38)
6	11.72(62.04)	27.11(69.72)	-18.22(123.10)	27.89(108.40)	9.83(133.43)
7	1.39(10.00)	11.06(16.36)	-3.56(21.33)	6.50(18.52)	13.89(12.54)
8	11.61(12.5	-2.67 (23.27)	-24.28(39.52)	-7.22(15.58)	6.22(22.41)

Table 32: Galga 5 = Strain Gauge 5: Analyses Results.

	p-value
Cycle effect	0.717
Phase effect	< 0.001
Torsion effect	0.140
Interactions:	
Phase/Cycle	1
Phase/Torsion	< 0.001
Cycle/Torsion	0.889

Table 33: Galga 5 = Strain Gauge 5: Cycle Effect.

	p-value
Cycle 1 vs. Cycle 2	0.945
Cycle 1 vs. Cycle 3	0.700
Cycle 2 vs. Cycle 3	0.878

Table 34: Galga 5 = Strain Gauge 5: Phase Effect.

	p-value Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Phase 1	< 0.001	0.707	0.759	0.960	0.001	0.019	0.883
Phase 2	---	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Phase 3	---	---	1.0	0.999	0.179	0.693	1.0
Phase 4	---	---	---	1.0	0.148	0.637	1.0
Phase 5	---	---	---	---	0.040	0.314	1.0
Phase 6	---	---	---	---	---	0.990	0.080
Phase 7	---	---	---	---	---	---	0.469

Table 35: Galga 5 = Strain Gauge 5: Torsion Effect.

	p-value Torsion –15	Torsion 0	Torsion 15	Torsion 30
Torsion -30	0.370	0.837	0.997	0.554
Torsion -15	---	0.939	0.205	0.998
Torsion 0	---	---	0.648	0.989
Torsion 15	---	---	---	0.350

Figure 13: Strain Gauge 5 : Torsion vs. Cycle

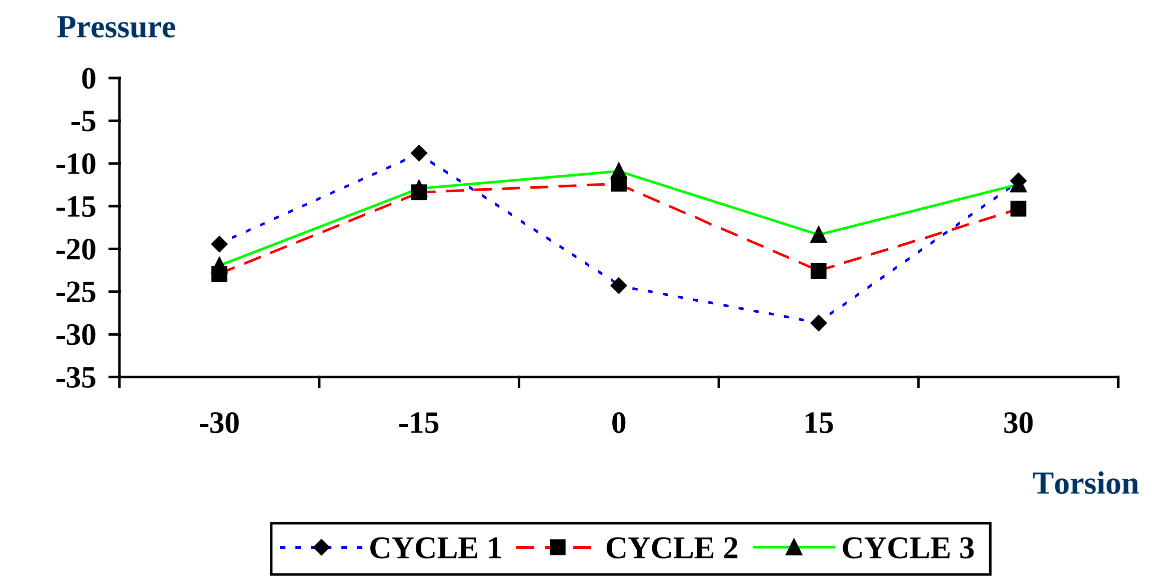


Figure 14: Strain Gauge 5 : Cycle vs. Phase

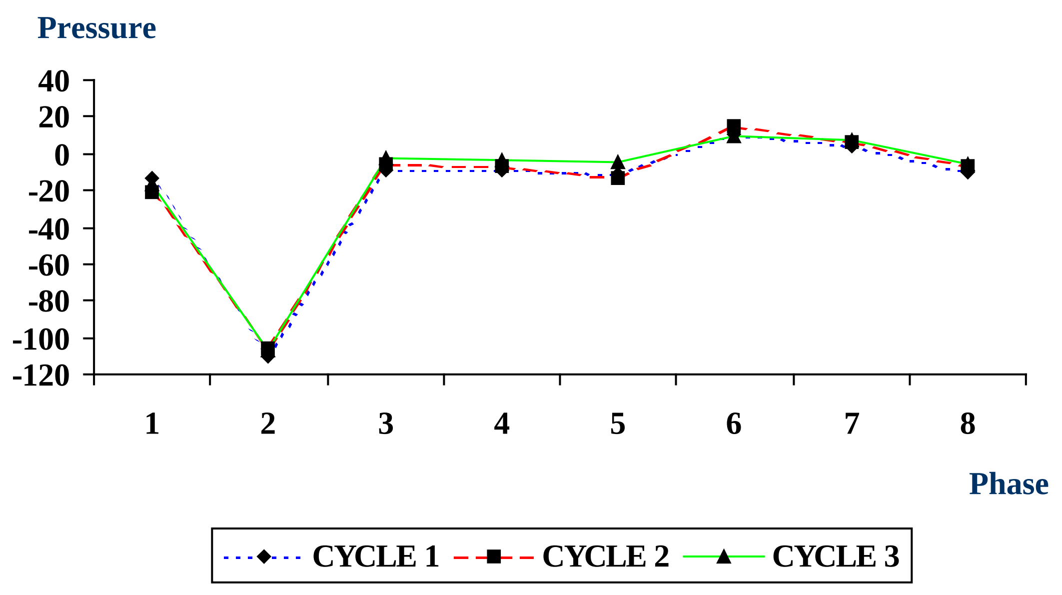
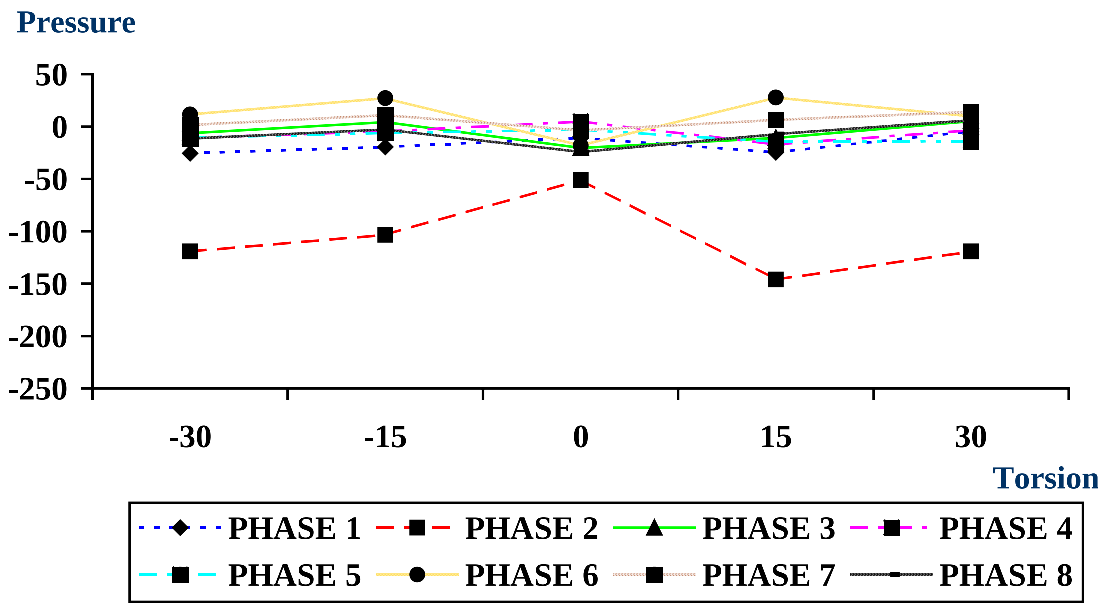


Figure 15: Strain Gauge 5 : Torsion vs. Phase



Strain Gauge (5) :

The interactions between Phase/Cycle and Cycle/Torsion did not reach statistical significance (p = 1, and 0.889 Respectively) **(Table 32).**

Nevertheless a significant interaction has been situated between Phase/Torsion (p < 0,001) **(Table 32).** Basically the Phases 6 and 8 has a different behavior that the phases 2 and 4 specially in the torsion 0^0 and 15^0. **(Figure 15).**

Cycle Effect: An effect has not been observed cycle (p < 0.717) **(Figure 13 and Figure 14) (Table 32 and Table 33).**

Phase Effect: An effect has been observed phase (p < 0,001). **(Figure 14 and Figure15**). In the phase 2 lower values of Microdeformations are observed, presented significant differences with the rest of the phases. **(Table 32 and Table 34).**

Torsion Effect: An effect has not been observed torsion (p < 0,140) **(Figure 13 and Figure15) (Table 32 and Table 35).**

Table 36: Galga 6 = Strain Gauge 6: Microdeformations between Cycles and Torsions.

Torsion :	Cycle 1	Cycle 2	Cycle 3
-30	-30.98 (134.52)	3.50 (51.97)	-21.58 (179.89)
-15	-21.83 (152.67)	-13.87 (202.25)	-21.79 (218.88)
0	-40.40 (159.77)	-46.21 (168.35)	-43.48 (178.53)
15	-14.29 (170.50)	-16.85 (178.16)	-25.94 (180.47)
30	32.15 (226.41)	20.19 (290.35)	-2.35 (214.99)

Table 37: Galga 6 = Strain Gauge 6: Microdeformations between Cycles and Phases.

Phase :	Cycle 1	Cycle 2	Cycle 3
1	18.40(182.39)	90.83 (35.42)	68.67 (223.60)
2	-108.00 (261.36)	-95.50(360.96)	-141.23(234.10)
3	-58.80(156.76)	-66.00(159.56)	-68.00(159.44)
4	-38.70(143.96)	-42.37 (146.86)	-44.53 (145.74)
5	-12.21 (128.11)	-32.30 (116.80)	-30.07 (120.50)
6	60.63 (154.15)	54.20 (152.70)	51.57 (146.95)
7	-0.41 (25.31)	-4.33 (22.88)	-7.00 (23.24)
8	15.97 (193.37)	10.27 (188.35)	-13.63 (180.25)

Table 38: Galga 6 = Strain Gauge 6: Microdeformations between Torsions and Phases.

	Torsion				
Phase :	-30	-15	0	15	30
1	100.72 (359.84)	118.39 (368.07)	13.67 (238.41)	-27.44(154.99)	91.17(305.42)
2	-154.00(196.27)	-150.39(181.17)	-143.06(167.20)	-127.06(256.20)	-0.06(508.65)
3	-52.00(125.82)	-60.11(127.44)	-117.61(223.75)	-53.17(141.45)	-38.44(150.44)
4	-40.17(151.76)	-52.06(148.64)	-56.83(120.41)	-32.83(15.66)	-27.44(155.58)
5	-21.06(128.87)	-28.67(115.88)	-45.00(83.97)	-9.89(145.84)	-20.12(132.08)
6	29.94(105.40)	19.00(92.76)	42.22(149.17)	100.28(214.72)	85.89(154.15)
7	-5.72(19.13)	-8.83(18.53)	-18.83(24.43)	6.89(28.89)	7.35(16.34)
8	11.44(212.30)	9.33 (193.10)	-21.44(170.14)	-9.00(163.56)	30.67(202.71)

Table 39: Galga 6 = Strain Gauge 6: Analyses Results.

	p-value
Cycle effect	0.593
Phase effect	< 0.001
Torsion effect	0.007
Interactions:	
Phase/Cycle	0.939
Phase/Torsion	0.339
Cycle/Torsion	0.960

Table 40: Galga 6 = Strain Gauge 6: Cycle Effect.

	p-value
Cycle 1 vs. Cycle 2	0.918
Cycle 1 vs. Cycle 3	0.811
Cycle 2 vs. Cycle 3	0.570

Table 41: Galga 6 = Strain Gauge 6: Phase Effect.

	p-value Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Phase 1	< 0.001	< 0.001	< 0.001	0.001	1.0	0.035	0.108
Phase 2	---	0.183	0.007	< 0.001	< 0.001	< 0.001	< 0.001
Phase 3	---	---	0.952	0.510	< 0.001	0.055	0.015
Phase 4	---	---	---	0.991	< 0.001	0.557	0.292
Phase 5	---	---	---	---	0.002	0.967	0.830
Phase 6	---	---	---	---	---	0.062	0.170
Phase 7	---	---	---	---	---	---	1.0

Table 42: Galga 6 = Strain Gauge 6: Torsion Effect.

	p-value Torsion –15	Torsion 0	Torsion 15	Torsion 30
Torsion -30	1.0	0.262	1.0	0.235
Torsion -15	---	0.542	1.0	0.164
Torsion 0	---	---	0.536	0.002
Torsion 15	---	---	---	0.167

Figure 16: Strain Gauge 6 : Torsion vs. Cycle

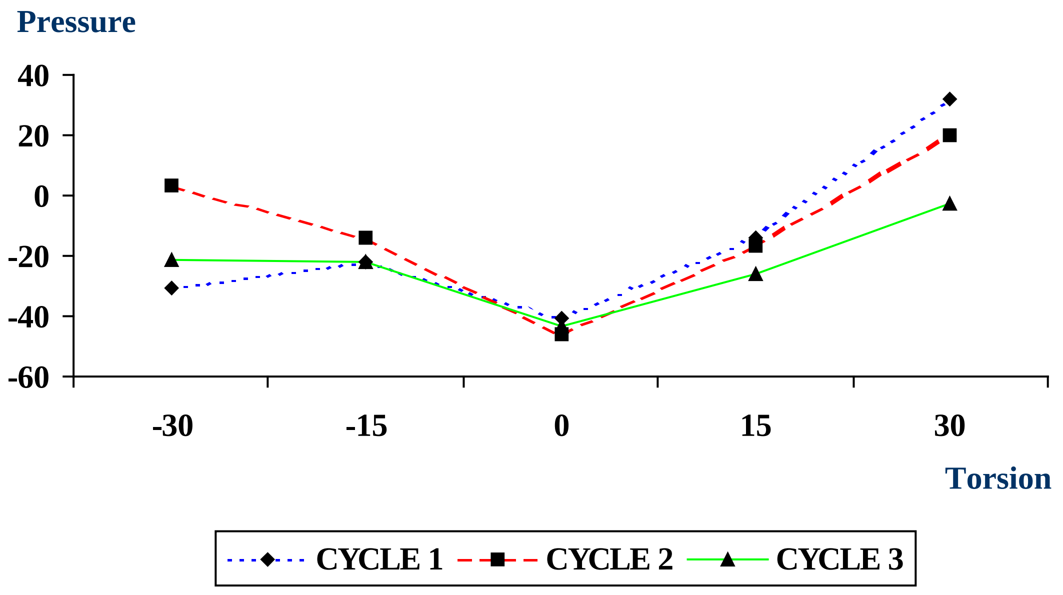


Figure 17: Strain Gauge 6 : Cycle vs. Phase

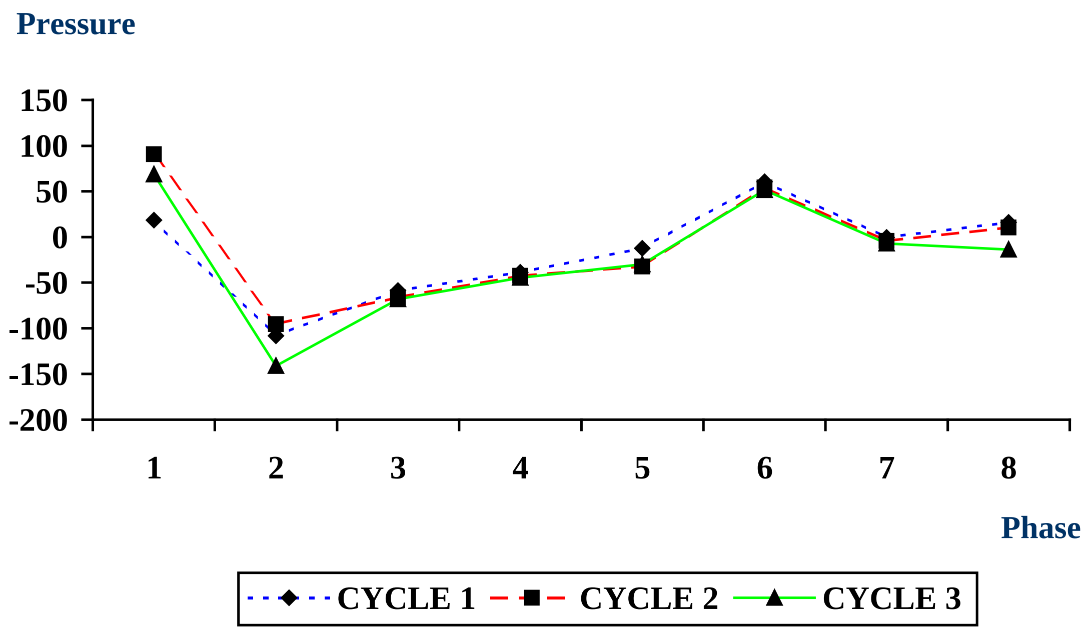
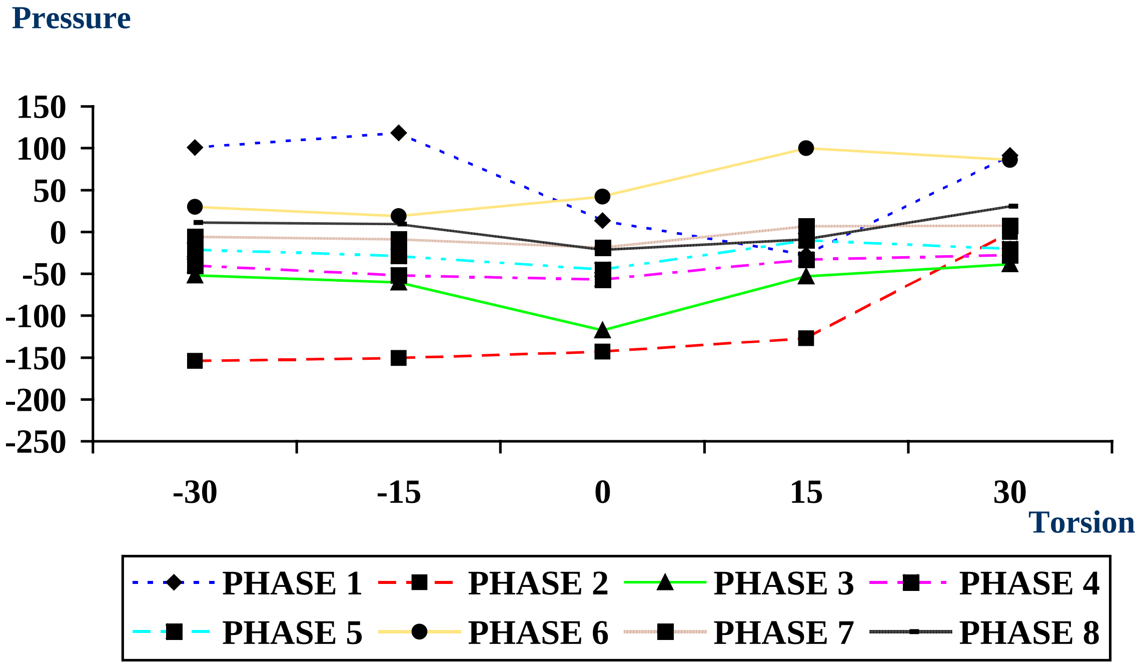


Figure 18: Strain Gauge 6 : Torsion vs. Phase



Strain Gauge (6) :

None of the interactions between two variables Phase/Cycle, Phase/Torsion and Cycle/Torsion has reached statistical significance(p = 0.939, 0.339 and 0,960 Respectively). **(Table 39).**

Cycle Effect: An effect has not been observed cycle ($p < 0.593$) **(Figure 16 and Figure 17) (Table 39 and Table 40).**

Phase Effect: An effect has been observed phase ($p < 0{,}001$). **(Figure 17 and Figure 18).** The principal differences meet between the phase 1 very high values and the phase 2 very low values of Microdeformations. **(Table 39 and Table 41).**

Torsion Effect: An effect has been observed torsion ($p < 0{,}007$) **(Figure 16 and Figure 18).** The significant differences are situated only between the torsion 0^0 (very low values) and 30^0 (very high values). **(Table 39 and Table 42).**

Statistical Analysis.

- A generalized linear model was performed. Microdeformations observed in each Strain Gauges were established as dependent variable. Fixed factors were ***TORSION, PHASE*** and ***CYCLE***. Replicates done in each bone-knee was considered a random effect. All two variables interactions between fixed factors were also analyzed. P-values for pair-wise comparisons were performed by **Tukey test.**
- Results are presented by mean followed of standard deviation in brackets.

DISCUSSION.

DISCUSSION.

In international bibliography there are various researches that, relate the increase of femoral anteversion with the tibia torsion abnormalities, and that relate these with patellar habitual dislocations, femoropatellar gonarthrosis, femorotibial gonarthrosis and, on a lower rate, with internal femorotibial arthrosis. And also normal patellofemoral contact area stress that we measured were in the midrange of values reported by others. Somewhat higher areas were reported by authors who used the injection of cement or rubber to measure area. These differences are probably due to limited penetration of viscous materials into the joint space. Somewhat smaller contact-area stress values were reported using dye techniques. Apart from the use of different techniques, these variations in reported values may also result from population differences in patellar size or from differences in loading magnitudes or times, or both**.** Given the existence of different information partly contradictory and partly obtained by static measurements we decide to use in our study the technology of Strain Gauge extensiometricas. Extensometry is a dynamic deformation method whereas all previous methods, like the Fuji film method (Megapascale), were static in compression. The strain gauge is employ for tension and compression and also dynamic.

Measurements of dynamic contact patterns are problematic because many techniques require invasive procedures such as Fuji film, or injection of material into the joint. These methods permit only static contact measurements, and often require in vitro techniques, which may not reflect the actual, joint function. Alternatively, methods based on mathematical joint modelling (**e.g. Scherrer et al., 1979**) can be used to estimate dynamic in situ or potentially in vivo contact areas. These methods require precise kinematics measurements, and accurate joint surface measurements.

Our method permits to static and dynamic measurements. And too analytical methods that currently succeed in reproducing dynamic methods tend to be inappropriate because they do not employ real a specimen as our method does.

When talking about lower limbs torsion defects, the definition of ***Torsion*** was used initially by some author **Kizinguer** [27] as the deformation when fixing a solid and exerting a transversal rotating movement on one of its parts, leaving the rest of the parts fixed or subject to a movement on the opposite sense. **Taussig** [30] defined it as the deformity that takes place in the bone, in itself and around the longitudinal axis.

The definition of ***Anteversion*** as the external rotation of the upper half of the femur head and neck onwards and the greater trochanter backwards (Virenque, Pasquie, Salanova) is also accepted by **Kizinguer** [27]**.** Later, **Taussig** [30] defined ***Rotation*** as the bone movement in relation with an adjacent bone, around a longitudinal axis. This movement takes place in the joint turning both bones. **Judet** [13] referred to the triple deformation by including in it: an exaggerated anteversion of the femoral neck, a leg external rotation and a genu varus. The exaggerated anteversion originated this triple deformation, through a complex mechanism, when treating the extremity secondary internal rotation, twisting the tibia outwards, also using a valgus flat foot, and therefore justifying a surgical treatment to prevent arthrosis. As far as pathologic tibia torsion, **Kizinguer** [27] states that the secondary deformation in external rotation takes place after the age of four, in children suffering from a foetal anteversion as compensation to the muscle internal rotation. He also states that external tibia torsion is associated to a genu varus and to the persistence of an exaggerated anteversion.

Blaimont [28] was the first person to link gonarthrosis with a torsional abnormality by describing two cases of gonarthrosis with an internal tibia torsion (one congenital and the other acquired), ensuring that in both cases the gonarthrosis could not be justified by a deviation in the frontal plane, or by alterations of the external A-bracket. On the contrary, when walking, the patient would correct the foot position with a small external rotation achieved by an external femoral rotation, which provoked an abnormally wide internal rotating movement to the condyles, and some dynamic external rotating forced movements to the tibia. Both cases justified gonarthrosis.

From the above-mentioned researches, **Turner and Smille** [(29)] measured the tibia torsion in 1,200 adult patients treated for a gonalgia. They observed an increase of the external tibia torsion in the extensor apparatus pathology **(Patellar Instabilities and Osgood-Schlatter).**

They also saw a slight external tibia torsion in those cases were there was panarticular gonarthrosis, although they stated that this possible relationship should be studied in further detail, and that monocompartmental arthrosis was associated to a medium tibia torsion, which could be compared to the one in the control group.

As for the consequences of femoral anteversion increase in the hip, **Jaeger** [(44)] states that it is not completely sure that it is caused by coxarthrosis, although some researches, like the ones made by **Merchant (1965),** show that if the gait goes with an exaggerated external rotation, the pressure transmitted to the femoral head during the support phase is highly increased. In other words, if the femoral anteversion increase goes with an internal rotating gait, an instinctive protection of the hip takes place, although it might not be manifested because of the existence of an associated external tibia torsion. On the contrary, if the increased intervention goes with an external rotating gait, hyperpressure will take place in the anterior part of the articulation, which could lead to coxarthrosis.

In his review about the effects of lower extremities torsional abnormalities to the knee, **Grammont**[(47)] states that every knee has its flexion axis inwards. Knowing that every femoral condyle and throclea are inclined inwards, and that every tibial tuberosity and all feet are inclined outwards, strong external tibial anatomic torsions, associated to femoral anteversions, improve during the gait of the knee, which is more solicited in external tibial dynamic torsion, but the valgus worsens the situation in the braking phase.

In his research on femoropatellar and femorotibial pressures in relation to the condyle of tibia tuberosity position shows that in a normal knee the femoropatellar pressures proportional to the flexion degree that the isolated section of the patellar ailerons does not mean a modification of the forced movement that the forward movement made by the condyle of tibia tuberoses in the saggital plane makes them slightly drop, and that the medial movement helps the increase of the medial femorotibial and femoropatellar movements. On the other hand, he points out the rotational characteristics of some internal gonarthrosis **(Tibia External Rotation On The Femur),** because they prove a non-uniformed central sclerosis in the internal tibia plateau, contrary to gonarthrosis by genu varus.

Elmslie-Trillat technique, **Pache and cols** [(54)] explain that these patients showed an anteversion in the normal femoral neck, a slightly exaggerated femoral torsion, external tibia torsion and a genu varus, which would usually appear together with a high patella, increasing the pressure in the internal compartment compression, and decreasing the external rotation control mainly in the 30 first knees flexion degrees.

After measuring by CT the lower extremities rotating alignment in 43 patients with gonarthrosis, **Takai** [(57)] classifies them in three groups according to what compartment was affected: (Femoropatellar, Internal Femorotibial and External Femorotibial). He proves that femoral torsion in internal femoropatellar arthrosis was much bigger than internal femoropatellar arthrosis that the leg external torsion in femotopatellar arthrosis increased along with the femoral torsion, causing a compensatory increase of the leg external torsion in the gonarthrosis. He also proves that there is a relationship between the femoral anterversion and the external tibia torsion in the group suffering from femoropatellar arthrosis, the external tibia torsion being 5 degrees less in the internal femorotibial arthrosis than in the control group. He states that femoral anteversion is not compensated enough by the external tibia torsion, that external tibia torsion and the leg external torsion in the group suffering from internal femorotibial arthrosis has a relationship with the femoral anteversion. He finally concludes by proving that among aetiological factors in gonarthrosis femorotibial angle and femoral torsion should be included.

Podovani and cols [55] consider **Somerville Syndrome (1957)** as a different one, where increased external tibia torsion is due to an excessive femoral anteversion. They observe that isolated increased external tibia torsions take place in the proximal tibia quarter, approximately at the age of 10, which comes together with a patellar convergent strabism, when the child puts his feet together. They also observe that there is an increase of the Osgood Slatter Effect, an increase of patellar instability in the femoropatellar joint, and an increase of mono and three-compartment arthrosis.

Studying torsional abnormalities in-depth, **Duparc** [46] measured, through CT, 47 arthrosic knees where the internal compartment was affected. He classified them into three groups, based on **Lerat's Research** [48,49,50]**,** according to the torsional morphotype described as the extremity torsion accumulated index. He then compared all the groups with each other.

The results show that there is a femoral torsion medium value of –16 degrees**,** with an important degree of dispersion. The tibia torsion is constantly external and has an average rate of 27.7 degrees, the medium femorotibial rotation reaches 3 degrees, hip internal rotation reaches an average rate of 21.8 degrees and the external rotation are 32 degrees. The accumulated torsional index is of an average rate of +11.7 degrees, but it also has an important dispersion (from –7 to +32 degrees).

This would show dispersion on the results, even when there is such symmetry among the lower extremities on the same patient. After getting these results, he separated them into three groups:

- **Group of medium torsion** accumulated index (considered to be the normal one), with an average rate of +14 degrees. Medium values of femoral torsion and tibia torsion are associated with this group. In the case of arthrosis, the most important factor in this group would be a varus in the frontal plane, according to the mechanical model described by **Maquet** [52]**.**

- **Group of soft torsion** accumulated index (lower than 10 degrees), with an average rate of 1.9 degrees. A strong anteversion and soft external tibia torsion are associated with this group. If the step angle is open, and the hip external rotation increased, the knee gravitational centre moves forward and outwards, improving the global varus axis.

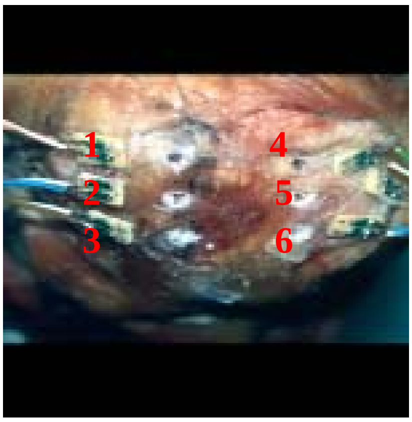
- **Group of strong torsion** accumulated index (higher than 20 degrees), with an average rate of 30.1 degrees. A soft anteversion, a strong external tibia torsion, a knee internal rotation, and a decrease of the hip internal rotation is associated with this group. This is the only group where femorotibial rotation is negative or internal, causing a cartilage shearing when distributing the pressure over tibial plateaus.

They conclude by stating that the torsional accumulated index **(TAI)** allows us to get the joint compensatory angle necessary to get the exact step angle. There are three levels of adaptation: the hip, where external rotation might contribute to open the soft TAI step angle; the knee, where the internal rotation might contribute to decrease the strong TAI step angle; and the submaleollar detorsion. It seems to be accepted that an increased femoral anteversion modifies the extremity torsional evolution, and originates an internal rotation of the knee, since femoral condyles and throcleas are inclined inwards and tibial tuberosities outwards? It also originates a compensatory External Tibia Torsion [13]**.** There is a possibility that when the child is 9 years of age, a non-modifiable external rotation is set up, leading to a correction of the femoral anteversion to what is normal from 9 to 12-13 years of age**.**

Their results show the increase of a patella habitual dislocation, and other patellar pathologies such as patellar instabilities, Osgood-Schlatter's Effect**,** femoropatellar gonarthrosis and a possible tendency to a femorotibial gonarthrosis, which couldn't be proven because of the great variety of lower extremities morphotypes.

Ballester Soleda(68,69) classified the torsional anomalies of the lowest extremity under 5 principal groups that allow the group for a correct randomisation of all the patients **(to see table. page 109)** in order to follow the evolution of the lower extremity or to arrange a chirurgical intervention, when giving a diagnosis on torsional abnormalities, independently from the clinical examination, it is absolutely necessary to perform a computerized axial tomography (CT), as it is the most reliable method.

In the statistical analysis of all measurements, it is proven that at **30 degrees to 60^0** , the patella gets the maximum compression motive for which we realized the valuation of the measurements that we have obtained in the **Phases 5 and 6** are those who correspond to the above mentioned angular values. and also we have explained previously, the position of the strain gauge on the patella as following: -

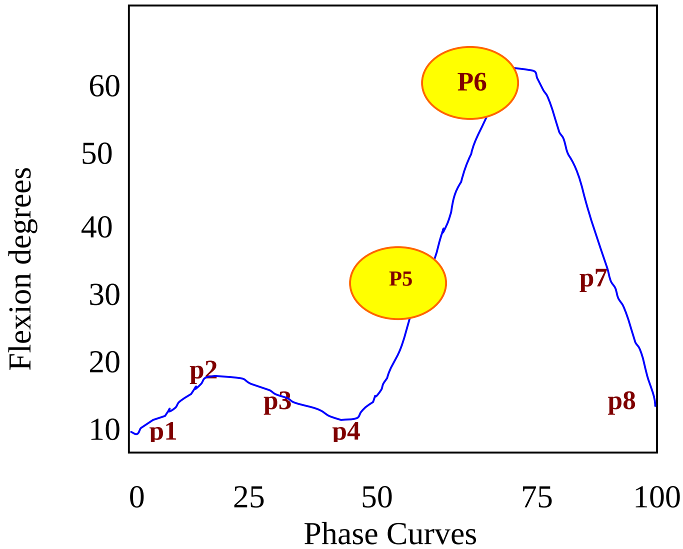


1 = Superior External.
2 = Medium External.
3 = Inferior External.

4 = Superior Internal.
5 = Medium Internal.
6 = Inferior Internal.

- **Stress (+) ⇨ Traction.**
- **Stress (-) ⇨ Compression.**

To Remember: Scheme of gait curve (Phase Curve). To indicate the phases on the curve.



Scheme Of Gait Curve (Phase Curve). (Flexion Degrees)
(% of Gait)

As we have explained previously in material chapter these phases could be divided into:

1) Initial Foot Contact With The Ground: During this phase the knee is flexed some 5^0. This initial angle will range on each individual between -2^0 and + 5^0. After the initial contact phase there is a quick flexion up to 18^0 of flexion corresponding to the 15% of gait. A gradual extension takes place during the rest of the contact phase until it reaches 3^0 of flexion and covers for a 40% of gait.

2) Swing Phase: At the end of the monopodal-feet phase the knee reaches some 7^0 of flexion. At the beginning of the bipodal-feet phase there is a quick flexion of the knee reaching some 63^0 and a 70%. after this quick flexion there is an equally quick extension. At the end of the swing phase there is a slow down of extension that finishes it up to 2^0 when the 97% of the cycle are completed. Afterwards the knee bends in flexion once again reaching up to 5^0 and it enters the ground contact phase. Maximum and minimum angles reached by the articulation vary with each individual.

Strain Gauge (1): Figure (3). Page 188.

Torsion	0^0	15^0	30^0
Phase 5	-70	-20	-30
Phase 6	-100	-110	-140

Phase 5 ■ 30^0
Phase 6 ■ 60^0 } ⇒ **Flexion knee.**

As before The statistical analysis of all the measurements, this is proved that in 30 degrees, the measurement of tension of the above table, when to the knee one applies the torsion of 0^0, 15^0 and 30^0 femoral anteversion, we observed **Phase 5** it increase of the compression stress on the patella as –70, -20, and –30 with a significant statistical result. But when to the knee one applies the torsion of 0^0, 15^0 and 30^0 femoral anteversion, we observed **Phase 6** it increase of the compression stress on the patella as –100, -110, and –140 with a significant statistical result. It is where in general are observed values significantly higher than the rest of torsion.

Strain Gauge (2): Figure (6). Page 193.

Torsion	0^0	15^0	30^0
Phase 5	-20	-60	-80
Phase 6	-70	-190	-200

The measurement of tension of the above table, when to the knee one applies the torsion of 0^0, 15^0 and 30^0 femoral anteversion, we observed **Phase 5** it increase of the compression stress on the patella as –20, -60, and –80 with a significant statistical result. But we observed **Phase 6** increase of the compression stress on the patella as –70, -190, and –200 with a significant statistical result. It is where in general are observed values significantly higher than the rest of torsion.

Strain Gauge (3): Figure (9). Page 198.

Torsion	**0^0**	**15^0**	**30^0**
Phase 5	-70	-110	-100
Phase 6	-90	-120	-110

The measurement of tension of the above table, when to the knee one applies the torsion of 0^0, 15^0 and 30^0 femoral anteversion, we observed **Phase 5** it increase of the compression stress on the patella as –70, -110, and –100 with a significant statistical result. and also we observed **Phase 6** it increase of the compression stress on the patella as –90, -120, and –110 with a significant statistical result. It is where in general are observed values significantly higher than the rest of torsion.

Strain Gauge (4): Figure (12). Page 203.

Torsion	**0^0**	**15^0**	**30^0**
Phase 5	-70	-140	-130
Phase 6	-50	-110	-150

The measurement of tension of the above table, when to the knee one applies the torsion of 0^0, 15^0 and 30^0 femoral anteversion, we observed **Phase 5** it increase of the compression stress on the patella as –70, -140, and –130 with a significant statistical result. and also we observed **Phase 6** it increase of the compression stress on the patella as –50, -110, and –150 with a significant statistical result. It is where in general are observed values significantly higher than the rest of torsion.

Strain Gauge (5): Figure (15). Page 208.

Torsion	0^0	15^0	30^0
Phase 5	-10	-20	-20
Phase 6	-20	+30	+10

The measurement of tension of the above table, when to the knee one applies the torsion of 0^0, 15^0 and 30^0 femoral anteversion, we observed **Phase 5** it increase of the compression stress on the patella as –10, -20, and –20 with a significant statistical result. and also we observed **Phase 6** it increase of the compression stress as –20, +30, and +10 with a significant statistical result.

Strain Gauge (6): Figure (18). Page 213.

Torsion	0^0	15^0	30^0
Phase 5	-50	-10	-20
Phase 6	+50	+100	+90

The measurement of tension of the above table, when to the knee one applies the torsion of 0^0, 15^0 and 30^0 femoral anteversion, we observed **Phase 5** it increase of the compression stress on the patella as –50, -10, and –20 with a significant statistical result. And also we observed **Phase 6** it increase of as +50, +100, and +90 with a significant statistical result.

In Our Research, we have founded in the:

Torsion	0^0	15^0	30^0
1 Superior External Phase 5 Phase 6	-70 -100	-20 -110	-30 -140
2 Medium External Phase 5 Phase 6	-20 -70	-60 -190	-80 -200
3 Inferior External Phase 5 Phase 6	-70 -90	-110 -120	-100 -110
4= Superior Internal Phase 5 Phase 6	-70 -50	-140 -110	-130 -150
5= Medium Internal Phase 5 Phase 6	-10 -20	- 20 +30	- 20 +10
6= Inferior Internal Phase 5 Phase 6	- 50 +50	- 10 +100	- 20 +90

1). Lateral Facet (1, 2, 3). We found too see our annotations in recipe: -

a). We observed that by increasing the femoral anteversion, there was an increase of the compression stress in external facet.

b). The inferior external only diminish slight at 60 flexion.

2). Medial Facet: (4,5,6). We found too see our annotations in recipe: -

a). Less compression stress in internal facet than the external facet.

b). We observed that by increasing the femoral anteversion, there was decrease of the compression stress in medial facet. In medial inferior zone appear inclusive forces of traction.

c). Only superior internal found high level of compression stress.

3). Superior Area --- 1 (External) and --- 4 (Internal).

We found too see our annotations in recipe: -

- Major compression stress at 30^0 of flexion. The compression stress increase proportionally in relation to the amount of antevesion

4). Medial Area --- 2 (External) and --- 5 (Internal).

We found too see our annotations in recipe: -

- We have obtained the maximum compression stress at 60^0 of flexion in the lateral zone.

5). Inferior Area --- 3 (External) and --- 6 (Internal).

We found too see our annotations in recipe: -

- Minimal compression stresses were founded in the inferior area and there decrease along the flexion. By incremented anteversion values the compression stress moves to traction stressing in this area.

- We agree with **Kaufman and cols** [(64)] when they state that this kind of test does not exactly reproduce the complete step mechanism for the following reason: when one begins to loosen the heel, an inward movement of the body weight takes place, modifying the spatial relation between the bodies weight axis and the support zone.

We also find this problem in the research made by **Lee and cols** [(208)], as following used Fuji pressures – sensitive film for measure patellofemoral contact pressure. that was cut to 5×5cm and wrapped and sealed with thin polyethylene sheets for use in a fully lubricated patellofemoral joint.

This in vitro study quantifies the effect of 20^0 and 30^0 of fixed rotational deformity of the femur on the tension in the quadriceps tendon and the intraarticular contact pressures in the patellofemoral joint.

The increases in the degree of fixed rotational deformities of the femur resulted in a nonlinear increase in patellofemoral contact pressures on the contralateral facets of the patella, although there is no specific mention on this regard?

In the model presented in this thesis, we have accepted the simplifications proposed by the above authors because with the experimental methodology we have today, it is not possible to do an accurate reproduction of the step mechanism. Since there are no experimental researches with similar characteristics, which would provide us with some reference values to validate our research; we have done the analysis of our results by comparing the results obtained after every modification with the first measurement taken from a virgin knee, and after applying a pressure of 15^0 on a femoral anteversion (AVF), and having it describe a mobile arch of 0^0 to 90^0. The tendency was **statistically analysed** through a descriptive analysis and by comparing all the medians in independent groups and coupled groups, with a significance level of 5%.

In every analysis performed before and after the anteversion and we observed two points of stress opposite to each other, in patella. We observed that some areas act as a ***compression,*** and other as ***traction,*** according to Pawels' model. This stress state is modified in relation to the localization of the pressure point (AVF). We observed that by increasing the AVF, there was an increase of the compression in lateral zones of the patella.

We observed the relationship between some femoropatellar pathologies and femorotibial **Turner and cols [29] and Yagi T [59]** and the femoral neck anteversion values. And also we observed our results are equal in similar all knees but the variations in reported values may also result from population differences in patellar size or from differences in loading magnitudes or times, or both. And in addition the age, axes and alignment. The conditions of our experience show a high rate of resemblance to the behaviour observed in the patella during human gait. It must be emphasised that the simulator employed reproduced gait kinematics and flexion and extension forces to which the knee is subject to. Forces simulated in order to reproduce normal gait are quadriceps tendon, femoral biceps and ground forces.

To sum up, it seems to be no doubt that the patellofemoral joint and, consequently, work together with distraction areas and compression areas. It also seems obvious that these areas are not always the same, but there are some torsional abnormalities that modify and distribute them, in such a way that the increase of femoral anteversion provokes the increase of the compression at ***an internal patellofemoral*** compartment level,

In our research, there are two main factors, which we cannot control: the previous state of the knee in its saggital axis (varus-valgus), and its previous tibia torsion or torsional morphotype. They are both very important because there are a great variety of torsional abnormalities [46] at femoral, patellar and tibial levels, which affect all three-space planes and have a great influence on the end results.

In the model presented in this thesis, we have accepted the simplifications proposed by the above authors because with the experimental methodology we have today; it is not possible to do an accurate reproduction of the step mechanism.

Since there are no experimental researches with similar characteristics, which would provide us with some reference values to validate our research, we have done the analysis of our results by comparing the results obtained after every modification with the first measurement taken from a virgin knee, and after applying a pressure of 15^0 on a femoral anteversion (AVF), and having it describes a mobile arch of 0^0 to 90^0.

In every analysis we observed two points of stress opposite to each other, in the patella and we observed that some areas act as a compression, and other as a traction, according to Pawels' model.

To sum up, it seems to be no doubt that the patellofemoral joint and, consequently, the work together with distraction areas and compression areas. It also seems obvious that these areas are not always the same, but there are some torsional abnormalities that modify and distribute them, in such a way that the increase of femoral anteversion provokes the increase of the compression at an internal patellofemoral compartment level, especially when the extremity is extended. It is also proved that the pressures are redistributed in such a way that the compression in the ***external patellofemoral***.

CONCLUSIONS.

CONCLUSIONS.

1- During knee flexion the patella responds with two different kind of stress, some zones being under ***Compression***, and other zones under ***Traction***.

2- The Strain Gauges are a good and reliable method to measure mechanical stresses of compression and traction in bones and joints

3- A generalized statistics linear model was performed. Microdeformations observed in each Strain Gauge was established as dependent variable. Fixed factors were ***Torsion, Phase*** and ***Cycle***.

4- A direct relationship, statistically significance, between femoral neck anteversion and the distribution of stresses in the patella was founded.

5- The increase of femoral anteversion produces an increase of the pressure on the lateral patella.

6- The increase of femoral anteversion reduces the pressure in the internal patella until obtaining traction forces in the biggest amount of tested anteversion.

BIBLIOGRAPHY

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1- **Beckman, M.; Craig, R.; Lehman, R.C.** "Rehabilitation of patellofemoral dysfunction in the athletes." Clin In Sports Med; **(8)4: 841-860. (1989).**

2- **Tiberio, D. "**The effect of excessive subtalar joint pronation on patellofemoral mechanics: A Theoretical Model." J. Orth & Sports Phys.Ther. **(9)4: 160-165. (1987)**

3- **Hammer, W.I.** Functional examination and treatment by manual methods: The extremities. Gaithersburg, Maryland; Aspen. **(1991).**

4- **Souza, T.** "Treatment of common knee disorders, Part II, Specific Conditions." Chirop Sports Med**; (4) 4: 119-128. (1990).**

5- **Ballester Soleda J,** Operative treatment for recurrent dislocation of the patella reconst. Surgery traumat. **12; 62. (1971).**

6- **Ballester Soleda J,** Tratamiento Quirúrgico de la Luxación Reicidivante de Rotula Rev.Ortop Traum. **22- IB; 265. (1978).**

7- **Coventry, M.b.:** Osteotomy about the knee for degenerative and rheumatoid arthritis indications, operative technique and results. J.Bone Joint Surg. **55-A23. (1973).**

8- **Navarro Quilis, A.:** Inestabilidad Ligamentosa de la Rodilla. Ponencia Official XXI Congreso de la SECOT. Garsi. **Madrid, (1983). Spain.**

9- **Steindler, A:** Kinesiology. Charles C. Thomas. **Illinois, (1935). U.S.A.**

10-**Takai, S.; Sakakida, K.; Yamashita, F.:** Rotational alignment of the lower limb in osteoarthritis of the knee. Int. Jour. Orthop. **9 (3); 209-215. (1985).**

11-**Taussig. G.:** Anetorsion Isolee du col Femoral de I´ enfant, etude. Clinique et Therapeutique. Ann. Chir. **40(6): 351-355. (1986).**

12-**Harris, N:** Rotational deformities and their secondary effects in the lower extremities in children. J.Bone.Surg. **54-B172. (1972).**

13- **Judet J. ET Judet H.** La Triple Deformatión Treatment ET Clinique. Acta Orthop Belga: **43, 550. (1977).**

14- **Goldberg, B.** Chronic anterior knee pain in the adolescent. Pediatric Annals, **20:4, April 186-187, 190-193. (1991).**

15- **Micheli, L., Stanitski, C.** Lateral patellar retinacular release. The American Journal of Sports Medicine, **9(5), Sept-Oct, 330-336. (1981).**

16- **Grana, W., Kriegshauser, L.** Scientific basis of extensor mechanism disorders, Clinics In Sports Medicine, **4(2), April, 247 -257. (1985).**

17- **Eng, J., Pierrynowski, M.** Evaluation of soft foot orthotics in the treatment of patellofemoral pain syndrome. Physical Therapy,**73(2), February 62-70. (1993).**

18- **James, S.L.** Chondromalacia of the patella in the adolescent. The injured adolescent's knee, Kennedy, J.C. (ed), Williams & Wilkins Co.: Baltimore, **205-251. (1979).**

19- **Baxter, M.** Knee pain in the paediatric athlete. Paediatric Medicine, **1(5), Fall, 211-218. (1986).**

20- **Watanabe, R.S.:** Embryology of the human hip. Clin. Orthop. **98: 8-26. (1974).**

21- **Esckoff, D.G.;** Femoral anteversion in arthritis of the knee. J. Pediat.Orthop.**15:700. (1995).**

22- **Aranow, S. And Zippel, H:** Undersuchung zur Femoral-Tibialen Torsion bei Patella Instabilitaten. Beitr.Orthop.Traumat. **37: 311-326. (1990).**

23- **Esckoff, D.G.; Montgomery, W.K., and Stamm, E.R.:** Femoral morphometry and anterior knee pain. Clin. Orthop. **302: 64-68. (1994).**

24- **D.Tonnis, M.D., Dortmund. And A. Heinecke. PH.D. Munster.** Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. Jour.Of Bone And Joint Surg. **Vol 81-A, NO.12 Decemb. (1999). Germany.**

25- **Swanson, A. B., Greene, P. W., Jr and Alis, H.D.,** Rotational deformities of the lower extremity in children and their clinical significance. Clin. Orthop. **27: 157-175. (1963).**

26- **Tonnis, D., AND Heinecke, A.:** Diminished Femoral Antetorsion Syndrome: A cause of pain and osteoarthritis. J. Pediat. Orthop. **11: 419-431. (1991).**

27- **Kizinguer, HY. Casifux, P.**: Les vices de Torsion du Member Inferieur.Acta Orthop Belg. **43 (4): 379-415. (1977).**

28- Blaimont, P.: Schoon, R: Apropos de 23 cas de Gonarthrose Associa. Une vice de Torsion Interne de la Tibia **.43(4): 476-481. (1977).**

29- Turner, MS, And Smillie, IS: The effect of tibial torsion on the pathology of the knee. J.Bone. Joint Surg. **63 B: 396-398. (1981).**

30- Taussig. G.: Les Anomalies de Rotation des Members Inferieurs Rev. Chir.Orthop. **68(1) 3-4. (1982).**

31- Bedouelle, J: Antétorsion des cols Fémoreaux. Rev. Chir. Orthop.**68 (1): 5-13. (1982).**

32- Cirotteau, Y: Corrélations des Structures Osseuses de La Hanche. Rev.Chir. Orthop. **68 (1) 14-19. (1982).**

33- Taussig. G.: Torsions Tibiales. Rev. Chir. Orthop. **68(1) 20-23. (1982).**

34- Jiang CC, Chen CH, Huang LT, Liu YJ, Chang SL, Wen CY, Liu TK. J. Forms Med Assoc, **92(4): 373-8. National Taiwan University. (1993).**

35- Hsu HC, Luo ZP, Rand JA, An KN. Influence of patellar thickness on patellar tracking and patellofemoral contact characteristics after total knee arthroplasty. J**.**Arthroplasty**. 11(1): 69-80. Jan. Mayo Clinic, Rochester, Minnesota, (1996) .USA.**

36- Nagamine R, Whiteside LA, Otani T, Effect of medial displacement of the tibial tubercle on patellar position after rotational of the femoral component in total knee arthroplasty. J. Arthroplasty .**Jan; 11 (1): 104. (1996). U.S.A.**

37- Briard JL, Hungerford DS. Patellofemoral Instability In Total Knee Arthroplasty. J. Arthroplasty**; 4 Suppl: S87-97.** Centre Medico-Chirurgical Du Cedre, Bois Guillaume, **(1989). France.**

38- P. Álvarez Díaz. Repercusión de las anomalías torsionales sobre las prótesis de rodilla. Desgaste Del Polietileno. **Monografías SECOT, 2. 39-45. Barcelona. Spain. (2000).**

39- Jaquemier, M.: Chrestian, P; Ramaherison, P.; Faure, F, et Bouyala, J.M.: Analyse des vies de Torsion chez I´enfant par la Tomodensitométrie. Rev. Chir. Orthop. **68 (1): 24-28. (1982).**

40- Heripret, G.: Torsion Fémorale et Torsion Tibiale. Mesure. Radiologiques. Rev.Chir. Orthop.**68(1): 29-31. (1982).**

41- Chrestian, P: Techniques ET Résultants des Ostéotomies de Dérotations chez I´ enfant. Rev.Chir. Orthop.**68 (1): 32-53. (1982).**

42- Bedouelle, J: Indications Thérapeutiques chez I´ enfant. Rev Chir. Orthop. **68 (1): 36.(1982)**

43- Lerat, J.L.; Moyen, B. et Bochu, M.: Examen Clinique des Axes chez. I´Adulte.Rev.Chir. Orthop. **68(1) 37-43. (1982).**

44- Lerat, Jaeger. L.; Morphotypes des Members Inférieurs de I´Adulte. Rev. Chir. Orthop. **68(1) 44-46. (1982).**

45- Jaeger, J.H.: Conséquences des Torsion du col Femoral sur la hanche. Rev.Chir.Orthop. **68(1): 47-49. (1982).**

46- Duparc, F.; Thomine, J.M.; Simonet, J. Biga, N.; Torsions Osseuses Femorales Et Tibiales Associees A La Gonarthrose Fémoro-Tibiale Interne. Rev. Chir. Orth.; **78; 430-437, (1992).**

47- Grammont, P.; et Trouilloud, P.: Retentissement des Anomalies Rotationnelles du Member Inférieurs Sur Le Genou. Rev. Chir. Orthop.**68 (1): 52-57, (1982).**

48- Lerat, J.L.; Morphotypes des Instabilitiés Rotuliennes. Rev.Chir. Orthop.**68 (1): 50-52. 1982).**

49- Lerat, J.L. et Raguet, M.: Résultats des Ostéotomies de Dérotation Chez I´Adulte.Rev. Chir.Orthop. **68(1): 64-66. (1982).**

50- Lerat, J.L.: Indications de La Correction des Troubles de Torsion des Members Inférieurs Chez I´Adulte.Rev.Chir.Orthop. **68(1): 66-70. (1982).**

51- Lerat, J.L.: Conclusion. Rev.Chir.Orthop. **68(1): 70-71. (1982).**

52- Maquet, P.: Biomécanique du Genou. Application á La Pathogénie et au Traitement Chirurgical de La Gonarthrose. Springer. **Berlin. (1977).**

53- Moyen, B.; Lerat, J.L. Bochu, M. Comtet, J.J.: Le Pied et Les Troubles de Torsion des Members Inférieurs. Rev.Chir.Orthop. **68(1): 57-61. (1982).**

54- Pache, T.; Mesystre, J.L.: Transplantation de La Tuberosite Tibiale Anterieure Selon La Technique d´ Elmslie-Trillat. Rev.Chir.Orthop. **71(6): 359-364. (1985).**

55- Padovani, G.: Anomalie di torsione tibia nell´ adulto. Chir. Organi Mov. **73(1): 21-26. (1988).**

56- Segal, Ph. Et Raguet, M.: L´ostéotomie tibiale de dérotation Chez I´Adulte.Rev.Chir.Orthop. **68(1): 61-63. (1982).**

57- Takai, S.; Yamashita, F.: Rotational alignment of the lower limb in osteoarthritis of the knee. Int. Journ. Orthop. **9(3): 209-215. (1985).**

58- Taussig, G.: Antetorsion Isolee du Col Femoral de L´ Enfant, etude clinique et Therapeutique. Ann. Chir. **40(6): 351-355. (1986).**

59- Yagi, T.: Tibial torsion in-patient with medial type osteoarthrosis of the knees. Clin.Orthop. **302: 52-56. (1994).**

60- Ryosuke Kuroda. Helen Kambic. Antonio Valdevit.Jack T. Andrish: Articular Cartilage Contact Pressure After Tibial Tuberosity Transfer: A Cadaveric Study. **Vol 29, Num 4, July/August. (2001).**

61- Mochizuki RM, Schurman DJ: Patellar Complications Following Total Knee Arthroplasty. J. Bone. Surg. Am. Sep; **61(6A): 879-883. (1979).**

62- Judet J. et Judet H. La Triple Deformatión Treatment et Clinique. Acta Orthop Belga: **43, 550. (1977).**

63- Kapandji, I.A.: Cuadernos de Fisiologia Artcular. Toray- Masson. **Barcelona, (1970).**

64- Kaufman, KR; Daniel, DM.: Joint Kinematics In Muscle-Stabilized Knee. En: Jacksom, **DW (ed)**: The Anterior Cruciate Ligament Current And Future Concepts. **New York.** Raven Press Ltd, **113-130. (1993).**

65- Lerat, J.L.; Moyen, B. et Bochu, M.: Examen Clinique des Axes chez. I´Adulte.Rev. Chir. Orthop. **68(1) 37-43. (1982).**

66- Lerat, J.L.; Morphotypes des Members Inférieurs de I´Adulte. Rev. Chir. Orthop. **68(1) 44-46. (1982).**

67- Molina Ros, A: (Doctorate Thesis). Autónoma University Of Barcelona, **Spain. (1988).**

68- Ballester Soleda, J.: Anomalíes de Torsión de Las Extremidades Inferiors. Rev.Ortop. Trauma. **33- IB; 136-143. (1989).**

69- Ballester Soleda, J.; Molina Ros, A.; Aguilar, L.; Hernandez, C.: Alineación de Las Extremidades Inferiors. Anomalíes Torsionales. Clasificacion. Cirugia de La Rodilla. Editorial Jim’s s.a. **336-343. Capitulo 28. (1995).**

70- Christopher E. Smith, D.P.M. North American Congress On Biomechanics And Abnormal Torsions Of The Lower Extremity, **Canadian And American Society Of Biomechanics, Washington. U.S.A. March (1997).**

71- North American Congress, Problems Of Lower Extremities Torsional And Treatment In Children’s. **Canadian And American Society. Shriners Hospitals. U.S.A. May 22, (2001).**

72- **Heller, and Langman, J.** The menisco-femoral ligaments of the human knee. J. Bone Joint Surg. **46B: 307. (1964).**

73- **Fairbank, T.J.;** Knee joint changes after meniscectomy. J.Bone Joint Surg. **30B: 664- 670. (1948).**

74- **Gardner, E, And O'Railly, R.;** The early development of the knee joint in staged human Embryos. J. Anat, **102 (2): 289. (1968).**

75- **Hosea, T., Tria, A, And Bechler, J.;** Embryology of the knee. In Scott, W.N. (ed) ligament and extensor mechanism injuries of the knee: Diagnosis And Treatment. St. louis, C.V. Mosby Co./ Year Book. **(1991).**

76- **Streeter, G.L.;** Development horizons in human embryos; Description of age **Group XI, 13 To 20** Somites and age **Group XII, 21 To 29** Somites. Contrib., Embryol. **30:211. (1942).**

77- **Streeter, G.L.:** Development horizons in human embryos, description of age **Groups XI – XXIII**. Embryology Reprint Volume II. **Washington, D.C.,** Carnegie Institution. **(1951).**

78- **Warren, L.F., And Marshall, J, L.:** The Supporting Structures And Layers On The Medial Side Of The Knee. J. Bone Joint Surg., **61A: 56 –62. (1979).**

79- **Wiberg, G.:** Roentgenographic And Anatomic Studies On The Femoro- Patellar Joint. Acta Orthop. SCAND. **12: 319-410, (1941). & LAST'S ANATOMY; 8. Edition. (1990).**

80- **Bone, J.V, Teixeira. K., Roger, D.J., And Sibeni, T.:** Central Third Patellar Ligament Graft: The Anatomic " Taper." Am. J Knee Surg**.,** **7 (1): 36- 38. (1994).**

81- **Reider, B., Marshall, J.L., Koslin, D., Ring, B., And Girgis, F.G.:** The anterior aspect of the knee joint: An Anatomic Study. J. Bone Joint Surg. , **63A: 351- 356. (1981).**

82- **Scapinielli, R.:** Studies on the vasculature of the human knee joint. Acta Anat. **70: 305 – 331, (1968).**

83- **Scuderi, G., Scharf, S.C., Meltzer, L., And Scott, W.N.;** The relationship of lateral releases to patella viability in total knee arthroplasty. J. Arthroplasty, **2: 209- 214.(1987).**

84- **Warren, L.F., And Marshall, J.L.:** The supporting structures and layers on the medial side of the knee. J. Bone Joint Surg. **61A: 56 – 62. (1979).**

85- **Warren, L.F., Marshall, J.L., And Girgis, F.G.,** The prime static stabilizer of the medial side of the knee. J. Bone Joint surg., **56A: 665- 674. (1974).**

86- Brantigan, O.C., And Voshell, A.F., The mechanics of the ligaments and menisci of the knee joint. J. Bone Joint Surg. , **23: 44 – 66.(1941).**

87- Grood, E, S., Noyes, F.R., Butler, D.L., Ligamentous and capsular restraints preventing straight medial and lateral laxity in intact **Human Cadaver Knee.** J. Bone Joint Surg. **63A: 1257. (1981).**

88- Seebacher, J.R., Inglis, A.E., Marshall, J.L., And Warren, R.F., The structure of the postero-lateral aspect of the knee. J. Bone Joint Surg., **64A: 536 – 541. (1982)** & Clinical Anatomy; **Richard S. Snell. 5 Editions. (1995).**

89- Tria, A.J., Johnson, C.D., And Zawadsky, J.P., The Popliteus Tendon. J.Bone Joint Surg**. 71A: 714- 715. (1989).**

90- Kennedy, J.C., Alexander, I.J., And Hayes, K.C., Nerve supply of the human knee and its functional importance. Am. J. Sports Med**., 10: 329- 335. (1982).**

91- Kettelkamp, D, B., Johnson, R.J., Smidt, G.L., et al.: An Electrogoniometric study of knee motion in normal gait .J. Bone Joint Surg. **52- A: 775. (1970).**

92- Marans, H.J., Jackson, R, W., Glossop, N.D., et al.: Anteriorcruciate ligament insufficiency: a dynamic three – dimensional motion analysis. Am. J. Sports Med**. 17: 325. (1989).**

93- Jackson, J.P.: Surgery Of The Knee Joint, **In Jackson, J.P., And Waugh, W. (eds)**: Surgery Anatomy. **Philadelphia, J.B. Lippincott. (1984).**

94- Mcleod, W.D., Moschi, A., Andrews, J.R., et al.: Tibial Plateau Topography. Am. J. Sports Med. **5: 13. (1977).**

95- Kapandji, I.A.: The Physiology of The Joint, **Vol. 2**. Lower Limb. **Edinburgh,** Churchill Livingston. **(1970).**

96- Outerbridge, R.E.: Further studies on the aetiology of chondromalacia patellae. J.Bone Joint Surg. **46- B: 179. (1964).**

97- Maquet, P.: Advancement of the tibia tuberosity. Clin. Orthop .**115: 225. (1976)**.

98- Maquet, P.: Mechanics and osteoarthritis of the patellofemoral joint. Clin.Orthop. **144: 70. (1979).**

99- Frankel, V.H. And Burstein, A.H. Orthopaedic Biomechanics, **2-nd edn** Lea & Febiger: **Philadelphia. U.S.A. (1984)**.

100- Kettlecamp, D.B. And Chao, E. Y. Clinical Orthopaedics And Related Research. **83, 202. (1972).**

101- Morrison, J.B. Bioengineering analysis of force action transmitted by the knee joint. Biomedical Engineering **3, 164. (1968).**

102- Mukherjee, A. D. Phil Thesis, University of Oxford. (1976).

103- Maquet, P. Biomechanics of the knee with application to the pathogenesis and surgery treatment of osteoarthritis, **2-nd edn**. Springer- Verlag: **Berlin. (1984).**

104- Walker, P.S. And Erkman, M.J. The role of the menisci in force transmission Across The Knee. Clinical Orthopaedics And Related Research .**109, 184-192. (1975).**

105- Hughston, J.C. Andrews, J.R. Cross, M.J. And Moshi, A. Classification of the knee ligament instabilities. Part 1: Medial Compartment And Cruciate Ligament. Journal Of Bone And Joint Surgery **58 A, 159- 172. (1976).**

106- Slocum, D.B. James, S.L., Larson, R.L. And Singer, K.M. Clinical test for anterolateral rotatory instability of the knee. Clinical Orthopaedics And Related Research **118, 63-69. (1976).**

107- Furman, W., Marshall, J.L. And Girgis F.G. The anterior cruciate ligament. A function analysis based on post-mortem studies. Journal of Bone And Joint Surgery. **58, 179-185 (1976).**

108- Welsh, R.P. Knee Joints Structure And Function. Clinical Orthopaedics And Related Research. **147, 7- 14. (1980).**

109- Grood E.S. Placement of knee ligament grafts in: knee surgery – current practice. Edited By P.M. Aichroth, W. Dilworth Cannon And V.P. Patel. Martin Dunitz: **London. (1992).**

110- Smillie, I.S. Injuries Of The Knee Joint, **5 th edn.** Churchill Livingston: **Edinburgh, London, New York. (1978)**

111- Kennedy, J.C. And Fowler, P.J. Medial and anterior instability of the knee. Journal of bone and joint surgery. **53A 1257**. **(1971)**.

112- Hughston. J.C., Bowden, J.A., Andrews, J.R. And Norwood, L.A. Acute tears of the posterior cruciate ligament: Results of operative treatment. Journal of bone and joint surgery. **62A, 438- 450. (1980).**

113- **Girgis, F.G., Marshall, S.L. And Monajem, A.N.S.** The cruciate ligament of the knee joint. Anatomical, Functional And Experimental Analysis. Clinical Orthopaedics And Related Research. **106, 216-231. (1975).**

114- **Bandi W:** Chondromalacia patella and femoropatellare arthrose. Helv Chir Acta.**1 (suppl): 3, (1972)**.

115- **Kaufer H:** Mechanical function of the patella. J Bone Joint Surg. **53 A : 1551, (1971).**

116- **Smidt GL:** Biomechanical analysis of knee flexion and extension. J Biomech. **6:79, (1973)**.

117- **Stougard J:** Chondromalacia of the patella. Incidence, Macroscopical and Radiographical findings at autopsy. Acta Orthop Scand. **46: 809, (1975)**.

118- **Denham RA, Bishop Red**: Mechanics of the knee and problems in reconstructive surgery. J Bone Joint surg .**60B: 345, (1978).**

119- **Radin E, Leach R:** Anterior displacement of tibial tubercle for patello- femoral arthrosis. Ortho Trans. **3: 291, (1979)**.

120- **Smidt GL:** Biomechanical analysis of the knee flexion and extension. J.Biomechanical. **6: 79, (1973).**

121- **Kettelkamp DB, DeRosa GP**: Surgery of the patellofemoral joint. **p. 25**. In American Academy Of Orthopaedic Surgeons Instructional Course Lectures. **Vol. 25. (1976).**

122- **Perry J, Antonelli D, Ford W**: Analysis of knee joint forces during flexed- knee stance. J. Bone Joint Surg .**57A: 961. (1975).**

123- **Ficat RP, Hungerford DS**: Disorders of the patellofemoral joint. Williams **&** Wilkins, Baltimore. **(1977).**

124- **Morrison JB**: The Mechanics of the knee joint in relation to normal walking. Biomechanics. **3: 51. (1970)**.

125- **Morrison JB**: Function of the knee joint in various activities. Biomed Eng. **4: 573. (1969).**

126- **Lieb FJ, Perry J:** Quadriceps Function. J Bone Joint Surg. **50 A : 1535.(1968).**

127- **Radin EL, Burr DB, Caterson B et al.** Mechanical Determinants of Osteoarthritis. Semin. Arth.Rheu. **21 (Suppl 2): 12-21. (1991).**

128- Hernborg JS, Nilsson BE. The natural course of untreated osteoarthritis of the Knee. Clin.Orthop. Rel. Research**. 123: 130-137. (1997).**

129- Kettlekamp DB, Hillberry BM, Murrish DW, Heck DA. Degenerative arthritis of the knee secondary to fracture malunion. Clin. Orthop. Rel. Research. **234: 159-169. (1988).**

130- Pauwels F. Biomechanics of the locomotors apparatus. New York, Springer Verlag. **(1980).**

131- Chao EYS, Neluheni E V D, Hsu RWW, Paley D. Biomechanics of mal-alignment. Orth. Clin.**N.A. 25: 379- 386. (1994).**

132- Hsu RWW, Himeno S, Coventry MB, Chao EYS. Normal axial alignment of the lower extremity and load bearing distribution at the knee. Clin. Orthop. Rel. Research. **255: 215 –227. (1990).**

133- Moreland JR, Bassett LW, Hanker GJ. Radiographic analysis of the axial alignment of the lower extremity. J. Bone Joint Surg., **69A: 745 –749. (1987).**

134- McMaster M. Disability of the hindfoot after fracture of the tibial shaft. J. Bone Joint Surg., **58 B: 90- 93. (1970).**

135- Krackow KA. Approaches to planning lower extremity alignment for total knee arthroplasty and osteotomy about the knee. Advances In Orth Surg. **7; 68- 88. (1983).**

136- Haritidis JH, Kirkos JM, Zachos AD. Long term results of triple arthrodesis: 42 cases followed for 25 years. Foot & Ankle International. **15(10): 548 – 551. (1994).**

137- Tenuta J, Sheldon YA, Miller F. Long term follow up of triple arthrodesis in patients with cerebral palsy. J.Ped. Orthop. **13(6): 713-716. (1993).**

138- Graves SC, Mann RA, Graves KO. Triple arthrodesis in older adults. Results after long term follow up. J. Bone Joint Surgery (Am). **75(3): 355- 362. (1993).**

139- Wang JH, Kuo KN, Andriacchi TP, Galante JO. The influence of walking mechanics and time on the results of proximal tibial osteotomy. J. Bone Joint Surg. **72 A: 1040- 1043. (1989).**

140- Andriacchi TP. Dynamics of knee mal-alignment. **Orth Clin N.A. 25: 395- 406. (1984).**

141- Eckhoff DG. Effect of limb malrotation on mal-alignment and osteoarthritis. Orth Clin N.A.**25: 405- 414. (1994).**

142- Tonnis D, Heinecke A. Diminished femoral antetorsion syndrome: A cause of pain and osteoarthritis. J. Ped. Orthop. **11: 419- 431. (1991).**

143- Yagi T, Sasaki T. Tibial torsion in patients with medial type osteoarthritic knee. Clin. Orthop. Rel. Research. **213:177- 182. (1986).**

144- Eckhoff DG, Johnson RJ, Stamm ER, et al. Version of the osteoarthritis knee. J. Arthroplasty **.9: 73 –76. (1994).**

145- Paley D, Tetsworth K. Mal-Alignment and realignment of the lower extremity. Orth. Clin. N.A. **Vol 25, 367- 555, July. (1994).**

146- Paley D, Tetsworth K. Mechanical axis deviation of the lower limbs; preoperative planning of multiapical frontal plane angular deformities of the femur and tibia. Clin. Orthop **280: 65 –71. (1992).**

147- Cameron J.C.; Saha, S.: External Tibial Torsion: underrcognized cause of recurrent patellar dislocation. Clin. Orthop**. 328:177-184. (1996).**

148- Degado E.D; Schoenecker P.L.; Rich m.m.; Capelli A.M.: Treatment of severs torsional Mallignment Syndrome. J.Pediatr. Orthop. **16 (4) 484-488. (1996).**

149- Eckhoff: Femoral Morphometry And Anterior Knee Pain. Clin. Orthop. **302:64-68. (1994).**

150- Fabry G., Mac Ewenn, G.D., Shands, A.R.: Torsion of the femur: J. Bone Joint Surg **55-A 1726. (1973).**

151- Fabry G.: Normal and abnormal torsion development of the lower extremities. Acta.Orthop. Belg. **63 (4): 229-232. (1997)**.

152- Ficat, R.P., Hungerfort, D: Disorders of the patello-femoral joint. Baltimore, Masson. **(1977).**

153- Fox, T.A.: Dysplasia of the quadriceps mechanism. Surgical clinics of North America. **55 (1): 199. (1975).**

154- Fulkerson, F.P., Hungerfort, D: Disorders of the patellofemoral joint .**2 nd ed**. Williams And Baltimore**. (1990)**

155- Jacquemier M; Jouve J.L.; Jimeno M.T.: Ramaherisoson P; Giusiano B; Bollini G.: Morphotypes des Membres Inférieurs. Estude clinique chez 1401 enfants. Rev Chir . Orthop. Reparatrice Appar Mot. **83 (6) 531-539. (1997).**

156- Krivickas L.S: Anatomical factors associated with overuse sports injuries. Sports Med. **24 (2): 132-146. (1997).**

157- Lerat J.L.: Morphotypes des Instabilités Rotuliennes Rev. de Chirg. Ort. et Repar. **68 (1): 50-52. (1982).**

158- Lerat J.L., Monyen, B., Gramont, P.: Die Klinische undersuchuyng der untre exremitaten in drei Ebenene. Orthopade. **14 (4): 215-226. (1985)**.

159- Müller, W.: Das Femoropatellas Gelenk. Orthopäde, **14 (4) 204-214. (1985).**

160- Outerbridg, R.E., Dunlop, J.A.: The problem of chondromalacia patellae. Clin.Orthop. **110: 177. (1975)**.

161- Reikeas, O.: Patellofemoral characteristics in patients with increased femoral anteversion. Skeletal Radial. **21: 311-313. (1992)**.

162- Sharrarad, W.J.W: Les Torsions du Tibia. Acta Orthop. Belg. **43 (2): 449. (1971)**.

163- Siles. (Thesis Doctorate). Autónoma University Of Barcelona. Estudio experimental de las solicitaciones femorotibiales en anomalías torsionales y su modificación tres la osteotomia tridimensional. **Spain. (1998).**

164- Turner, M.S., Smille, J.S.: The effect of tibial torsion on the pathology of the knee. J.Bone Joint Surg. **63-B: 396. (1981).**

165- Ketteikamp, D.B., And Jacobs, A, W., Tibiofemoral contact area determination and implication, J. Bone Joint Surgery. **Vol. 54-A, pp. 349-356. (1972)**.

166- Maquet. P. G., Van de Berg, A., Simonet, J., Femorotibial Weight-Bearing Areas, J.Bone Joint Surg., **Vol. 57-A, pp. 766-771. (1975).**

167- Wiberg, G., Roentgenographic and anatomic studies on the femoropatellar joint. Acta Orthop Scand., **Vol. 12. 41. pp. 319-410. (1978).**

168- Greenwald, A.S., And O' Connor, J. J., The transmission of load through the human hip joint, Biomechanics. **Vol. 4. pp. 507-528. (1971).**

169- Goodfellow, J., Hungerford, D.S., And Zindel, M., Patello-Femoral joint mechanics and pathology, J. Bone joint Surg., **Vol. 58-B, pp287-290. (1976).**

170- Moran, J.M., Hemann, J.H., And Greenwald, A.S., Finger joint contact areas and pressures, J. Orthop. Res., **Vol. 3,pp 49-55. (1985).**

171- Matthews, L.S., Sonstegard, D.A., And Henke, J. A., Load bearing characteristics of the patello-femoral Joint, Acta Orthop. Scand., **Vol. 48, Pp. 511-516. (1977).**

172- Walker, P.S., And Hajek, J. V., The Load-Bering area in the knee joint, J. Biomechanics, **Vol. 5, pp. 581-589. (1972).**

173- Yao, J.Q., And Seedhom, B.B., A new technique for measuring contact areas in human Joints- the 3S Technique, J. Eng. Med., **Vol 205,pp. 69-72. (1991).**

174- Scherrer, P.K., Hillberry, B.M., And Van Sickle, D.C., Determining in vivo areas of contact the canine shoulder, ASME Journal of Biomechanical Engineering, **Vol. 101, pp.271-278. (1979).**

175- Soslowsky, L.J., Flatow, E.L., Bigliani, L.U., Pawluk, R.J., Ateshian, G.A., And Mow, V.C., Quantitation Of In Situ Contact Areas At The Glenohumeral joint A Biomechanical Study, J.Orthop. Res**. Vol. 10,pp. 524-534. (1992).**

176- Huiskes, R., Kremers, J., Lange, A. de, Woltring, H.J., Selvik, G.and Rens, Th. J.G. Van. Analytical Stereophotogrammetric Determination Of Three-dimensional Knee Joint Geometry, J. Biomechanics, **Vol. 18.pp .559-570. (1985).**

177-Ateshian, G. A., Rosenwasser, M. P., And Mow, V. C., Curvature characteristics and congruence of the thumb carpometacarpal joint, J. Biomechanics, **Vol, 25, pp. 591-608. (1992).**

178-Kwak, S. D., Newton, P. M., Setton, L. A., And Grelsamer, R. P., Cartilage thickness and contact area determination in the canine knee joint, trans. Orthop. Res. Soc., **Vol. 18 (2), pp .351. (1993).**

179-Ferguson, A. B., Brown, T. D., Fu, F. H., And Rutkowski, R., Relief of patellofemoral contact stress by anterior displacement of the tibial tubercle, J.Bone Joint Surg., **Vol. 61- A, pp. 159-166. (1979).**

180-Brown, T. D., And Shaw, D. T., In vivo contact stress distributions in the natural human hip, J.Biomechanics, **Vol, 16, pp. 373-384. (1983).**

181-Brown, T. D., And Shaw, D. T., In vitro contact stress distribution on the femoral condyles, J. Orthop. Res., **Vol. 2, pp. 190-199. (1984).**

182-Fukubayashi, T., And Kurosawa, H., The contact area and pressure distribution pattern of the knee, Acta Orthop. Scand., **Vol. 51, pp. 871-879. (1980).**

183-Huberti, H.H., And Hayes, W. C., Patellofemoral contact pressure, J. Joint Surg. **Vol. 66A,pp. 715-724. (1984).**

184-Huberti, H. H., And Hayes, W. C., Contact pressures in chondromalacia patellae and the effects of capsular reconstructive procedures, J. Orthop. Res.**Vol. 6, Pp. 499-508. (1988).**

185-Brown, T. D., Pope. D. F., Hale, J. E., Buckwalter, J. A., And Brand, R. A., Effects osteochondral defect size on cartilage contact stress, J. Orthop. Res. **Vol.9, pp. 559-567. (1991).**

186-Haut, R. C., Contact Pressures In the patellofemoral joint during impact loading of the human flexed knee, J.Orthop. Res., **Vol 7, pp. 272-280. (1989).**

187-Ahmed, A. M., And Burke, D. L., In vitro measurement of static pressure distribution in synovial joint- **Part I:** Tibial surface Of The Knee, ASME. J.Biomech. Engng. **Vol 105, pp 216-225. (1983).**

188- Ahmed, A. M., And Burke, D.L., And Yu, A., In vitro measurement of static pressure distribution in synovial joint – **Part II** Retropatellar Surface, ASME. J.Biomech. Engng. **Vol. 105. pp. 226-236. (1983).**

189- Hirokawa, S. And Matsumura, K., Variation of patellofemoral joint contact stress during walking. Med. Bioeng. Comp. **29 (suppl.), 176, (1991).**

190- Koh, T. J., Grabiner, M. D., And De Swart, R. J., In vivo tracking of the human patella. J. Biomech**. 25, 637. (1992)**.

191-Van Kampen, A. And Huiskes, R., The three-dimensional tracking of the human patella. J. Orthoped. Res., **8, 372. (1990).**

192-Ateshian, G. A., Kwak, S. D., Soslowski, L. J., and **Mow, V. C.,** A stereophotogrammetry method of determining in situ contact areas in diarthrodial joint: A comparison study. J. Biomech. In press. **(1993).**

193- Hirsch, C. A., Contribution to the pathogenesis of chondromalacia of the patella. Acta Chir. Scand. Suppl., **Vol, 83, pp 1-106. (1944).**

194- Askew, M. J., And Mow, V. C., The biomechanical function of the collagen ultra structure of articular cartilage, ASME. J. Of Biomehc. Engng. **Vol. 100, pp 105-115. (1978).**

195- Eberhardt, A. W., Keer, L. M., Lewis, J. L., **And Vithoontien, V.,** An analytical model of joint contact, ASME J.Biomecha. Engn. **Vol, 112, pp. 407-413. (1990).**

196- Eberhardt, A. W., Lewis, J. L., And Keer, L. M., Normal contact of elastic spheres with two elastic layers as a model of joint articulation, ASME. J. Biomecha. Engn.**Vol.113, pp. 410-417. (1991).**

197- Mow, V. V., Kuei, S. C., Lai, W. M., And Armstrong, C. G., Biphasic creep and stress relaxation of articular cartilage: theory and experiment, ASME. J. Biomecha. Engn. **Vol. 102, pp. 73-84. (1980).**

198- Mow, V. C., And Lai, W. M., Recent developments in synovial joint biomechanics, SIAM Review, **Vol. 22. pp. 275-317. (1980).**

199- Armstrong, C. G., An analysis of the stresses in a thin layer of articular cartilage in a synovial joint. Eng .Vol Med., **15, pp. 55-61. (1986).**

200- Ateshian, G. A., Lai, W. M., Zhu, W. B., And Mow, V. C.: A biphasic model for contact in diarthrodial joint. ASME Adv. Bioengn. **Vol 22, pp. 191-194. (1992).**

201- Ateshian, G. A., Lai, W. M., Zhu, W. B., Mow, V. C.: An asymptotic solution for two contacting biphasic cartilage layers, J.Biomechanics. In Review. **(1993).**

202- Hirokawa, S., Three-Dimensional mathematical model analysis of the patellofemoral joint. J. Biomechanics, **Vol. 24, pp 659-671. (1991).**

203- Wismans, J., Veldpaus, F., Janssen, J., Huson, A., And Struben, P., A three-dimensional mathematical model of the knee joint. J. Biomech. **13, 677-685. (1980).**

204- Hirokawa, S., Effect of variation on extensor elements and operative procedures in Patellofemoral Disorders. J.Biomech**. 25, 1393. (1992).**

205- Sauren, A.A. H.J., Huson, A., And Schouten, R.Y., An axisymmetric finite the analysis of the mechanical function of the meniscus. Int. J. Sport Med.**Vol. 5, pp 93-95. (1984).**

206- Hefzy, M.S., Grood, E.S., And Zoghi, m., Axisymmetric finite element model of the meniscus. ASME Adv. Bioeng, **pp. 51-52. New York. (1987).**

207- Aspden, R.M., A model for the function and failure of the meniscus. Eng. Med., **Vol. 199, pp. 119-122. (1985).**

208- Lee, Thay Q. Sanford H. Anzel, Kimberly A. Bennett, B.S. The Influence of fixed rotational deformities of femur on the patellofemoral contact pressures. Clin.Ortho And Related Research, **302,pp 69-74. May (1994).**