Original Article

Analysis of radiological measurement parameters that can predict the type of treatment to be applied in odontoid fractures: Clinical research

ABSTRACT

Introduction: Although various conservative and surgical treatment methods have been proposed, treatment options for patients with odontoid fractures remain controversial. This study was conducted to determine some demographic and radiological measurement parameters that can predict treatment options in patients with odontoid fractures.

Materials and Methods: The patients were separated into the surgery (−) group (n = 9) and the surgery (+) group (n = 10). Patient data were recorded of age, gender, type of odontoid fracture, morphological measurement results obtained from computed tomography images, treatment regimens, duration of stay in the hospital, and mortality rate. In the operating room, a halo-vest corset or Philadelphia-type cervical collar was applied to the surgery (−) patients after the reduction of the fracture under fluoroscopy. Anterior odontoid lag screw fixation was performed on surgery (+) patients.

Results: The amount of displacement of the fractured odontoid, the distance between the C1 vertebra and the odontoid process, the angle between the posterior wall of the odontoid process and the posterior wall of the clivus, the slip angle, and the anterior to posterior width of the spinal canal were not different between the groups. No difference was determined between the groups in respect of the amount of lateral displacement of the odontoid process in the spinal canal in the axial plane and the angle of the fractured odontoid process with the C2 vertebral body.

Conclusion: This preliminary study showed that the demographic data and radiological measurement parameters analyzed in the present study could not be used as predictive markers either in decision-making for treatment modality or mortality risk.

Keywords: Morphology, odontoid fracture, predictive, treatment

INTRODUCTION

In literature, Type I (<5%) odontoid fracture is defined as an oblique avulsion fracture passing through the upper part of the odontoid process at the alar ligament attachment point and is generally stable. Type II (>60%) fractures are defined as fractures that develop at the junction of the odontoid process and the axial body. Type III (30%) odontoid fracture is defined as the fracture line extending to the axial vertebral corpus and does not include the dens.[1-4] It has been suggested in the literature that a separation of >3 mm between the posterior wall of the C1 anterior arch and the anterior wall of the dens could be a sign of possible instability related to disruption or rupture of the transverse ligament.[5] Computed tomography (CT) effectively shows the fracture line and the degree of fragmentation.[6] Magnetic resonance (MR) can be useful in demonstrating transverse ligament integrity,

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but its effectiveness is limited and is not generally advised in neurologically intact patients.[7] Although conservative treatment is preferred for some fracture types (especially Type I and Type III) and surgical intervention is generally recommended, especially for Type II fractures through an anterior or posterior approach, the assessment and treatment of these patients remains a controversial issue.[8-10]

This study was conducted to determine some radiological measurement parameters that can predict conservative or surgical treatment options in patients with odontoid fractures.

MATERIALS AND METHODS

This research was approved by the Institutional Review Board of the institution to which the authors are affiliated.

Patients

This study included patients with odontoid fractures diagnosed between 2014 and 2021.

The patients were first divided into two groups as follows:

- Surgery (−) (Patients who were followed up conservatively, $n = 9$)
- Surgery (+) (Patients who underwent anterior odontoid screw fixation, $n = 10$).

Then, the patients were divided into two groups according to gender as follows:

- Female group ($n = 9$)
- Male group ($n = 10$).

The patients were divided into two groups according to the odontoid fracture type as follows:

- Type II (Patients who had type II odontoid fracture, $n = 11$)
- Type III (Patients who had type III odontoid fracture, $n = 5$).

Patients were excluded from the study if they had multiple low-segment vertebrae fractures, severe head trauma, severe internal organ injuries, pathological vertebrae fracture due to primary or metastatic tumors, or were not able to be followed up.

Materials

Patient data were recorded of age, gender, type of odontoid fracture, morphological measurement results obtained from the preoperative CT images, treatment regimens, duration of stay in the hospital, and mortality rate.

Radiological evaluation

All morphological measurements described below were performed on the sagittal and coronal reconstructed and axial CT images obtained at the time of admission to the hospital by a radiologist blinded to the data.

- TL-OD (R): The distance between the right process to which the transverse ligament attaches and the line passing through the midline of the dense axis [Figure 1a]
- TL-OD (L): The distance between the left process to which the transverse ligament attaches and the line passing through the midline of the dense axis [Figure 1a]
- C1 (A)-OD: The distance between the posterior border of the anterior arch of the C1 vertebra and the anterior border of the odontoid process [Figure 1b][4]
- C1 (P)-OD: The distance between the posterior border of the odontoid process and the anterior border of the posterior arch of the C1 vertebra [Figure 1b][4]
- C1 (P)-OFP: The distance between the posterior lower end of the odontoid fracture line and the anterior midpoint of the posterior arch of the C1 vertebra [Figure 1c]

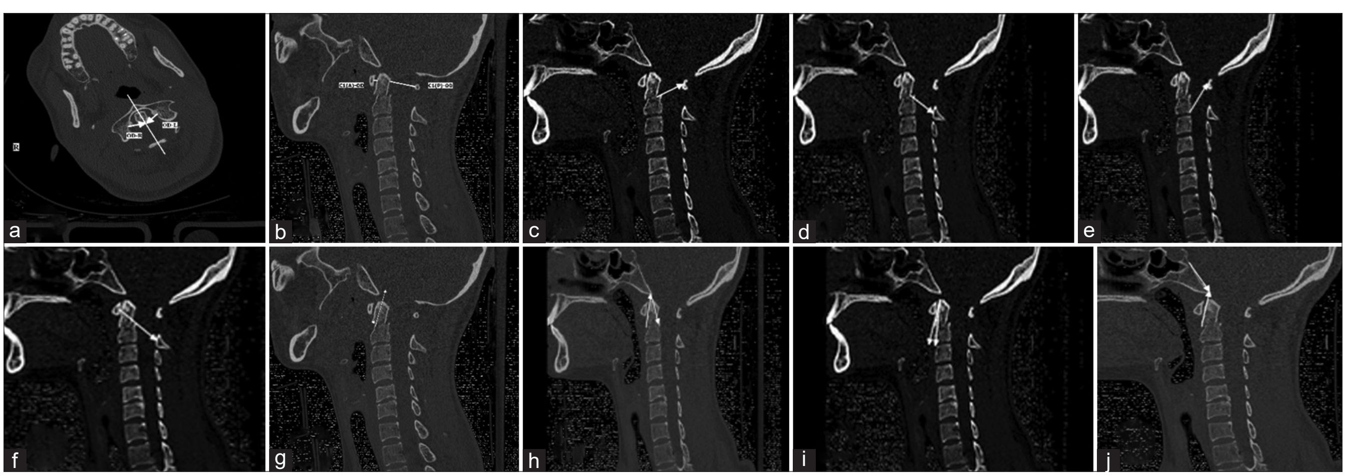

Figure 1: The microphotographs show the radiological measurement methods used in the study. (a) TL-OD (R) and TL-OD (L); (b) C1 (A)-OD and C1 (P)-OD; (c) C1 (P)-OFP; (d) C2 (P)-OFP; (e) C1 (P)-OIP; (f) C1 (A)-C2P; (g) OD FLIP; (h) AP-FRAP; (i) Sliding Angle; and (j) CL-OD

- C2 (P)-OFP: The distance between the posterior lower end of the odontoid fracture line and the midpoint of the anterior border of the C2 vertebral lamina [Figure 1d]
- C1 (P)-OIP: The distance between the posterior tip of the inferior endplate of the C2 vertebra and the anterior midpoint of the posterior arch of the C1 vertebra [Figure 1e]
- C1 (A)-C2P: The distance between the anterior face midpoint of the C2 vertebral lamina and the posterior midpoint of the anterior arch of the C1 vertebra [Figure 1f]
- OD FLIP: Distance of the anterior–posterior translation of the odontoid process [Figure 1g][9]
- AP-FRAP: The angle between the place where the apical ligament attaches to the dorsal tip of the clivus and the anterior of the odontoid process fracture line and posterior border of the C2 corpus [Figure 1h]
- Sliding Angle: The angle between the line passing in front of the fractured odontoid process and the line passing through the anterior surface of the C2 vertebral corpus [Figure 1i][5]
- CL-OD: Angle between the anterior line of the odontoid process and the dorsal line of the clivus [Figure 1j][4]
- F-GAP: The fracture gap between the odontoid process and the corpus of the C2 vertebra.[9]

Conservative treatment

For conservative treatment, a halo-vest corset or Philadelphia-type cervical collar was applied to the patients in the operating room after the reduction of the fracture under fluoroscopy.[11] The patients used these for at least 3 months. Patients with halo-vest corsets were checked at 2-week intervals, and any part of the corset that had become loose was tightened. At the end of 3 months, cervical CT was performed to evaluate fracture union. The cervical collars or halo-vest corsets were removed from patients with fracture union and the patients were referred to a physiotherapist.

Surgery

The anterior cervical approach was performed through a right-sided longitudinal neck incision with the patient in a supine position under general anesthesia. Then, a Kirschner wire was advanced to the fractured odontoid process under fluoroscopy guidance. After confirming that the wire was in the correct localization under fluoroscopy, a lag screw was sent over this wire [Figure 2a]. The same procedures were repeated with a second lag screw in patients who were determined to need a second lag screw [Figure 2b]. After the location of the screw(s) and the reduction of the fracture were checked under fluoroscopy, the wire was removed, then the surgical layers were sutured in proper order and the operation was terminated.[12] The patients used a Philadelphia-type cervical collar for 2 weeks.

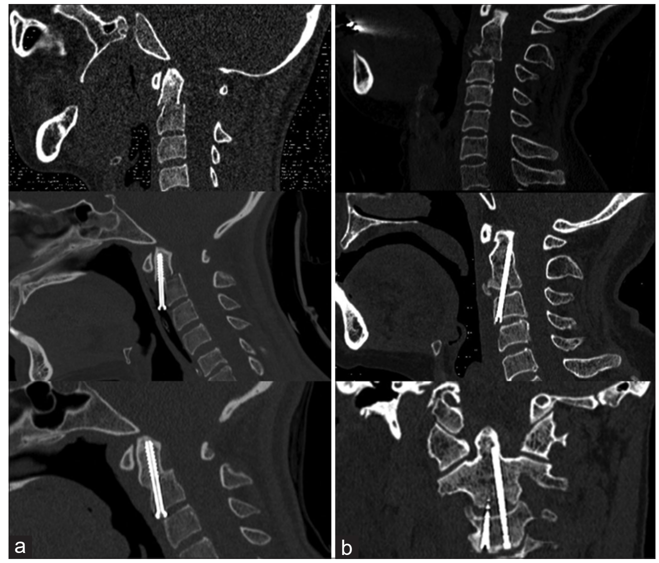

Figure 2: The micrographs show sagittal and coronal computed tomography images of a patient to whom a single odontoid lag screw was applied and then revised because of the screw malposition (a), and a patient to whom two odontoid lag screws were applied (b)

Statistical analysis

Pearson's Chi-square test was used to compare the categorical variables. The parametric variables were analyzed using the independent samples *t*-test and the nonparametric variables with the Mann–Whitney *U*-test. Correlations between parameters were examined using Spearman's rho Correlation test. Then, receiver operating characteristic (ROC)-Curve analysis was used to define the predictive parameter(s) in decision-making for screwing the fractured odontoid process, and the sensitivity and specificity rates of the parameter(s) were determined by obtaining "cutoff" values. To find the "best parameter," logistic regression analysis was used. The aspect and power of the association between patient data and surgical intervention risk were evaluated using the odds ratio (OR) and corresponding 95% confidence intervals. $P < 0.05$ was considered significant.

RESULTS

From a retrospective examination of the hospital's digital records, 36 patients with odontoid fractures were identified, and of these, the records of 19 patients were complete, so these patients were enrolled in the study [Table 1].

The patients comprised 10 males and 9 females with a mean age of 49.89 ± 23.07 years. The median length of stay in the hospital was 10 days (range, 2–36 days). The odontoid fractures occurred following a traffic accident in all the

Table 1: Descriptive table of demographic data and radiological measurement values of all the patients

Group	Age	Sex	Fracture type	TL-OD (right)	TL-OD (left)	C1(A)-OD	C1(P)-OD	C1(P)-OFP	C2(P)-OFP	C1(P)-OIP	C1(A)-C2(P)	OD-FLIP	AP-FRAP	Sliding angle	CL-OD	F-GAP	Stay in hospital
S (−)	23	Male	3	12.21	11.62	1.99	20.08	21.50	21.29	30.75	38.80	0.10	31.1	4.6	125.1	0.44	14
S (−)	28	Male	2	11.9	8.92	1.00	21.2	18.27	24.22	29.92	40.26	4.07	27.4	9.1	153.4	3.33	6
S (−)	30	Female	1	9.13	10.04	3.51	18.51	21.40	23.24	27.34	34.80	4.19	28.3	23.6	133.7	2.75	15
S (−)	30	Male	3	12.03	12.45	2.96	22.51	24.94	20.27	30.96	41.89	1.94	25.0	5.2	141.7	0.67	7
S (−)	41	Male	1	18.21	11.92	0.54	14.88	16.23	26.95	30.45	35.95	4.36	49.0	26.7	93.0	5.41	2
S (−)	51	Female	3	10.00	12.43	0.38	17.23	21.06	23.68	29.96	33.85	0.10	16.3	6.3	132.9	2.50	10
S (−)	73	Male	1	11.49	9.60	0.00	18.77	26.30	39.99	31.40	41.89	0.30	18.1	15.6	127.9	1.50	6
S (−)	77	Male	2	9.94	8.27	1.17	22.67	20.95	17.86	27.70	39.96	1.04	33.9	6.1	116.3	1.64	3
S (−)	83	Male	2	13.30	10.74	1.40	23.24	24.21	23.78	29.61	37.71	5.02	28.4	27.1	134.1	3.98	7
S (+)	23	Female	2	7.54	9.51	1.16	18.99	20.45	25.28	32.46	34.94	1.23	29.7	3.8	136.5	2.37	31
S (+)	33	Female	3	11.65	11.06	2.37	19.9	18.87	18.75	28.00	38.76	3.12	25.4	6.9	138.8	1.17	9
S (+)	38	Female	2	8.55	8.85	3.64	28.93	19.99	24.87	25.22	40.79	2.39	23.8	8.3	127.0	4.42	7
S (+)	45	Female	2	8.52	7.38	1.08	18.05	19.44	20.39	29.84	36.12	0.20	28.7	6.6	132.9	1.33	30
S (+)	63	Female	2	14.72	12.53	0.71	22.32	22.66	23.03	27.41	36.38	1.42	23.7	5.2	126.3	2.14	15
S (+)	67	Male	3	10.01	9.11	0.77	22.45	25.59	16.89	32.29	34.88	5.42	27.7	13.0	127.9	0.79	12
S (+)	69	Female	2	12.04	13.62	1.00	15.25	20.66	16.64	26.80	35.00	0.20	17.2	1.0	129.4	3.99	11
S (+)	76	Female	2	10.15	9.76	0.43	17.27	17.25	29.52	34.07	52.92	10.04	29.7	33.3	154.4	12.72	17
S (+)*	14	Male	2	8.77	7.22	4.67	15.22	18.52	27.81	27.96	45.06	9.74	17.1	23.3	161.2	3.51	36*
S (+)*	84	Male	2	11.27	10.05	1.54	26.17	30.57	15.25	40.41	27.09	3.08	37.0	39.2	107.8	7.46	8*

*Patients who died in the hospital after surgical treatment. S (−) - Surgery (−) group (patients who were followed up conservatively); S (+) - Surgery (+) group (patients who underwent anterior odontoid screw fixation)

patients. From the CT images, the fractures were classified as Type I in three patients, Type II in 11, and Type III odontoid fracture in 5. C1 anterior arch fracture accompanying odontoid fracture was seen in six patients (4 Type II and 2 Type III odontoid fractures), the fracture line extending to the transverse foramen was determined in three patients (2 Type II and 1 Type III odontoid fracture), and a teardrop fracture from the C2 vertebral body was detected in one patient (Type III odontoid fracture). The MR examinations performed on nine patients (seven patients received conservative treatment and two patients underwent surgical intervention) revealed no transverse ligament rupture.

Posterior odontoid displacement was detected in six patients compared to the C2 vertebral body, and anterior displacement in 13 patients. One of the patients with posterior displacement (Type III odontoid fracture) underwent surgical treatment. Type I odontoid fracture was found in 3, Type II odontoid fracture in 3, and Type III odontoid fracture in 3 of the nine patients who were treated conservatively. A halo-vest corset was applied to 2 of these patients, and a Philadelphia-type cervical collar to 7. Of the ten patients who underwent surgical treatment, eight had Type II odontoid fractures and two had Type III odontoid fractures. A single odontoid lag screw was applied in nine cases and 2 odontoid lag screws were applied to one case. Two patients with Type II odontoid fractures died after surgical intervention in the hospital.

No statistically significant difference was found between the patients who underwent surgical treatment and those who received conservative treatment in terms of age, type of the odontoid fracture, duration of stay in the hospital, and all radiological measurement parameter values except gender ($\chi^2 = 4.337$, $P = 0.037$) [Table 2].

When the patients were grouped as male and female, there was no statistically significant difference between the genders in terms of all the parameters examined [Table 3].

No statistically significant difference was found between the patients with Type II odontoid fracture and those with Type III odontoid fracture in terms of sex, duration of stay in the hospital, and all radiological measurement parameter values except the fracture gap between the odontoid process and the corpus of the C2 vertebra ($\chi^2 = -2.662$, $P = 0.008$) [Table 4].

The correlation analysis results applied to the parameters of all the patients showed a negative correlation between gender and the treatment regimen ($r = -0.478$, $P = 0.039$).

Table 2: Comparisons of the data of patients who underwent surgery and patients who were treated conservatively

Variable	Mean±SD/median (minimum–maximum)/*n* (%)		$t/Z/\chi^2$	*P*
	Surgery (-)	Surgery (+)		
Age (year)	48.44±23.51	51.20±23.85	−0.253*	0.803
Sex				
Female	2 (22.2)	7 (70.0)	4.337‡	0.037
Male	7 (77.8)	3 (30.0)		
Fracture type				
Type I	3 (33.3)	0	5.435‡	0.066
Type II	3 (33.3)	8 (80.0)		
Type III	3 (33.3)	2 (20.0)		
TL-OD (right) (mm)	12.02±2.67	10.32±2.15	1.537*	0.143
TL-OD (left) (mm)	10.67±1.55	9.91±2.04	0.902*	0.380
C1(A)-OD (mm)	1.17 (0.10–3.51)	1.12 (0.43–4.67)	−0.449†	0.653
C1(P)-OD (mm)	19.90±2.80	20.46±4.53	−0.317*	0.755
C1(P)-OFP (mm)	21.65±3.18	21.40±3.98	0.151*	0.882
C2(P)-OFP (mm)	24.59±6.34	21.84±4.99	1.055*	0.306
C1(P)-OIP (mm)	29.79±1.40	30.45±4.50	−0.420*	0.680
C1(A)-C2P (mm)	38.80 (33.85–41.89)	36.25 (27.09–52.92)	−0.327†	0.744
OD-FLIP (mm)	2.35±2.05	3.68±3.62	−0.975*	0.343
AP-FRAP (°)	28.61±9.53	26.00±6.02	0.722*	0.480
Sliding angle (°)	9.10 (4.60–27.10)	7.60 (1.00–39.20)	−0.204†	0.838
CL-OD (°)	128.68±16.93	134.22±15.05	−0.756*	0.460
F-GAP (mm)	2.47±1.61	3.99±3.65	−1.151*	0.266
Hospitalization (day)	7 (2–15)	13.5 (7–36)	−2.497†	0.013
Mortality rate				
No	9 (100)	8 (80.0)	2.012‡	0.156
Yes	0	2 (20.0)		

**t* value, independent samples *t*-test; †*Z* value, Mann–Whitney *U*-test; ‡χ^2 value, Pearson's Chi-square test, $P<0.05$. SD - Standard deviation; *n* - Number of participants

ROC-Curve analysis results showed that no radiological measurement parameter or demographic data could predict the decision-making for surgical intervention risk or the mortality risk. OR analysis showed that none of the study parameters increased the likelihood of surgical treatment being applied to the patients. The logistic regression analysis results showed that the female gender could be a weak predictive marker in decision-making for surgical intervention ($B = -2.100$, Wald $= 3.941$, $P = 0.047$) [Table 5].

DISCUSSION

The type of odontoid fracture, the patient's health status, age, neurological status, and the surgeon's preference are very important in deciding the treatment modality of patients.[10] The literature defines Type II and III fractures with a fracture gap of <2 mm, displacement of <5 mm, and angulation of <11° as stable fractures. In patients with these criteria, approximately 75% of Type II fractures and 85% of Type III fractures can be treated with conservative treatment methods. However, surgical treatment is recommended in patients with Type II fractures with displacement >4–6 mm, angulation >10°, neurological damage associated with external immobilization, a pathological fracture that will not be possible to reduce, and/or after unsuccessful closed reduction attempts.[9,13,14] Posterior stabilization techniques are considered major surgical interventions and can lead to significant complications, especially for patients of very advanced age.[15] In such cases, a viable alternative is conservative treatment with the immobilization of the segment for a variable period.[16] However, it has been reported that immobilization treatments may cause serious complications such as nonunion of the fracture.[17]

In this study, conventional measurements results including the amount of vertical and horizontal shift of the fractured odontoid, the distance between the C1 vertebra and the odontoid process, the angle between the posterior wall of the odontoid process and the posterior wall of the clivus, the slip angle, the anterior to posterior width of the spinal canal at the fracture level, and fracture gap were not different between the patients who underwent surgical treatment and those who received conservative treatment. In addition, using the measurements specific to this study, no significant difference was determined in respect of the amount of lateral displacement of the odontoid process in the spinal canal in the axial plane, the angle of the fractured odontoid process with the vertebral body, and spinal canal anterior-posterior

Table 3: Comparisons of the data of patients grouped by gender

Variable	Mean±SD/median (minimum–maximum)/*n* (%)		$t/Z/\chi^2$	*P*
	Female	Male		
Age (year)	47.56±18.51	52.00±27.37	−0.410*	0.687
Fracture type				
Type I	1 (11.1)	2 (20.0)	0.573‡	0.751
Type II	6 (66.7)	5 (50.0)		
Type III	2 (22.2)	3 (30.0)		
TL-OD (right) (mm)	10.26±2.23	11.91±2.57	−1.492*	0.154
TL-OD (left) (mm)	10.58±2.00	9.99±1.69	0.692*	0.499
C1(A)-OD (mm)	1.08 (0.38–3.64)	1.29 (0.10–4.67)	−0.286†	0.775
C1(P)-OD (mm)	19.61±4.01	20.72±3.57	−0.641*	0.530
C1(P)-OFP	20.20±1.57	22.71±4.40	−1.619*	0.124
C2(P)-OFP	22.82±3.82	23.43±7.16	−0.227*	0.823
C1(P)-OIP	29.01±2.84	31.15±3.56	−1.433*	0.170
C1(A)-C2P	36.12 (33.85–52.92)	39.38 (27.09–45.06)	−0.980†	0.327
OD-FLIP (mm)	2.54±3.15	3.51±2.91	−0.693*	0.498
Sliding angle (°)	6.60 (1.00–33.30)	14.30 (4.60–39.20)	−1.266†	0.205
AP-FRAP (°)	24.76±5.10	29.47±9.26	−1.352*	0.194
CL-OD (°)	134.66±8.47	128.84±20.40	0.794*	0.438
F-GAP	3.71±3.54	2.87±2.31	0.617*	0.546
Treatment				
Conservative	2 (22.2)	7 (70.0)	4.337‡	0.037
Surgery	7 (77.8)	3 (30.0)		
Hospitalization	15 (7–31)	7 (2–36)	−2.128†	0.033
Mortality				
No	9 (100)	8 (80.0)	2.012‡	0.156
Yes	0	2 (20.0)		

*t value, independent samples t-test; †Z value, Mann–Whitney U-test; ‡χ^2 value, Pearson's Chi-square test, $P<0.05$. SD - Standard deviation; n - Number of participants

width values measured between the odontoid process and C1 posterior arcus or C2 vertebral lamina.

In the literature, surgical treatment is recommended when the amount of odontoid displacement is >5 mm or when the angulation is >10°.[14] However, in this study, the mean odontoid displacement value was 0.21 ± 4.36 mm in patients who received conservative treatment and 2.01 ± 4.06 mm in patients who underwent surgical treatment, with no statistically significant difference determined between the two groups. In addition, as a result of the measurements made between the posterior wall of the C1 anterior arch and the anterior wall of the odontoid process, this distance was found to be 1.09 (0−5) mm in patients who received conservative treatment and 1.16 (0−4) mm in patients who underwent surgical treatment. Furthermore, the mean fracture GA*P* values were measured as 2.47 ± 1.61 mm in the surgery (−) group and as 3.99 ± 3.65 mm in the surgery (+) group. Although the mean fracture GA*P* value of the surgery (+) patients was numerically higher, these measurement values did not differ statistically between the groups. Cervical MR performed in nine patients showed no transverse ligament rupture, seven patients received conservative treatment, and two underwent surgical intervention. On the other hand, the fracture gap between the odontoid process and corpus of the C2 vertebra (F-GAP) was higher in patients with Type II odontoid fracture than in Type III odontoid fracture patients and it was seen that most of those patients were treated surgically. However, the ROC analysis revealed that neither demographic data nor radiological measurement values could be used as predictive markers in decision-making for surgical treatment or mortality risk. Furthermore, the OR test revealed that none of the study parameters increased the likelihood of surgical treatment. However, although the ROC test showed that gender was not a predictive marker in decision-making for surgical intervention, the logistic regression analysis showed that gender could be a weak predictor in the decision-making for surgical intervention. It was thought that this finding might be associated with most of the surgically treated patients being female or could be attributed to the low bone quality in older female patients, due to the high risk of osteoporosis, and therefore, a greater possibility of odontoid fractures developing in these patients.

At the end of the study, the demographic data and radiological measurement parameters were not considered to be adequate to make a decision on the treatment modality or to predict

Table 4: Comparisons of the data of patients who had type II odontoid fracture and those who had type III odontoid fracture

Variable	Mean±SD/median (minimum–maximum)/*n* (%)		*t*/*Z*/χ^2	*P*
	Type II	Type III		
Age (year)	54.55±25.75	40.80±17.92	1.072*	0.302
Gender				
Female	6 (54.5)	2 (40.0)	0.291‡	0.590
Male	5 (45.5)	3 (60.0)		
TL-OD (right)	10.61±2.24	11.18±1.09	−0.533*	0.602
TL-OD (left)	9.71±1.99	11.33±1.37	−1.638*	0.124
C1(A)-OD	1.16 (0.43–4.67)	1.99 (0.38–2.96)	−0.170†	0.865
C1(P)-OD	20.85±4.38	20.43±2.18	0.197*	0.847
C1(P)-OFP (mm)	21.18±3.69	22.39±2.81	−0.650*	0.526
C2(P)-OFP (mm)	22.60±4.57	20.18±2.57	1.099*	0.290
C1(P)-OIP (mm)	30.13±4.25	30.39±1.58	−0.133*	0.896
C1(A)-C2P (mm)	38.75±6.53	37.64±3.27	0.356*	0.727
OD-FLIP	1.83±4.70	−0.81±3.15	0.695*	0.513
AP-FRAP	26.96±6.18	25.10±5.48	0.577*	0.573
Sliding angle (°)	8.30 (1.00–39.20)	6.30 (4.60–13.00)	−0.794†	0.427
CL-OD	134.48±16.33	133.28±7.02	1.344*	0.289
F-GAP (mm)	3.51 (1.33–12.72)	0.79 (0.44–2.50)	−2.662†	0.008
Treatment				
Conservative	3 (27.3)	3 (60.0)	1.571‡	0.210
Surgery	8 (31.6)	2 (40.0)		
Hospitalization	15.55±11.58	10.40±2.70	0.964*	0.351
Mortality rate				
No	9 (81.9)	5 (100.0)	1.039‡	0.308
Yes	2 (18.2)	0		

*t value, independent samples t-test; †Z value, Mann–Whitney U-test; ‡χ^2 value, Pearson's Chi-square test, $P<0.05$. SD - Standard deviation; n - Number of participants

Table 5: The logistic regression analysis results showed that the female gender can be used as a weak predictive marker in decision-making for surgical intervention

Logistic regression test for surgical intervention risk						
Variable	*B*	Wald	*P*	OR	95% CI	
					Lower	Upper
Gender	−2.100	3.941	0.047	0.122	0.015	0.974

$P<0.05$. OR - Odds ratio; CI - Confidence interval

the mortality risk in patients with odontoid fractures. In addition, it was determined that all these results were similar for both male and female patients. It was assumed from these results that surgical treatment was mostly performed on patients with a fracture that could not be reduced under fluoroscopy, and this was thought to explain the similarity of the measurement results of the surgically treated patient group and the conservative treatment group.

Limitations

This retrospective study had some limitations, primarily that it was conducted in a single center. Therefore, these results cannot be generalized to the general population because of the low number of patients. However, no study was found in the literature which has identified and tested the parameters that could help surgeons in decision-making for the surgical treatment of patients with odontoid fractures.[6] Therefore, this preliminary study can be considered of value in creating a new discussion area to emphasize the above-mentioned deficiency in the literature. Second, the data of patients who underwent odontoid lag screw through the anterior approach could not be compared with the data of patients who underwent stabilization by the posterior approach (such as C2-C3 fusion). Finally, the data of this study did not include the patients' short-term and/or long-term follow-up results, because they were outside the study scope.[15]

CONCLUSION

This study's results indicated that neither the patients' demographic data nor the CT radiological measurement parameters could be used as predictive markers in decision-making for surgical intervention or mortality risk. Therefore, there is a need for further studies of the larger patient populations to investigate different radiological measurement methods that could be used in making the surgical treatment decision or predicting the risk of mortality in patients with odontoid fractures.

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Conflicts of interest

There are no conflicts of interest.

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