frontiers

*Supplementary Material*

# Advancements in Veterinary Medicine: The Use of Flowgy for Nasal Airflow Simulation and Surgical Predictions in big Felids (a case of study in lions).

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## 1 Supplementary Data

Table 1. Data of the specimen of *Panthera leo* ZPB_PL_001. Average data of temperature (Temp.) in Kelvin units and absolute humidity (Humid.) in $Kg/m^3$ units variables in the three simulated scenarios, at 28 ºC or 301.15 K (temperate biome) with a RH of 60%; at 40 ºC or 313.15 K (desert biome) with a RH of 05%; and at 5 ºC or 278.18 K (arctic or high mountain biome) with a RH of 10%. In addition, there is a standardization of the cut coordinates (distance) so that they are homologous and equidistant by subtracting the first coordinate value a from all the coordinate values.

| Study Slices | xCoord | Distance | Temp. 28 | Temp. 40 | Temp. 5 | Humid. 60 | Humid. 05 | Humid. 10 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.6858 | 0.0000 | 301.1500 | 313.1500 | 278.1500 | 0.0163 | 0.0026 | 0.0007 |
| 2 | 0.6478 | 0.0380 | 306.3630 | 312.4040 | 294.7070 | 0.0312 | 0.0241 | 0.0231 |
| 3 | 0.6232 | 0.0626 | 310.6410 | 311.7930 | 308.3750 | 0.0440 | 0.0425 | 0.0422 |
| 4 | 0.5986 | 0.0872 | 311.4470 | 311.6790 | 310.9920 | 0.0466 | 0.0463 | 0.0462 |
| 5 | 0.5739 | 0.1118 | 311.6320 | 311.6530 | 311.5930 | 0.0473 | 0.0472 | 0.0472 |
| 6 | 0.5493 | 0.1365 | 311.6480 | 311.6500 | 311.6450 | 0.0473 | 0.0473 | 0.0473 |
| 7 | 0.5247 | 0.1611 | 311.6500 | 311.6500 | 311.6490 | 0.0473 | 0.0473 | 0.0473 |
| 8 | 0.5001 | 0.1857 | 311.6500 | 311.6500 | 311.6480 | 0.0473 | 0.0473 | 0.0473 |
| 9 | 0.4755 | 0.2103 | 311.5100 | 311.6700 | 311.2170 | 0.0469 | 0.0467 | 0.0467 |

Table 2. Data from the operated *Panthera leo* specimen ZPB_PL_001. Average data of temperature (Temp.) in Kelvin units and absolute humidity (Humid.) in $Kg/m^3$ units variables in the three simulated scenarios, at 28 ºC or 301.15 K (temperate biome) with a RH of 60%; at 40 ºC or 313.15 K (desert biome) with a RH of 05%; and at 5 ºC or 278.18 K (arctic or high mountain biome) with a RH of 10%. In addition, there is a standardization of the cut coordinates (distance) that they are homologous and equidistant by subtracting the first coordinate value a from all the coordinate values.

| Study Slices | xCoord | Distance | Temp. 28 | Temp. 40 | Temp. 5 | Humid. 60 | Humid. 05 | Humid. 10 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.6858 | 0.0000 | 301.1500 | 313.1500 | 278.1500 | 0.0163 | 0.0026 | 0.0007 |
| 2 | 0.6478 | 0.0380 | 307.0950 | 312.2990 | 297.0560 | 0.0334 | 0.0272 | 0.0263 |
| 3 | 0.6232 | 0.0626 | 310.9480 | 311.7490 | 309.3700 | 0.0450 | 0.0439 | 0.0437 |
| 4 | 0.5986 | 0.0872 | 311.5220 | 311.6680 | 311.2320 | 0.0469 | 0.0467 | 0.0466 |
| 5 | 0.5739 | 0.1118 | 311.6380 | 311.6520 | 311.6120 | 0.0473 | 0.0473 | 0.0473 |
| 6 | 0.5493 | 0.1365 | 311.6490 | 311.6500 | 311.6480 | 0.0474 | 0.0474 | 0.0474 |
| 7 | 0.5247 | 0.1611 | 311.6500 | 311.6500 | 311.6490 | 0.0474 | 0.0474 | 0.0474 |
| 8 | 0.5001 | 0.1857 | 311.6500 | 311.6500 | 311.6490 | 0.0474 | 0.0474 | 0.0474 |
| 9 | 0.4755 | 0.2103 | 311.4910 | 311.6730 | 311.1570 | 0.0469 | 0.0467 | 0.0466 |

Table 3. Data of the specimen of *Panthera leo* ZPB_PL_003. Average data of temperature (Temp.) in Kelvin units and absolute humidity (Humid.) in $Kg/m^3$ units variables in the three simulated scenarios, at 28 ºC or 301.15 K (temperate biome) with a RH of 60%; at 40 ºC or 313.15 K (desert biome) with a RH of 05%; and at 5 ºC or 278.18 K (arctic or high mountain biome) with a RH of 10%. In addition, there is a standardization of the cut coordinates (distance) that they are homologous and equidistant by subtracting the first coordinate value a from all the coordinate values.

| Study Slices | xCoord | Distance | Temp. 28 | Temp. 40 | Temp. 5 | Humid. 60 | Humid. 05 | Humid. 10 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.8733 | 0.0000 | 301.1510 | 313.1520 | 278.1490 | 0.0163 | 0.0026 | 0.0007 |
| 2 | 0.7836 | 0.0897 | 309.0290 | 312.0210 | 303.1560 | 0.0390 | 0.0354 | 0.0347 |
| 3 | 0.7367 | 0.1366 | 310.8260 | 311.7660 | 308.9570 | 0.0445 | 0.0433 | 0.0431 |
| 4 | 0.6897 | 0.1836 | 311.4400 | 311.6800 | 310.9630 | 0.0466 | 0.0462 | 0.0462 |
| 5 | 0.6427 | 0.2306 | 311.5990 | 311.6570 | 311.4910 | 0.0472 | 0.0471 | 0.0471 |
| 6 | 0.5958 | 0.2775 | 311.6170 | 311.6550 | 311.5480 | 0.0472 | 0.0472 | 0.0472 |
| 7 | 0.5488 | 0.3245 | 311.6140 | 311.6550 | 311.5380 | 0.0472 | 0.0472 | 0.0472 |
| 8 | 0.5018 | 0.3715 | 311.5810 | 311.6600 | 311.4370 | 0.0472 | 0.0471 | 0.0470 |
| 9 | 0.4548 | 0.4184 | 311.4700 | 311.6760 | 311.0930 | 0.0468 | 0.0466 | 0.0466 |

Table 4. Data from the obstructed *Panthera leo* specimen ZPB_PL_003. Average data of temperature (Temp.) and relative humidity (Humid. or RH) variables in the three simulated scenarios, at 28 ºC or 301.15 K (temperate biome) with a RH of 60%; at 40 ºC or 313.15 K (desert biome) with a RH of 05%; and at 5 ºC or 278.18 K (arctic or high mountain biome) with a RH of 10%. In addition, there is a standardization of the cut coordinates (distance) that they are homologous and equidistant by subtracting the first coordinate value a from all the coordinate values.

| Study Slices | xCoord | Distance | Temp. 28 | Temp. 40 | Temp. 5 | Humid. 60 | Humid. 05 | Humid. 10 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.8733 | 0.0000 | 301.1510 | 313.1520 | 278.1490 | 0.0163 | 0.0026 | 0.0007 |
| 2 | 0.7836 | 0.0897 | 304.5810 | 312.6590 | 289.0770 | 0.0261 | 0.0167 | 0.0155 |
| 3 | 0.7367 | 0.1366 | 309.7760 | 311.9150 | 305.5580 | 0.0413 | 0.0387 | 0.0382 |
| 4 | 0.6897 | 0.1836 | 311.1960 | 311.7140 | 310.1430 | 0.0458 | 0.0451 | 0.0449 |
| 5 | 0.6427 | 0.2306 | 311.5910 | 311.6580 | 311.4610 | 0.0472 | 0.0471 | 0.0471 |
| 6 | 0.5958 | 0.2775 | 311.6160 | 311.6550 | 311.5450 | 0.0473 | 0.0472 | 0.0472 |
| 7 | 0.5488 | 0.3245 | 311.6140 | 311.6550 | 311.5390 | 0.0473 | 0.0472 | 0.0472 |
| 8 | 0.5018 | 0.3715 | 311.5810 | 311.6600 | 311.4370 | 0.0472 | 0.0471 | 0.0471 |
| 9 | 0.4548 | 0.4184 | 311.4700 | 311.6760 | 311.0930 | 0.0469 | 0.0467 | 0.0466 |

Table 5. Data from the operated *Panthera leo* specimen ZPB_PL_003. Average data of temperature (Temp.) in Kelvin units and absolute humidity (Humid.) in $Kg/m^3$ units variables in the three simulated scenarios, at 28 ºC or 301.15 K (temperate biome) with a RH of 60%; at 40 ºC or 313.15 K (desert biome) with a RH of 05%; and at 5 ºC or 278.18 K (arctic or high mountain biome) with a RH of 10%. In addition, there is a standardization of the cut coordinates (distance) that they are homologous and equidistant by subtracting the first coordinate value a from all the coordinate values.

| Study Slices | xCoord | Distance | Temp. 28 | Temp. 40 | Temp. 5 | Humid. 60 | Humid. 05 | Humid. 10 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.8733 | 0.0000 | 301.1510 | 313.1520 | 278.1490 | 0.0163 | 0.0026 | 0.0007 |
| 2 | 0.7836 | 0.0897 | 308.3400 | 312.1200 | 300.9660 | 0.0370 | 0.0325 | 0.0317 |
| 3 | 0.7367 | 0.1366 | 310.7160 | 311.7820 | 308.6030 | 0.0442 | 0.0428 | 0.0426 |
| 4 | 0.6897 | 0.1836 | 311.4150 | 311.6830 | 310.8780 | 0.0465 | 0.0461 | 0.0461 |
| 5 | 0.6427 | 0.2306 | 311.5990 | 311.6570 | 311.4890 | 0.0472 | 0.0471 | 0.0471 |
| 6 | 0.5958 | 0.2775 | 311.6140 | 311.6550 | 311.5380 | 0.0472 | 0.0472 | 0.0472 |
| 7 | 0.5488 | 0.3245 | 311.6120 | 311.6550 | 311.5320 | 0.0473 | 0.0472 | 0.0472 |
| 8 | 0.5018 | 0.3715 | 311.5800 | 311.6600 | 311.4330 | 0.0472 | 0.0471 | 0.0471 |
| 9 | 0.4548 | 0.4184 | 311.4670 | 311.6770 | 311.0810 | 0.0469 | 0.0466 | 0.0466 |

Table 6. Data of the specimen of *Panthera leo* ZPB_PL_002. Average data of temperature (Temp.) in Kelvin units and absolute humidity (Humid.) in $Kg/m^3$ units variables in the three simulated scenarios, at 28 ºC or 301.15 K (temperate biome) with a RH of 60%; at 40 ºC or 313.15 K (desert biome) with a RH of 05%; and at 5 ºC or 278.18 K (arctic or high mountain biome) with a RH of 10%. In addition, there is a standardization of the cut coordinates (distance) so that they are homologous and equidistant by subtracting the first coordinate value a from all the coordinate values.

| Study Slices | xCoord | Distance | Temp. 28 | Temp. 40 | Temp. 5 | Humid. 60 | Humid. 05 | Humid. 10 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.8733 | 0.0000 | 301.1500 | 313.1500 | 278.1500 | 0.0163 | 0.0026 | 0.0007 |
| 2 | 0.7836 | 0.0897 | 308.8670 | 312.0450 | 302.6470 | 0.0385 | 0.0346 | 0.0340 |
| 3 | 0.7367 | 0.1366 | 310.8770 | 311.7590 | 309.1210 | 0.0447 | 0.0436 | 0.0434 |
| 4 | 0.6897 | 0.1836 | 311.4680 | 311.6760 | 311.0500 | 0.0467 | 0.0464 | 0.0463 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | 0.6427 | 0.2306 | 311.6170 | 311.6550 | 311.5470 | 0.0472 | 0.0472 | 0.0472 |
| 6 | 0.5958 | 0.2775 | 311.5100 | 311.6700 | 311.2170 | 0.0469 | 0.0467 | 0.0467 |
| 7 | 0.5488 | 0.3245 | 311.6420 | 311.6510 | 311.6250 | 0.0473 | 0.0473 | 0.0473 |
| 8 | 0.5018 | 0.3715 | 311.6010 | 311.6570 | 311.4990 | 0.0472 | 0.0472 | 0.0472 |
| 9 | 0.4548 | 0.4184 | 311.4350 | 311.6810 | 310.9860 | 0.0468 | 0.0465 | 0.0465 |

Table 7. Data from the obstructed *Panthera leo* specimen ZPB_PL_002. Average data of temperature (Temp.) in Kelvin units and absolute humidity (Humid.) in $Kg/m^3$ units variables in the three simulated scenarios, at 28 ºC or 301.15 K (temperate biome) with a RH of 60%; at 40 ºC or 313.15 K (desert biome) with a RH of 05%; and at 5 ºC or 278.18 K (arctic or high mountain biome) with a RH of 10%. In addition, there is a standardization of the cut coordinates (distance) so that they are homologous and equidistant by subtracting the first coordinate value a from all the coordinate values.

| Study Slices | xCoord | Distance | Temp. 28 | Temp. 40 | Temp. 5 | Humid. 60 | Humid. 05 | Humid. 10 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.8733 | 0.0000 | 301.1490 | 313.1500 | 278.1500 | 0.0163 | 0.0026 | 0.0007 |
| 2 | 0.7836 | 0.0897 | 304.4240 | 312.6830 | 288.5680 | 0.0386 | 0.0159 | 0.0147 |
| 3 | 0.7367 | 0.1366 | 309.7990 | 311.9080 | 305.7220 | 0.0447 | 0.0390 | 0.0385 |
| 4 | 0.6897 | 0.1836 | 311.2200 | 311.7100 | 310.2300 | 0.0467 | 0.0452 | 0.0450 |
| 5 | 0.6427 | 0.2306 | 311.6100 | 311.6560 | 311.5170 | 0.0473 | 0.0472 | 0.0472 |
| 6 | 0.5958 | 0.2775 | 311.5020 | 311.6700 | 311.2140 | 0.0469 | 0.0468 | 0.0467 |
| 7 | 0.5488 | 0.3245 | 311.6420 | 311.6510 | 311.6260 | 0.0473 | 0.0473 | 0.0473 |
| 8 | 0.5018 | 0.3715 | 311.6010 | 311.6570 | 311.4990 | 0.0472 | 0.0472 | 0.0472 |
| 9 | 0.4548 | 0.4184 | 311.4300 | 311.6810 | 310.9860 | 0.0468 | 0.0465 | 0.0465 |

Table 8. Data from the operaded *Panthera leo* specimen ZPB_PL_002. Average data of temperature (Temp.) in Kelvin units and absolute humidity (Humid.) in $Kg/m^3$ units variables in the three simulated scenarios, at 28 ºCor 301.15 K (temperate biome) with a RH of 60%; at 40 ºCor 313.15 K (desert biome) with a RH of 05%; and at 5 ºCor 278.18 K (arctic or high mountain biome) with a RH of 10%. In addition, there is a standardization of the cut coordinates (distance) so that they are homologous and equidistant by subtracting the first coordinate value a from all the coordinate values.

| Study Slices | xCoord | Distance | Temp. 28 | Temp. 40 | Temp. 5 | Humid. 60 | Humid. 05 | Humid. 10 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.8733 | 0.0000 | 301.1500 | 313.1500 | 278.1500 | 0.0163 | 0.0026 | 0.0007 |
| 2 | 0.7836 | 0.0897 | 308.1780 | 312.1440 | 300.4570 | 0.0365 | 0.0317 | 0.0310 |
| 3 | 0.7367 | 0.1366 | 310.7670 | 311.7750 | 308.7670 | 0.0444 | 0.0431 | 0.0429 |
| 4 | 0.6897 | 0.1836 | 311.4430 | 311.6790 | 310.9650 | 0.0466 | 0.0463 | 0.0462 |
| 5 | 0.6427 | 0.2306 | 311.6170 | 311.6550 | 311.5450 | 0.0473 | 0.0472 | 0.0472 |
| 6 | 0.5958 | 0.2775 | 311.5070 | 311.6700 | 311.2070 | 0.0469 | 0.0467 | 0.0467 |
| 7 | 0.5488 | 0.3245 | 311.6400 | 311.6510 | 311.6190 | 0.0473 | 0.0473 | 0.0473 |
| 8 | 0.5018 | 0.3715 | 311.6000 | 311.6570 | 311.4950 | 0.0472 | 0.0472 | 0.0472 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | 0.4548 | 0.4184 | 311.4320 | 311.6820 | 310.9740 | 0.0468 | 0.0465 | 0.0465 |

## 2. Statistical analysis

Table 1S. Wilcoxon test for related samples, Case 01 original (within obstruction) Vs Case 01 Operated (Without obstruction). The significance level exceeds (α: 0,05), so the differences between the original and the operated obstructed situation are statistically significant with a p-value: 0.186, using the Monte Carlo bootstrapping method for small samples.

| Case 01: Original-Operated |
|---|
| N: 9 |
| Mean: -0,18166 Mean: -0,16996 |
| Median: -0,0132 Median: -0,0122 |
| |
| t test |
| Mean difference: 0,0117 95% conf.: (-0,0067081 0,030108) |
| t : -1,4657 p (same mean): 0,18091 |
| Exact: p (same mean): 0,125 |
| Sign test |
| r: 4 p (same median): 0,375 |
| |
| Wilcoxon test: |
| W: 13 |
| Normal appr. z : 1,4832 p (same median): 0,13801 |
| Monte Carlo (n=99999): p (same median): 0,18603 |
| Exact: p (same median): 0,1875 |

Figure 1S. Violin and box plot between Case 01 Original and Case 01 Operated. On the Cartesian Y axis, standardization of temperature and humidity data (θ) obtained from the 3 simulations (28ºC at 60%; 40ºC at 05%; 05ºC at 10%) applying the method described in the work of Burgos, 2014.

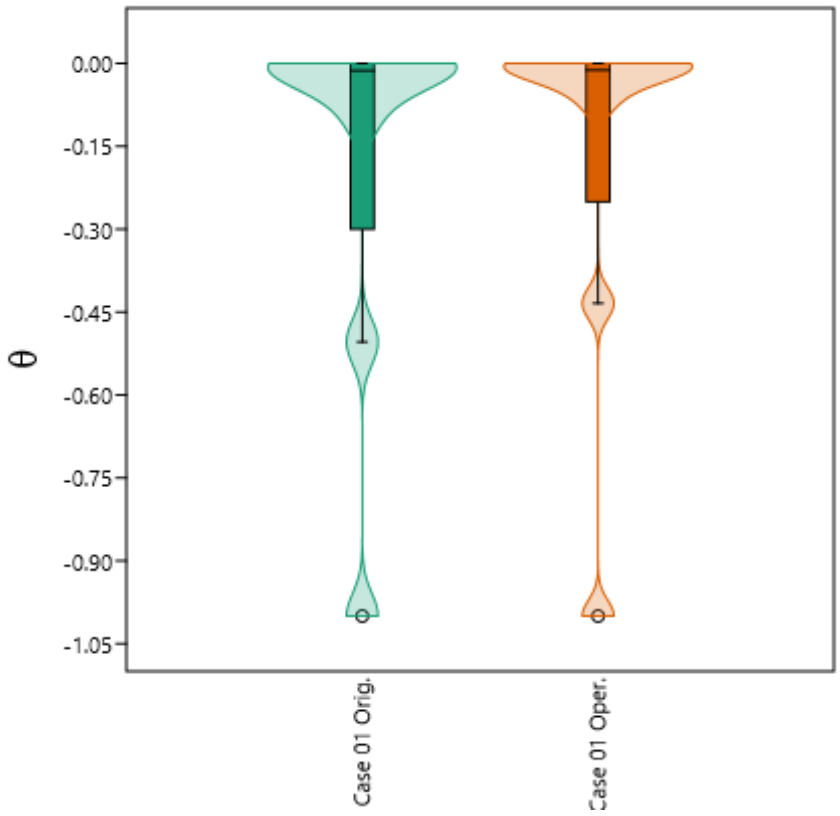


Table 2S. OLS regression between Case 2 and Case 3. Linear regression applied to the average data (θ) for both temperature and humidity obtained by applying Burgos, 2014. A). Original Case in both Case 2 and Case 3. The statistical data indicate a slope of 0.99 and a Pearson correlation coefficient r=0.99. (See Figure 2SA).

| Ordinary Least Squares Regression: Case 02-Case 03 Orig. |
|---|
| |
| Slope a: 0,99818 Std. error a: 0,0078371 |
| t: 127,37 p (slope): 4,8507E-13 |
| Intercept b: 0,0014061 Std. error b: 0,002711 |
| |
| 95% bootstrapped confidence intervals (N=1999): |
| Slope a: (0,93331, 1,1717) |
| Intercept b: (-0,0033393, 0,0063274) |
| |
| Correlation: |
| r: 0,99978 |
| r2: 0,99957 |
| t: 127,37 |
| p (uncorr.): 4,8507E-13 |
| Permutation p: 0,0001 |

Table 3S. OLS regression between Case 2 and Case 3. Linear regression applied to the average data (θ) for both temperature and humidity obtained by applying Burgos, 2014. B). Operated Case in both Case 2 and Case 3. The statistical data indicate a slope of 0.99 and a Pearson correlation coefficient r=0.99. (See Figure 2SB).

| Ordinary Least Squares Regression: Case 02 -Case 03 Oper. |
|---|
| |
| Slope a: 0,99724 Std. error a: 0,007756 |
| t: 128,58 p (slope): 4,5401E-13 |
| Intercept b: 0,0012463 Std. error b: 0,0027336 |
| |
| 95% bootstrapped confidence intervals (N=1999): |
| Slope a: (0,92551, 1,0517) |
| Intercept b: (-0,003588, 0,0058646) |
| |
| Correlation: |
| r: 0,99979 |
| r2: 0,99958 |
| t: 128,58 |
| p (uncorr.): 4,5401E-13 |
| Permutation p: 0,0001 |

Figure 2S. OLS regression between Case 2 and Case 3 plots. Linear regression applied to the average data (θ) for both temperature and humidity obtained by applying Burgos, 2014. A). Original Case in both Case 2 and Case 3. The statistical data indicate a slope of 0.99 and a correlation of 0.999 (both r and $r^2$), see Table 2S; B). Operated Case in both Case 2 and Case 3. The statistical data indicate a slope of 0.99 and a correlation of 0.999 (both r and $r^2$), see Table 3S.

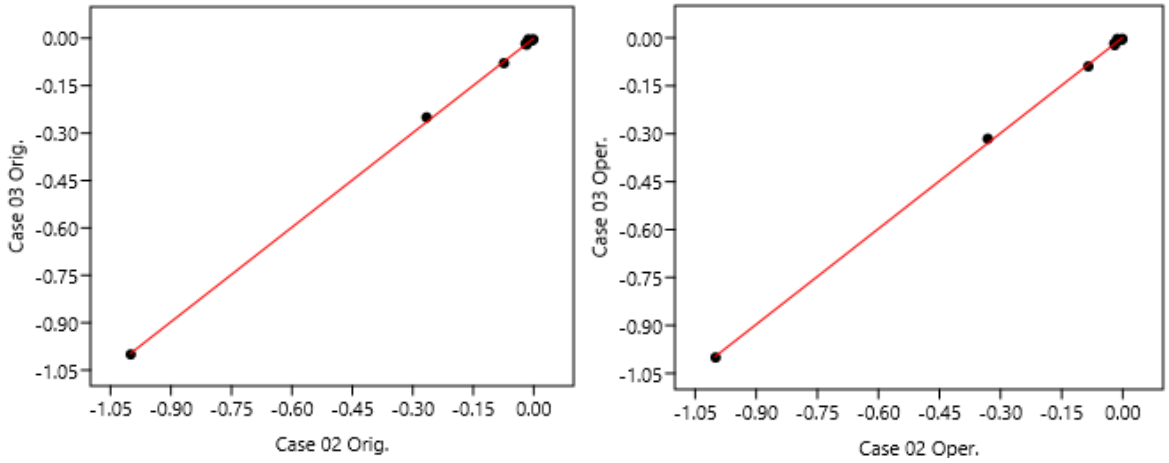


Figure 3S. Violin and box plots comparing Case 02 and 03. It has a very similar data dispersion and based on the statistical data of the linear regression applying OLS, a higher similarity is observed.

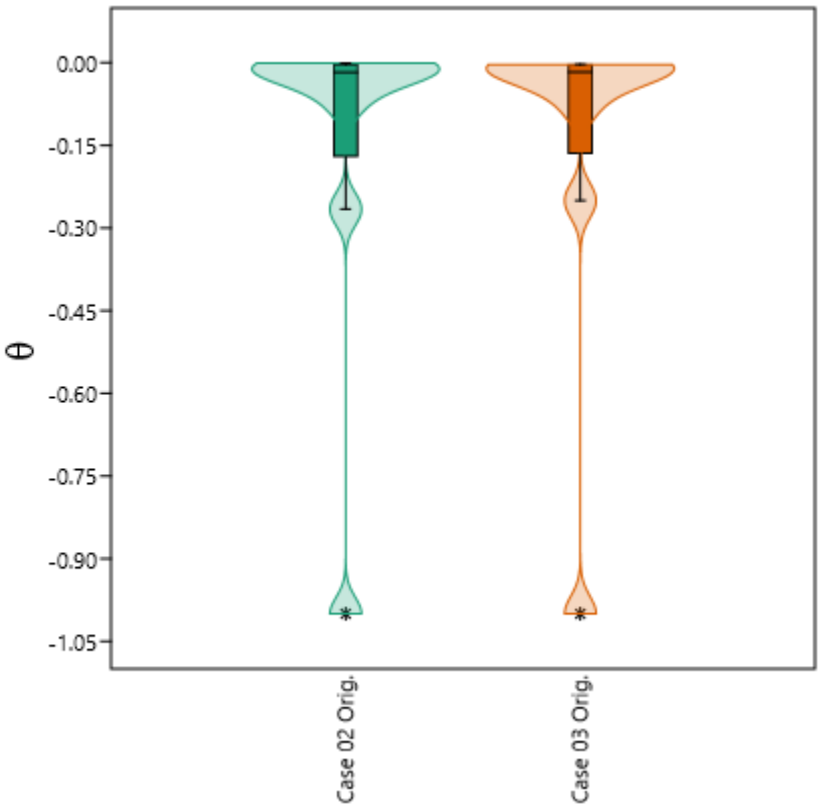


Table 4S. Wilcoxon test for Case 02 original Vs Case 02 Operated (Without obstruction). The significance level is less than (α: 0,05), so the differences between the original and the operated situation are not statistically significant with a p-value of 0.015, using the Monte Carlo bootstrapping method for small samples. This indicates that the operation has been close to 100% successful.

| Case 02 Original-Operated |
|---|
| N: 9 |
| Mean: -0,15546 Mean: -0,16429 |
| Median: -0,0175 Median: -0,0198 |
| |
| t test |
| Mean difference: 0,0088333 95% conf.: (-0,0077691 0,025436) |
| t : 1,2269 p (same mean): 0,25474 |
| Exact: p (same mean): 0 |
| |
| Wilcoxon test: |
| W: 28 |
| Normal appr. z: 2,3664 p (same median): 0,01796 |
| Monte Carlo (n=99999): p (same median): 0,01567 |
| Exact: p (same median): 0,015625 |

Figure 4S. Violin and box plots comparing Cases 02: original, obstructed and operated. The obstructed Case 02 has a higher data dispersion due to the correct functional loss of airflow acclimatization. The operated Case 02 has a very similar data dispersion to the original Case 02, based on Table 4S, they are statistically equal. The operation corrects almost 100% of the millimeter scale induced obstruction.

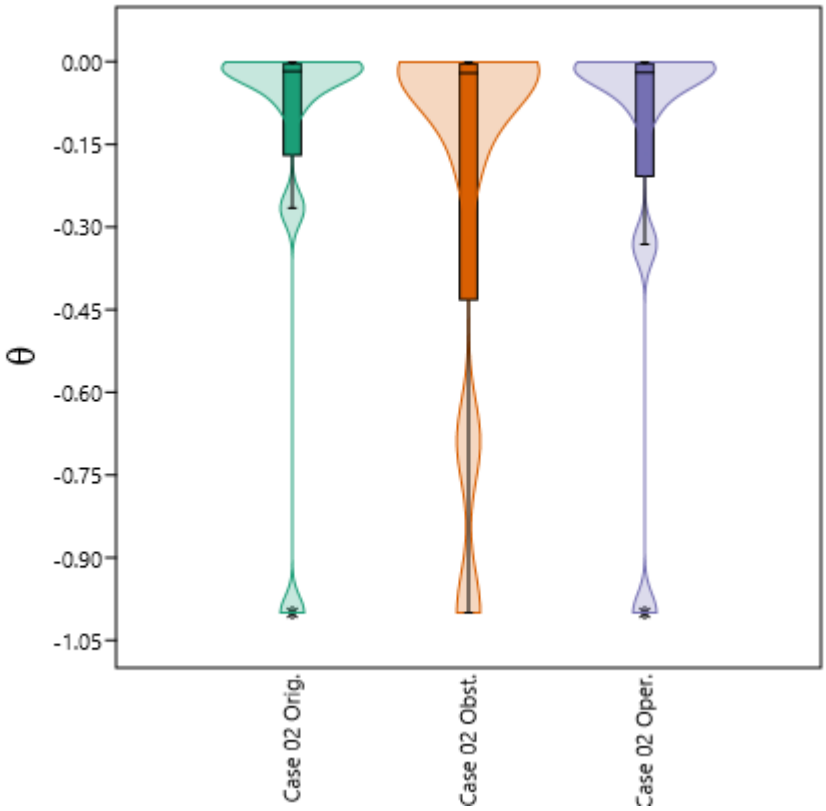


Table 5S. Wilcoxon test for Case 03 original Vs Case 03 Operated (Without obstruction). The significance level is less than (α: 0,05), so the differences between the original and the operated situation are not statistically significant with a p-value of 0.015, using the Monte Carlo bootstrapping method for small samples. This indicates that the operation has been close to 100% successful.

| Case 03 Original-Operated |
|---|
| N: 9 |
| Mean: -0,15377 Mean: -0,16259 |
| Median: -0,017 Median: -0,0175 |
| |
| t test |
| Mean difference: 0,0088222 95% conf.: (-0,0077549 0,025399) |
| t: 1,2272 p (same mean): 0,25462 |
| Exact: p (same mean): 0 |

| |
|---|
| Wilcoxon test: |
| W: 28 |
| Normal appr. z: 2,3707 p (same median): 0,017756 |
| Monte Carlo (n=99999): p (same median): 0,01522 |
| Exact: p (same median): 0,015625 |

Figure 5S. Violin and box plots comparing Case 03: original, obstructed and operated. The obstructed Case 03 has a higher data dispersion due to the correct functional loss of airflow acclimatization. The operated Case 03 has a very similar data dispersion to the original Case 03, based on Table 5S, they are statistically equal. The operation corrects almost 100% of the millimeter scale induced obstruction.