

Morphometric analysis of atlas and axis vertebrae in humans of Indian origin

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Abstract

Objective: In this study, forty dried specimens of atlas and axis vertebrae were examined using direct anatomical measurements.

Methods: Various dimensions of the atlas and the axis vertebrae were quantitatively measured, with special emphasis on their relationship with the vertebral artery foramen.

Results: As the vertebral artery foramen was present entirely in the transverse process of all specimens, screw implantation in the facet of atlas proved relatively safe.

Conclusions: The anatomy of the atlas and axis vertebrae exhibits complex, three-dimensional structures, showing extensive variability in morphology. Characteristics of the atlas and axis vertebrae must be noted before any spinal operation such as transpedicular screw fixation, transarticular screw fixation, screw fixation of dens axis, interspinous wiring, and interlaminar clamp.

Keywords: anatomy, atlas, axis, vertebral artery

Introduction

Among other cervical vertebrae first and second cervical vertebrae, namely the atlas (C1) and the axis (C2), have peculiar anatomical features [1]. Various surgical techniques which are now a days done for crre the instability of the atlantoaxial complex or occipito-cervical junction which are caused by numerous traumatic and non-traumatic conditions. These include interlaminar clamp, interspinous wiring, plate and screw fixation [2]. Recently, trans-articular and transpedicular screws fixation have been widely used for stabilization of the cervical column [3]. Controversy still exists regarding its potential risks despite the benefits conferred by transpedicular screw fixation in the cervical column [4]. Damage to adjacent vital structures such as the spinal cord, nerve roots, cranial nerves, and vertebral arteries can be caused by incorrect insertion of pedicle screws [5, 6]. Clinically, during an approach to the atlantoaxial region is rare iatrogenic injury to the vertebral artery but has a potential hazard [7, 8]. Few reports are in literature on the quantitative anatomy of the atlas and axis in literature [9, 10].

Aims and objectives

This study is done evaluate the various dimensions of the first two vertebrae quantitatively and to analyse their relationship with vertebral artery foramen in determining the safe sites for different surgical approaches. The aim of this study is to examine sex differentiation based on quantitative parameters i.e. surface geometry of atlas and axis.

Materials and Methods

Twenty-four human C1 and C2 vertebrae, twelve of male and twelve of female in the Department of Anatomy, AIIMS Bhubaneswar were examined. All samples were inspected to ensure that the vertebrae were intact and free from osteophytes or metastatic tumours before measurements were

made and any bone malformations were discarded. All parameters for C1 and C2 were measured using Digital Vernier Calliper accurate to 0.1 mm for linear measurements. The data were evaluated by descriptive statistics and paired sample test using the Graph Pad Prism 7 statistics program. Mean \pm Standard Deviation (SD), Median and Standard Error of Mean (SEM) of each individual parameter in Atlas and Axis vertebrae in both males and females were analysed. Statistically significance was accepted at probability values of less than 0.005.

- In case of Atlas Vertebrae following parameters were measured:
 1. Distance between both tip of transverse process,
 2. Outer distance of vertebral artery foramen,
 3. Inner distance of vertebral artery foramen,
 4. Outer distance of vertebral artery groove,
 5. Inner distance of vertebral artery groove,
 6. Maximum transverse diameter of vertebral canal,
 7. Maximum Antero-posterior diameter of vertebral canal,
 8. Minimum Antero-posterior diameter of vertebral canal,
 9. Length of superior articular facet,
 10. Width of superior articular facet,
 11. Length of inferior articular facet,
 12. Width of inferior articular facet.
- In case of Axis Vertebrae following parameters were measured:
 1. Width of dens axis,
 2. Height of dens axis,
 3. Height of anterior corpus axis,
 4. Distance of superior articular facet,
 5. Distance of transverse process,
 6. Length of inferior articular facet,
 7. Width of inferior articular facets,
 8. Length of superior articular facet,
 9. Width of superior articular facet.

Results

1. Distance between both tips of transverse process of atlas

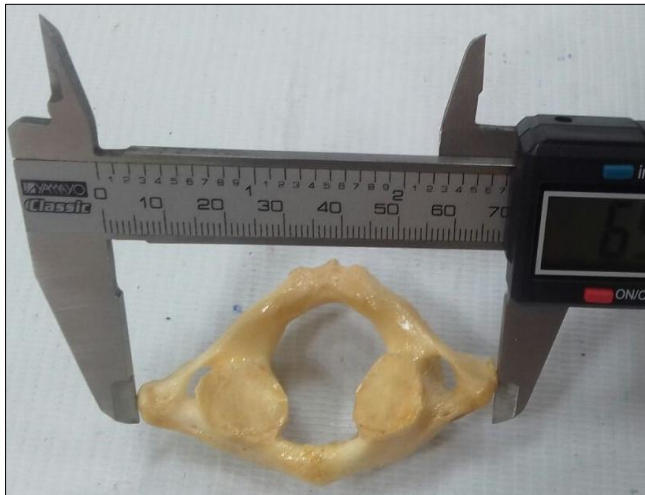


Fig 1

Table 1

	Group A	Group B
Col. title	Males	Females
Mean	71.3675	68.7491666667
Standard deviation (SD)	3.879	7.183
Sample size (N)	12	12
Std. error of mean(SEM)	1.120	2.074
Lower 95% conf. limit	68.903	64.185
Upper 95% conf. limit	73.832	73.313
Minimum	64.590	59.270
Median (50th percentile)	71.745	66.675
Maximum	77.630	82.360
Normality test KS	0.1751	0.1692
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.2786, considered not significant. t = 1.111 with 7:2 degrees of freedom.

95% confidence interval

Mean difference = -2.618 (Mean of Females minus mean of Males) The 95% confidence interval of the difference: -7.506 to Z.Z69

Assumption test: Are the standard deviations equal?

The t test assumes that the columns come from populations with equal SDs.

The following calculations test that assumption.

F-3, 429

The F value is 0.0523.

F = The P value is 0.05:3. This test suggests that the difference between the two SDs is not quite significant.

2. Outer Distance of Vertebral Artery Foramen of Atlas.



Fig 2

Table 2

	Group A	Group B
Col. title	Males	Females
Mean	54.8925	53.7883333333
Standard deviation (SD)	3.881	5.802
Sample size (N)	12	12
Std. error of mean(SEM)	1.120	1.675
Lower 95% conf. limit	52.427	50.102
Upper 95% conf. limit	57.358	57.475
Minimum	49.290	47.640
Median (50th percentile)	54.830	51.970
Maximum	61.100	65.160
Normality test KS	0.1940	0.1719
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.5892, considered not significant. t = 0.5480 with 22 degrees of freedom.

95% confidence interval

Mean difference = -1.104 (Mean of Females minus mean of Males) The 95% confidence interval of the difference: -5.283 to 3.075

Assumption test: Are the standard deviations equal?

The t test assumes that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 2.235

The P value is 0.1979.

This test suggests that the difference between the two SDs is not significant.

3. Inner Distance of Vertebral Artery Foramen of Atlas.



Fig 3

Table 3

	Group A	Group B
Col. title	Males	Females
Mean	43.515	42.6916666667
Standard deviation (SD)	3.318	4.925
Sample size (N)	12	12
Std. error of mean(SEM)	0.9577	1.422
Lower 95% conf. limit	41.407	39.563
Upper 95% conf. limit	45.623	45.821
Minimum	38.390	37.790
Median (50th percentile)	42.710	41.445
Maximum	48.960	51.880
Normality test KS	0.2170	0.1821
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.6357, considered not significant. t = 0.4803 with 22 degrees of freedom.

95% confidence interval

Mean difference = -0.8233 (Mean of Females minus mean of Males) The 95% confidence interval of the difference: -4.378 to 2.731

Assumption test: Are the standard deviations equal?

The t test assumes that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 2.203

The P value is 0.2059.

This test suggests that the difference between the two SDs is not significant.

4. Outer Distance of Vertebral Artery Groove of Atlas.



Fig 4

Table 4

	Group A	Group B
Col. title	male	Female
Mean	20.625	20.5925
Standard deviation (SD)	3.187	2.725
Sample size (N)	12	12
Std. error of mean(SEM)	0.9199	0.7866
Lower 95% conf. limit	18.600	18.861
Upper 95% conf. limit	22.650	22.324
Minimum	17.810	17.450
Median (50th percentile)	20.060	19.920
Maximum	29.490	25.490
Normality test KS	0.2556	0.1637
Normality test P value	0.0293	>0.10
Passed normality test?	No	Yes

P value

The two-tailed P value is 0.9788, considered not significant. Welch correction applied. This test does not assume equal variances.

Welch's approximate t = 0.02685 with 21 degrees of freedom.

95% confidence interval

Mean difference = -0.03250 (Mean of Female minus mean of male) The 95% confidence interval of the difference: -2.550 to 2.485

5. Inner Distance of Vertebral Artery Groove of Atlas.



Fig 5

Table 5

	Group A	Group B
Col. title	Males	Females
Mean	12.0091666667	12.4841666667
Standard deviation (SD)	1.681	1.773
Sample size (N)	12	12
Std. error of mean(SEM)	0.4854	0.5118
Lower 95% conf. limit	10.941	11.358
Upper 95% conf. limit	13.077	13.611
Minimum	9.670	10.670
Median (50th percentile)	12.110	12.155
Maximum	15.090	16.380
Normality test KS	0.1256	0.1559
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.5077, considered not significant. t = 0.6734 with 22 degrees of freedom.

95% confidence interval

Mean difference = 0.4750 (Mean of Females minus mean of Males) The 95% confidence interval of the difference: -0.9378 to 1.938

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 1.112

The P value is 0.8635.

This test *suggests* that the difference between the *two* SDs is not significant.

6. Maximum Transverse Diameter of the Vertebral Canal of Atlas.



Fig 6

Table 6

	Group A	Group B
Col. title	m laes	Females
Mean	26.1991666667	26.0275
Standard deviation (SD)	1.824	2.094
Sample size (N)	12	12
Std. error of mean(SEM)	0.5265	0.6045
Lower 95% conf. limit	25.040	24.697
Upper 95% conf. limit	27.358	27.358
Minimum	23.180	23.240
Median (50th percentile)	26.475	25.425
Maximum	29.620	30.570
Normality test KS	0.1455	0.2494
Normality test P value	>0.10	0.0378
Passed normality test?	Yes	No

P value

The two-tailed P value is 0.8324, considered not significant. t = 0.2142 with 22 degrees of freedom.

95% confidence: nte=a1

Mean difference = -0.1717 (Mean of Females minus mean of m laes) The 95% confidence interval of the difference: -1.834 to 1.491

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 1.318

The P value is 0.6546.

This test *suggests* that the difference between the *two* SDs is not significant.

7. Maximum Antero-Posterior Diameter of the Vertebral Canal of Atlas.



Fig 7

Table 7

	Group A	Group B
Col. title	Males	Females
Mean	30.9241666667	29.7916666667
Standard deviation (SD)	2.155	2.355
Sample size (N)	12	12
Std. error of mean(SEM)	0.6220	0.6797
Lower 95% conf. limit	29.555	28.296
Upper 95% conf. limit	32.293	31.288
Minimum	27.520	26.570
Median (50th percentile)	30.920	29.270
Maximum	34.840	33.460
Normality test KS	0.1680	0.1544
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.23:0, considered not significant. t = 1.229 with 22 degrees of freedom.

95% confidence interval

Mean difference = -1.133 (Mean of Females minus mean of Males) The 95% confidence interval of the difference: -3.043 to 0.7782

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 1.194

The P value is 0.7735.

This test *suggests* that the difference between the two SDs is not significant.

8. Minimum Antero-Posterior Diameter of the Vertebral Canal of Atlas.



Fig 8

Table 8

	Group A	Group B
Col. title	Males	Females
Mean	28.5491666667	27.8033333333
Standard deviation (SD)	1.991	2.733
Sample size (N)	12	12
Std. error of mean(SEM)	0.5748	0.7890
Lower 95% conf. limit	27.284	26.067
Upper 95% conf. limit	29.814	29.540
Minimum	25.970	23.180
Median (50th percentile)	28.190	27.545
Maximum	32.830	32.310
Normality test KS	0.1979	0.1039
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.452:9, considered not significant. t = 0.7641 with 22 degrees of freedom.

95% confidence interval

Mean difference = -0.7458 (Mean of Females minus mean of Males) The 95% confidence interval of the difference: -2.770 to 1.278

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 1.884

The P value is 0.3084.

This test *suggests* that the difference between the two SDs is not significant.

9. Length of Superior Articular Facets of Atlas.



Fig 9

Table 9

	Group A	Group B
Col. title	Males	females
Mean	17.1358333333	16.9183333333
Standard deviation (SD)	1.973	1.823
Sample size (N)	12	12
Std. error of mean(SEM)	0.5695	0.5262
Lower 95% conf. limit	15.882	15.760
Upper 95% conf. limit	18.389	18.077
Minimum	13.510	14.220
Median (50th percentile)	17.225	16.750
Maximum	20.660	20.680
Normality test KS	0.1574	0.1080
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.7817, considered not significant. t = 0.2805 with 22 degrees of freedom.

95% confidence interval

Mean difference = -0.2175 (Mean of females minus mean of Males) The 95% confidence interval of the difference: -1.826 to 1.391

Assumption test: Are the standard deviations equal?

The t test assumes that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 1.171

The P value is 0.7981.

This test suggests that the difference between the two SDs is not significant.

10. Width of Superior Articular Facets of Atlas.



Fig 10

Table 10

	Group A	Group B
Col. title	Males	Females
Mean	14.4341666667	14.2533333333
Standard deviation (SD)	0.9077	1.493
Sample size (N)	12	12
Std. error of mean(SEM)	0.2620	0.4311
Lower 95% conf. limit	13.857	13.305
Upper 95% conf. limit	15.011	15.202
Minimum	12.800	10.900
Median (50th percentile)	14.475	14.290
Maximum	15.850	16.720
Normality test KS	0.1856	0.1417
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.7234, considered not significant. t = 0.3585 with 22 degrees of freedom.

95% confidence interval

Mean difference = -0.1808 (Mean of Females minus mean of Males) The 95% confidence interval of the difference: -1.227 to 0.8653

Assumption test: Are the standard deviations equal?

The t test assumes that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 2.706

The P value is 0.1134.

This test suggests that the difference between the two SDs is not significant.

11. Length of Inferior Articular Facets of Atlas.



Fig 11

Table 11

	Group A	Group B
Col. title	Males	Females
Mean	17.1358333333	16.9183333333
Standard deviation (SD)	1.973	1.823
Sample size (N)	12	12
Std. error of mean(SEM)	0.5695	0.5262
Lower 95% conf. limit	15.882	15.760
Upper 95% conf. limit	18.389	18.077
Minimum	13.510	14.220
Median (50th percentile)	17.225	16.750
Maximum	20.660	20.680
Normality test KS	0.1574	0.1080
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.7817, considered not significant. t = 0.2.805 with 2: degrees of freedom.

95% confidence interval

Mean difference = -0.:175 (Mean of Females minus mean of Males) The 95% confidence interval of the difference: -1.8:6 to 1.391

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 1.171

The P value is 0.7981.

This test *suggests* that the difference between the two SDs is not significant.

12. Width of Inferior Articular Facets of Atlas.



Fig 12

Table 12

	Group A	Group B
Col. title		
Mean	14.4341666667	14.2533333333
Standard deviation (SD)	0.9077	1.493
Sample size (N)	12	12
Std. error of mean(SEM)	0.2620	0.4311
Lower 95% conf. limit	13.857	13.305
Upper 95% conf. limit	15.011	15.202
Minimum	12.800	10.900
Median (50th percentile)	14.475	14.290
Maximum	15.850	16.720
Normality test KS	0.1856	0.1417
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.7234, considered not significant. t = 0.3585 with 22 degrees of freedom.

95% confidence interval

Mean difference = -0.1808 (Mean of Column B minus mean of Column A) The 95% confidence interval of the difference: -1.227 to 0.8653

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 2.706

The P value is 0.1134.

This test *suggests* that the difference between the two SDs is not significant.

13. Width of Dens of Axis.



Fig 13

Table 13

	Group A	Group B
Col. title	MALES	FEMALES
Mean	9.1916666667	9.2408333333
Standard deviation (SD)	0.7383	0.7967
Sample size (N)	12	12
Std. error of mean(SEM)	0.2131	0.2300
Lower 95% conf. limit	8.723	8.735
Upper 95% conf. limit	9.661	9.747
Minimum	7.840	7.700
Median (50th percentile)	8.955	9.190
Maximum	10.370	10.220
Normality test KS	0.1753	0.1329
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.8768, considered not significant. t 0.1568 with 22 degrees of freedom.

95% confidence interval

Mean difference 0.04917 (Mean of immaxes minus mean of MALES) The 95% confidence interval of the difference: - 0.6011 to 0.6994

Assumption test: Are the standard deviations equal?

The ttest assumes that the columns come from populations with equal *SOB*. The following calculations test that assumption.

1.164

The P value is 0.8051.

This test suggests that the difference between the two SDa is not significant.

14. Height of Dens of Axis.



Fig 14

Table 14

Col. title	MALES	FEMALES
Mean	16.6558333333	16.7575
Standard deviation (SD)	1.460	1.863
Sample size (N)	12	12
Std. error of mean(SEM)	0.4215	0.5377
Lower 95% conf. limit	15.728	15.574
Upper 95% conf. limit	17.584	17.941
Minimum	14.470	13.890
Median (50th percentile)	16.670	16.610
Maximum	18.680	19.980
Normality test KS	0.1397	0.1131
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.8831, considered not significant. t = 0.1488 with 22 degrees of freedom.

95% confidence interval

Mean difference = 0.1017 (Mean of FEMALES minus mean of MALES) The 95% confidence interval of the difference: - 1.315 to 1.518

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal *SDs*. The following calculations test that assumption.

F = 1.627

The P value is 0.4322.

This test *suggests* that the difference between the two *SDs* is not significant.

15. Height of Anterior Corpus Axis.



Fig 15

Table 15

Col. title	MALES	FEMALES
Mean	20.5008333333	20.2891666667
Standard deviation (SD)	1.348	1.583
Sample size (N)	12	12
Std. error of mean(SEM)	0.3890	0.4569
Lower 95% conf. limit	19.645	19.284
Upper 95% conf. limit	21.357	21.295
Minimum	19.030	18.330
Median (50th percentile)	19.945	20.180
Maximum	22.630	23.410
Normality test KS	0.2504	0.1087
Normality test P value	0.0363	>0.10
Passed normality test?	No	Yes

P value

The two-tailed P value is 0.776, considered not significant. $t = 0.3527$ with 22 degrees of freedom.

95% confidence interval

Mean difference = -0.2117 (Mean of FEMALES minus mean of MALES) The 95% confidence interval of the difference: -1.456 to 1.033

Assumption test: Are the standard deviations equal?

The t test assumes that the columns come from populations with equal SDs. The following calculations test that assumption.

$F = 1.380$

The P value is 0.6027.

This test suggests that the difference between the two SDs is not significant.

16. Distance of Superior Articular Facet of Axis.



Fig 16

Table 16

	Group A	Group B
Col. title	MALES	FEMALES
Mean	23.1566666667	23.1608333333
Standard deviation (SD)	1.670	2.490
Sample size (N)	12	12
Std. error of mean(SEM)	0.4820	0.7188
Lower 95% conf. limit	22.096	21.579
Upper 95% conf. limit	24.217	24.743
Minimum	20.530	19.610
Median (50th percentile)	23.515	22.580
Maximum	25.580	29.270
Normality test KS	0.1762	0.1789
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.9962, considered not significant. $t = 0.004815$ with 22 degrees of freedom.

95% confidence interval

Mean difference = 0.004167 (Mean of FEMALES minus mean of MALES) The 95% confidence interval of the difference: -1.791 to 1.799

Assumption test: Are the standard deviations equal?

The t test assumes that the columns come from populations with equal SDs. The following calculations test that assumption.

$F = 2.224$

The P value is 0.2006.

This test suggests that the difference between the two SDs is not significant.

17. Distance of Transverse Process of Axis.



Fig 17

Table 17

Col. title	MALES	FEMALES
Mean	29.8008333333	29.8541666667
Standard deviation (SD)	4.068	3.424
Sample size (N)	12	12
Std. error of mean(SEM)	1.174	0.9886
Lower 95% conf. limit	27.216	27.678
Upper 95% conf. limit	32.385	32.030
Minimum	21.980	21.200
Median (50th percentile)	30.045	30.075
Maximum	36.820	34.330
Normality test KS	0.1784	0.2247
Normality test P value	>0.10	0.0957
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.9726, considered not significant. t = 0.03475 with 22 degrees of freedom.

95% confidence interval

Mean difference = 0.05333 (Mean of FEMALES minus mean of MALES) The 95% confidence interval of the difference: -3.130 to 3.237

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 1.411

The P value is 0.5777.

This test *suggests* that the difference between the two SDs is not significant.

18. Length of Inferior Articular Facets of Axis.



Fig 18

Table 18

Col. title	MALES	FEMALES
Mean	11.8925	12.5883333333
Standard deviation (SD)	0.8685	2.450
Sample size (N)	12	12
Std. error of mean(SEM)	0.2507	0.7071
Lower 95% conf. limit	11.341	11.032
Upper 95% conf. limit	12.444	14.145
Minimum	10.770	8.250
Median (50th percentile)	11.840	12.320
Maximum	13.050	17.090
Normality test KS	0.2074	0.1550
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.3638, considered not significant. c 0.9274 with 22 degrees of freedom.

95% confidence interval

Mean difference 0.6958 (Mean of FEMALES minus mean of MALES) The 95% confidence interval of the difference: -0.8601 to 2.282

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

F 7.955

The P value is 0.0018.

This test suggests that the difference between the two SDs is very significant. Since the t test assumes populations with equal SDs, you should consider transforming your data (reciprocal or log), selecting a nonparametric test, or selecting the alternate (Welch) C test.

19. Width of Inferior Articular Facets of Axis.



Fig 19

Table 19

Col. title	MALES	FEMALES
Mean	9.6566666667	9.8433333333
Standard deviation (SD)	1.483	1.279
Sample size (N)	12	12
Std. error of mean(SEM)	0.4282	0.3691
Lower 95% conf. limit	8.714	9.031
Upper 95% conf. limit	10.599	10.656
Minimum	6.730	7.470
Median (50th percentile)	10.135	10.015
Maximum	11.480	11.550
Normality test KS	0.2357	0.1712
Normality test P value	0.0642	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.7444, considered not significant. $t = 0.3302$ with 22 degrees of freedom.

95% confidence interval

Mean difference = 0.1867 (Mean of FEMALES minus mean of MALES) The 95% confidence interval of the difference: -0.9858 to 1.359

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

$F = 1.346$

The P value is 0.6308.

This test *suggests* that the difference between the two SDs is not significant.

20. Length of Superior Articular Facets.



Fig 20

Table 20

Col. title	MALES	FEMALES
Mean	17.5675	16.4458333333
Standard deviation (SD)	1.104	1.781
Sample size (N)	12	12
Std. error of mean(SEM)	0.3187	0.5142
Lower 95% conf. limit	16.866	15.314
Upper 95% conf. limit	18.269	17.578
Minimum	15.450	13.810
Median (50th percentile)	17.655	16.350
Maximum	19.080	20.290
Normality test KS	0.2236	0.1166
Normality test P value	0.0994	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.0772, considered not quite significant.

$t = 1.854$ with 22 degrees of freedom.

95% confidence interval

Mean difference = -1.122 (Mean of FEMALES minus mean of MALES) The 95% confidence interval of the difference: -2.376 to 0.1329

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

$F = 2.604$

The P value is 0.1275.

This test *suggests* that the difference between the two SDs is not significant.

21. Width of Superior Articular Facets.



Fig 21

Table 21

Col. title	MALES	FEMALES
Mean	15.565	14.8458333333
Standard deviation (SD)	1.274	1.347
Sample size (N)	12	12
Std. error of mean(SEM)	0.3677	0.3887
Lower 95% conf. limit	14.756	13.990
Upper 95% conf. limit	16.374	15.701
Minimum	13.060	12.950
Median (50th percentile)	15.775	14.365
Maximum	17.900	17.450
Normality test KS	0.1286	0.1933
Normality test P value	>0.10	>0.10
Passed normality test?	Yes	Yes

P value

The two-tailed P value is 0.19:6, considered not significant. t = 1.344 with: degrees of freedom.

coS% confidence interval

Mean difference = -0.7192 (I-lean of FEMALES minus mean of MALES) The 9S confidence interval of the difference: -1.329 to 0.3904

Assumption test: Are the standard deviations equal?

The t test *assumes* that the columns come from populations with equal SDs. The following calculations test that assumption.

F = 1.115

The P value is 0.5570.

This test *suggests* that the difference between the two SDs is not significant.

Discussion

In both males and females Mean ± Standard Deviation (SD), Median and Standard Error of Mean (SEM) of each individual parameter in Atlas and Axis vertebrae were analysed. This study aims to evaluate the various dimensions of the first and second cervical vertebrae quantitatively and analyse their relationship with the vertebral artery foramen. The rate of recognized vertebral artery injury was identified as 2% in Gupta and Goel's report [11], 4.1% in Wright and Laurysen's study [12] and 8% in Madawi *et al.* paper [13]. Our study correlated well and the two-tailed P-value was also analysed for each parameter which were not much significant in our study in respect of other earlier values reported earlier.

Conclusion

This study in addition to determining safe sites for different surgical procedures such as interlaminar clamp, interspinous wiring, plate and screw fixations to correct the instability of the atlantoaxial complex or occipito-cervical junction and trans-articular and transpedicular screws fixation in stabilizing the cervical column, caused by numerous traumatic and non-traumatic conditions as incorrect insertion of pedicle screws can cause damage to adjacent vital structures such as spinal cord, nerve roots, cranial nerves and vertebral arteries. Significance of the work lies in the fact that transverse diameter of atlas, height of dens of axis as well as antero-posterior diameter, if they are greater the gender may be categorized as male whereas if these diameters are smaller the sex may be female.

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Conflicts of interests- None

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