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*Original Research*

# Measurement of the Anterior Uterocervical Angle for Predicting the Displacement of Copper Intrauterine Devices (T-Cu380A): A Prospective Cohort Study

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**Abstract**

**Background**: To determine the value of the uterocervical angle for predicting the displacement of copper intrauterine devices (IUDs). **Methods**: We conducted a prospective cohort study between December 2020–June 2021 at the family planning outpatient clinics of the Kanuni Sultan Suleyman Training and Research Hospital, Istanbul Health Sciences University. A total of 143 patients who had copper IUDs (T-Cu380A) inserted for contraception were evaluated from the 6th week to 5 years after insertion. Patients were divided into two groups according to ultrasonographic examinations that revealed whether their IUD were "displaced" or in the "normal" position. The uterocervical angle (UCA) of patients was measured by transvaginal ultrasonography and investigated as to whether it was predictive for the displacement of copper IUDs. **Results**: Of the 143 women participating in the study, 67 (46.9%) had a displaced IUD position, and 76 (53.1%) had a normal IUD position. No statistically significant difference was found between the two groups for patient age, body mass index, educational status, gravida, parity, and mode of delivery ($p > 0.05$). The mean anterior UCA of patients with displaced IUDs was 139.7 $\pm$ 8.2 degrees, while the mean UCA of patients with normal IUD positions was 125.3 $\pm$ 12.9 degrees. Multiple logistic regression analysis revealed that IUD displacement increased 1.31-fold with each one degree increase in the UCA (95% confidence interval (CI): 1.06–1.63, $p = 0.012$). **Conclusions**: The anterior UCA has predictive value for the displacement of copper IUDs. Measurement of the anterior UCA is a feasible method for predicting copper IUD displacement and can thus be used as a screening tool to allow additional counseling for patients. The cut-off predictive value for the UCA was measured as 139.5 degrees. Women with a UCA >139.5 degrees may benefit from additional counseling and closer follow-up after device placement.

**Keywords:** displacement; contraception; family planning; T-Cu380A; uterocervical angle

## 1. Introduction

Family planning uses several methods of protection, one of which is copper intrauterine devices (IUDs). This has become a favored contraception method due to its long-acting effect, rapid return to fertility once discontinued, and ease of use. Worldwide, IUDs are the third most common method of contraception after tubal ligation and male condoms [1]. Comparison of long-acting contraception methods revealed a failure rate for copper IUDs of 0.8% per year [2]. Factors that affect the displacement of IUDs are the application time [3], application technique [4], uterus dimensions [5], endometrial cavity length [6], parity [7], and mode of delivery [8]. Displacement of an IUD from its usual position at the fundal segment of the uterus is known to decrease its contraceptive efficacy. The above-mentioned factors causing copper IUD displacement can reduce the effectiveness of these devices, thereby increasing the possibility of unplanned pregnancy.

The displacement of copper IUDs triggers uterine contraction and forces foreign body expulsion from the endometrial cavity through the cervix. Several studies have explored the function of the uterine cervix by measuring the uterocervical angle (UCA) and the cervical length using ultrasonography [9,10]. UCA is the angle in the triangular region between the anterior uterine segment and the cervical canal [9]. It has been used to predict the risk of preterm birth, embryo transfer success, and the severity of primary dysmenorrhea [9–11]. The UCA could play a role in the downward expulsion of copper IUDs during ill-fitting positions because it represents the relationship between the cervix and the endometrial cavity. This angle might influence the position of copper IUDs in the uterine border by applying a negative force against uterine contraction. The aim of the current research was therefore to investigate whether there is a cause-effect relationship between the utero-cervical junction and the displacement of copper IUDs. Thus, we studied the utility of UCA measurements for predicting the displacement of copper IUDs.

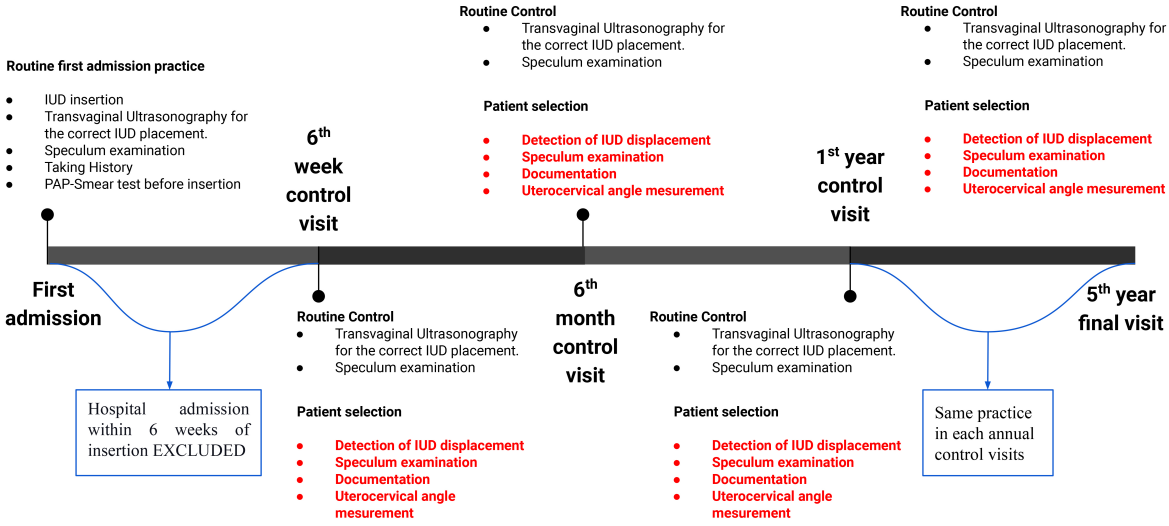


**Fig. 1. A flow-chart diagram illustrating patient selection and scheduled visits during 5 years of period.** IUD, Intrauterine device; PAP-Smear, Papanicolaousmear.

## 2. Material and Methods

### *2.1 Patient Selection*

Included in this study were female patients aged 21–45 years who applied to our family planning outpatient clinic between January 2021 to June 2021 for control visits or attending with any complaints. We only included patients who were referred to our family outpatient clinic for IUD insertion earlier and then attended their follow-up visits. Follow-up visits were scheduled in the 6th week, at 6 months, and then annually after the first year until the 5th year (Fig. 1). Patients were divided into two groups either coming to their routine control visit and having a normal IUD position or referring to our outpatient clinic with various complaints due to IUD usage and having a dislocated IUD during ultrasonographic evaluation. Exclusion criteria were: hospital admission within 6 weeks of insertion, IUD insertions outside of our hospital, space-occupying lesions (polyps, myomas), pelvic inflammatory diseases, cervical polyps, uterine myomas, adenomyosis, uterine anomalies, connective tissue diseases, descensus uteri, abnormal uterine bleeding, immune suppression, anticoagulant usage, copper allergy or copper metabolism disorders (Wilson disease), or previous treatment for Atypical Squamous Cells of Undetermined Significance (ASCUS), Low-grade squamous intraepithelial lesion (LSIL), High-grade squamous intraepithelial lesion (HSIL), Cervical intraepithelial neoplasia (CIN) lesions or malignancy by any method (cryotherapy, Loop electrosurgical excision procedure (LEEP) or cone biopsy).

### *2.2 Physical Examination*

IUD insertions were performed by the same certified and trained midwife (SS) at the Family Planning Center, Health Sciences University Istanbul, Kanuni Sultan Suleyman Training and Research Hospital (Turkey). IUD insertions in our family planning outpatient clinic are performed on the 3rd day of the menstrual period, at the 6th week postpartum, and at the 6th week post-cesarean. On rare occasions we also inserted IUDs after menstrual regulation, after dilatation curettage, and after cesarean section. Patients were informed of the risks of IUD expulsion at each time period, and IUDs were initiated based on their personal preference. Gynecological examinations and The Papanicolaousmear screening were performed prior to IUD insertion. After insertion, transvaginal ultrasonography (TV-USG) was performed to confirm the correct IUD placement. Follow-up visits were scheduled in the 6th week, at 6 months, and then annually after the first year. Speculum examination and TV-USG was performed on all patients at each follow-up visit. Patients were questioned for the presence of symptoms related to IUD use. Demographic characteristics, type of delivery, the last delivery time, insertion time, education status, gynecological symptom history (chronic pelvic pain, menorrhagia, dysmenorrhea, dyspareunia, leukorrhea), hygiene habits (vaginal douche), menstrual pattern, medical history and previous IUD displacement were documented. The presence of IUD thread, leukorrhea, vaginal bleeding, or foul-smelling discharge was investigated by examination of the speculum.

### *2.3 Ultrasonographic Evaluation*

TV-USG was performed to ascertain the device position. Ultrasounds were performed vaginally using an ultrasound instrument (Aloka Prosound 6, 2008, Tokyo, Japan) with a 3.5 MHz vaginal transducer. Patients were examined in the lithotomy position and were asked to empty their bladder before examination. All measurements were performed by a single physician (OK) in order to ensure the standardization of ultrasonographic parameters and to min-

imize inter- and intra-observer variation. Measurements included the uterus position (anteversion, retroversion, anteflexion, retroflexion), cervical length, uterocervical angle (UCA), fundal length (FL), endometrial cavity length (ECL), the distance behind the intersection of the uppermost vertical arm of the IUD and the fundal endometrium (IUD-End), and uterine volume ($cm^3$) (Fig. 2).

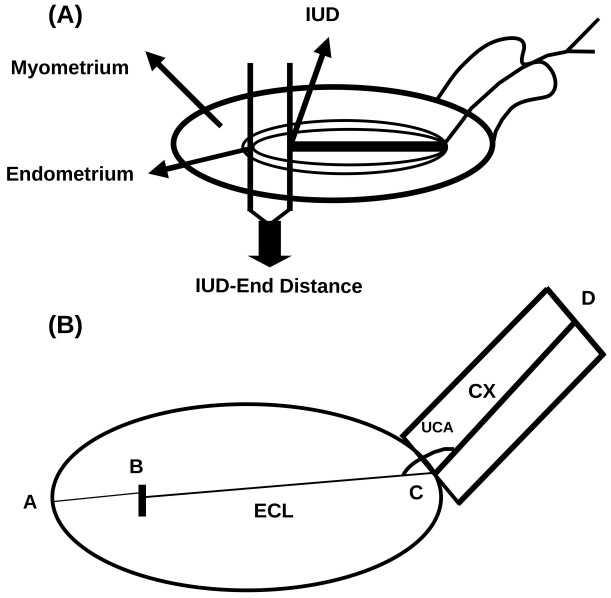


**Fig. 2. A schematic illustration of ultrasonographic uterine measurements.** (A) Schematic illustration of the distance between the top of the intrauterine device (IUD) and the end of the endometrial cavity (IUD-End). (B) Schematic illustration of the ultrasonographic parameters defined for the uterus. A–B: IUD-fundus length (FL); B–C: endometrial cavity length (ECL); C–D: cervical length (CX); uterocervical angle (UCA); total uterine length (TUL): FL + ECL + CX [(A–B) + (B–C) + (C–D)].

The UCA is the angle measured in the triangular region between the anterior uterine segment and the cervical canal. For measurements made in the sagittal section, the first line forming the angle was drawn between the external os and the internal os along the endocervical canal. If the cervical canal was not linear, this first line was determined as the straight line drawn between the internal os and the external os. The secondary line forming the UCA was determined as the straight line extending from the beginning of the internal os to the top of the fundus along the anterior uterine segment [10].

Measurements of the uterine cervical longitudinal axis were performed after the image was enlarged to cover 3/4 of the screen. The internal cervical ostium, external cervical ostium, cervical canal, and endocervical mucosa were viewed simultaneously [11]. Three different images were obtained during the examination of each patient, and the ideal and shortest cervical length were recorded. Uterine volume was measured as follows: the uterine length was first calculated from the fundus to the internal os with a vaginal probe on a sagittal plane. The transducer was then moved 90° towards the transverse plane and adjusted to give the maximum anteroposterior diameter. Following this, the anteroposterior and transverse diameters were measured. Volume was calculated using the formula for a prolate ellipsoid: Volume = (0.52 $\times$ length $\times$ anteroposterior diameter $\times$ transverse diameter) [12]. The distance between the intersection of the uppermost vertical arm of the IUD and the junction between the endometrium and the uterine cavity (IUD-ED) was measured with TV-USG in the mid-sagittal plane. The maximum IUD-ED distance required to provide sufficient contraception is still controversial. To prevent unnecessary removal, we therefore defined displacement as an IUD-ED of $>$10 mm [13]. Normally positioned IUDs were defined as a distance of $<$10 mm between the top of the IUD and the end of the endometrial cavity, with both arms fully extended and parallel to the axis of the uterine cornua, and with the vertical part of the IUD lying centrally in the uterine cavity. "Displaced" IUDs were defined as any deviation from this normal position. Displacement was considered to be the non-fundal location of an IUD when the distance between the top of the IUD and the end of the endometrial cavity was $>$10 mm [13]. "Lower uterine segment" was defined as above the internal cervical ostium, or at the isthmus level. Patients whose IUDs were found to be displaced between the 6th week and up to 5 years after insertion and who attended our Family Planning Outpatient Clinic for control examination were divided into four subgroups as illustrated above (Fig. 3).

### *2.4 Statistical Analysis*

Statistical analyses were performed using SPSS v.21 (SPSS Inc., Chicago, IL, USA). The distribution of variables was tested for normality using histograms and the Kolmogorov Smirnov and Shapiro-Wilk W tests. Parametric continuous data are presented as the mean $\pm$ standard deviation, nonparametric continuous data as the median (min–max), and categorical variables as numbers (percentages). The *t*-test and Mann-Whitney U test were used to compare continuous data between two independent groups, while Chi-square and Fisher's exact tests were used to compare categorical data. Factors affecting IUD displacement were analyzed using binary logistic regression. Age and variables thought to affect the displacement in univariate analysis ($p < 0.25$) were added to the regression model. Variables that remain in the multiple regression model were determined by the Backward Logistic Regression (LR) method. The Hosmer-Lemeshow test was performed to evaluate the goodness-of-fit of the regression model. Receiver operator characteristic curve (ROC) analysis was performed to evaluate the predictive value of the UCA for IUD displacement. All tests were bilateral and the level of significance was set at a *p*-value of $<$0.05.

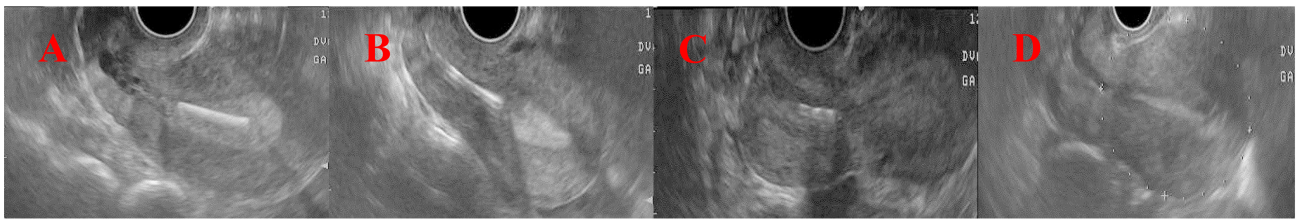


**Fig. 3. Illustration of abnormal copper intrauterine device positions.** (A) Group 1: patients whose IUD fundus distance was >10 mm but did not extend to the lower uterine segment (low lying). (B) Group 2: patients whose IUDs were located in the lower uterine segment but did not extend to the cervix (partial expulsion). (C) Group 3: patients with cervical IUDs (cervical). (D) Group 4: patients whose IUDs were not detected (complete expulsion).

**Table 1. Patient demographic characteristics and obstetric history.**

| Parameter | Displaced (n = 67) | Control (n = 76) | *p*-value |
|---|---|---|---|
| Age (years) Mean ± SD | 33.2 ± 7.2 | 33.7 ± 5.8 | 0.661[1] |
| BMI (kg/m$^2$) Mean ± SD | 27.5 ± 5.1 | 26.4 ± 4.6 | 0.158[1] |
| Education n (%) | | | |
| No education | 9 (13.4) | 13 (17.1) | 0.889[2] |
| Primary school | 26 (38.8) | 26 (34.2) | |
| Secondary school | 19 (28.4) | 21 (27.6) | |
| High school | 9 (13.4) | 13 (17.1) | |
| University or PhD | 4 (6) | 3 (3.9) | |
| Gravida Mean (IQR) | 3 (2–4) | 3 (2–4) | 0.296[3] |
| Parity Mean (IQR) | 3 (2–4) | 2 (2–3) | 0.115[3] |
| Abortion Mean (IQR) | 0 (0–0) | 0 (0–0.75) | 0.769[3] |
| Curettage n (%) | | | |
| No | 58 (86.6) | 67 (88.2) | 0.775[2] |
| Yes | 9 (13.4) | 9 (11.8) | |
| Route of previous delivery n (%) | | | |
| Vaginal | 45 (67.2) | 42 (55.3) | 0.445[4] |
| CS | 13 (19.4) | 23 (30.3) | |
| Nulliparous | 1 (1.5) | 1 (1.3) | |
| Vaginal + CS | 8 (11.9) | 10 (13.2) | |
| Duration of IUD use n (%) | | | |
| >6th week–<6 months | 13 (19.4) | 17 (22.4) | 0.816[2] |
| 6–12 months | 11 (16.4) | 10 (13.2) | |
| >12 months | 43 (64.2) | 49 (64.5) | |
| Timing of IUD insertion n (%) | | | |
| Postpartum 6th week | 48 (71.6) | 44 (57.9) | 0.077[3] |
| 6 weeks after cesarean | 16 (23.9) | 26 (34.2) | |
| After menstrual regulation | 3 (4.5) | 1 (1.3) | |
| After D&C | 0 (0) | 3 (3.9) | |
| After cesarean | 0 (0) | 2 (2.6) | |

n (%), Number (Percentage); SD, Standard deviation; BMI, Body mass index; CS, Cesarean section; IUD, Intrauterine device; IQR, Inter quantile range; PhD, Doctorate of Philosophy; D&C, Dilatation and curretage.

[1]Independent sample *t*-test, [2]Chi square test, [3]Mann Whitney U, [4]Fisher exact test.

## 3. Results

### *3.1 Demographic and Clinical Characteristics*

A total of 143 patients were enrolled in this study. Patients were categorized according to the position of their IUD as detected by ultrasonography during their 6-week follow-up visit after insertion. IUD displacement was observed in 67 patients (displaced group), while no IUD displacement was seen in 76 patients (control group). The mean age, body mass index (BMI), median parity, delivery type, timing of insertion, and IUD insertion time were not significantly different between these two groups. A comparison of the demographic characteristics of the two patient groups is shown in Table 1.

**Table 2. Clinical characteristics of patients.**

| Parameters | Displaced (n = 67) | Control (n = 76) | *p*-value |
|---|---|---|---|
| Length of menstrual cycle (days) Mean (IQR) | 7 (6–9) | 7 (5–8) | 0.230[1] |
| Menstrual pattern n (%) | | | |
| Regular | 33 (49.3) | 59 (77.6) | <0.001[2] |
| Irregular | 34 (50.7) | 17 (22.4) | |
| Menorrhagia history n (%) | | | |
| Yes | 29 (43.3) | 19 (25) | 0.021[2] |
| No | 38 (56.7) | 57 (75) | |
| Dyspareunia history n (%) | | | |
| Yes | 29 (43.3) | 30 (39.5) | 0.644[2] |
| No | 38 (56.7) | 46 (60.5) | |
| Dysmenorrhea history n (%) | | | |
| Yes | 34 (50.7) | 37 (48.7) | 0.806[2] |
| No | 33 (49.3) | 39 (51.3) | |
| Leukorrhea history n (%) | | | |
| Yes | 48 (71.6) | 58 (76.3) | 0.524[2] |
| No | 19 (28.4) | 18 (23.7) | |
| Vaginal douche history n (%) | | | |
| Yes | 25 (37.3) | 27 (35.5) | 0.825[2] |
| No | 42 (62.7) | 49 (64.5) | |
| Chronic pelvic pain n (%) | | | |
| Yes | 15 (22.4) | 17 (22.4) | 0.998[2] |
| No | 52 (77.6) | 59 (77.6) | |

Data are mean or n (%).
[1]Mann Whitney U test, [2]Chi Square test.

The clinical characteristics of patients are shown in Table 2. Patients with displaced IUDs showed more frequent menorrhagia (43% *vs*. 25%, $p = 0.021$) and irregular menstrual pattern (51% *vs*. 22%, $p < 0.001$) compared to those without displacement.

Table 3 shows the incidence of symptoms during presentation at follow-up. The incidence of vaginal bleeding (28.4%) during speculum examination of patients with IUD displacement was significantly higher than in patients without displacement (5.3%) ($p < 0.001$). No significant differences were observed between the two groups for the incidence of foul-smelling discharge, leukorrhea, or missing IUD thread in the speculum examination and abdominal examination (Table 3).

The uterine characteristics of the two patient groups are compared in Table 4. Patients with IUD displacement had significantly shorter cervical length ($p = 0.005$), longer endometrial cavity length ($p < 0.001$), longer total uterine length ($p < 0.001$), larger uterine volume ($p < 0.001$), and larger UCA ($p < 0.001$) compared to patients without displacement.

Ultrasonographic evaluation of the 67 patients with IUD displacement revealed that 64 (95.5%) had a displacement, one (1.5%) had a perforation, and two (3%) had IUD displacement and pregnancy. Of these 67 patients, the presentations for IUD displacement were: low but not extending to the cervix (62.7%), low and extending to the cervix (19.4%), cervical (14.9%), and complete expulsion (3%).

**Table 3. Presenting symptoms during evaluation.**

| | Displaced (n = 67) | Control (n = 76) | *p*-value |
|---|---|---|---|
| Leukorrhea n (%) | | | |
| Yes | 59 (88.1) | 58 (76.3) | 0.069[1] |
| No | 8 (11.9) | 18 (23.7) | |
| Vaginal bleeding n (%) | | | |
| Yes | 19 (28.4) | 4 (5.3) | <0.001[1] |
| No | 48 (71.6) | 72 (94.7) | |
| Foul-smelling discharge n (%) | | | |
| Yes | 4 (6) | 6 (7.9) | 0.652[1] |
| No | 63 (94) | 70 (92.1) | |
| Missing IUD string (%) | | | |
| Yes | 6 (9) | 12 (15.8) | 0.219[1] |
| No | 61 (91) | 64 (84.2) | |
| Abdominal examination n (%) | | | |
| Normal | 61 (91) | 71 (93.4) | 0.743[2] |
| Tenderness | 5 (7.5) | 5 (6.6) | |
| Rigidity | 1 (1.5) | 0 (0) | |

n (%), Number (Percentage). [1]Chi-square test, [2]Fisher exact test.

### *3.2 Identification of Factors Predictive of IUD Displacement*

Patient age and all the variables identified in univariate analysis as being associated with IUD displacement with a *p*-value of <0.25 were added to the regression model. Variables that remained in the multiple regression model were

**Table 4. Uterine anatomical characteristics.**

| Uterine position/characteristics | Displaced (n = 67) | Control (n = 76) | *p*-value |
|---|---|---|---|
| Uterine position 1 n (%) | | | |
| Anteverted | 51 (76.1) | 65 (85.5) | 0.378[1] |
| Retroverted | 13 (19.4) | 9 (11.8) | |
| Anterior midline | 3 (4.5) | 2 (2.6) | |
| Uterine position 2 n (%) | | | |
| Anteflexed | 5 (7.5) | 6 (7.9) | 0.923[2] |
| Retroflexed | 62 (92.5) | 70 (92.1) | |
| Cervix length (mm) Mean ± SD | 28.7 ± 3.2 | 30.2 ± 3.1 | 0.005[3] |
| Endometrial cavity length (mm) Mean ± SD | 48.8 ± 8.9 | 41.4 ± 6.6 | <0.001[3] |
| Fundal length (mm) Mean ± SD | 13.7 ± 3.5 | 13.7 ± 3.2 | 0.992[3] |
| Total uterine length (mm) Mean ± SD | 91.3 ± 10.2 | 85.3 ± 8.9 | <0.001[3] |
| Uterine volume ($cm^3$) Mean ± SD | 34.6 ± 6.8 | 20 ± 4.4 | <0.001[3] |
| Uterocervical angle (degree) Mean ± SD | 139.7 ± 8.2 | 125.3 ± 12.9 | <0.001[3] |

Values are presented as Mean ± SD, or n (%).

[1]Fisher exact test, [2]Chi-square test, [3]Independent sample *t*-test.

**Table 5. Multivariate logistic regression analysis of variables predictive of IUD displacement.**

| Variable | Odds ratio | 95% CI | *p*-value |
|---|---|---|---|
| BMI ($kg/m^2$) | 1.27 | 0.93–1.74 | 0.126 |
| Parity | 1.15 | 0.02–1.16 | 0.069 |
| Vaginal bleeding (speculum examination) | | | |
| No | *Ref* | *Ref* | 0.038 |
| Yes | 86.9 | 1.3–5885.3 | |
| Cervical length | 0.53 | 0.25–1.12 | 0.097 |
| Endometrial cavity length | 2.02 | 1.03–3.96 | 0.041 |
| Total uterine length | 0.52 | 0.28–0.99 | 0.045 |
| Uterine volume | 2.32 | 1.29–4.19 | 0.005 |
| Uterocervical angle | 1.31 | 1.06–1.63 | 0.012 |

BMI, Body mass index; CI, Confidence interval; IUD, Intrauterine device; Ref, Reference.

determined using the backward LR method (Table 5). The variables remaining in the model (BMI, parity, and cervical length) had no significant effect on IUD displacement ($p = 0.126$, $p = 0.069$, and $p = 0.097$, respectively). However, the presence of vaginal bleeding upon the examination of speculum was associated with an approximately 86.9-fold (95% confidence interval (CI): 1.3–5885.3) increase in IUC displacement compared to patients without signs of bleeding ($p = 0.038$). Each one mm increase in the endometrial cavity length increased IUD displacement by 2.02-fold (95% CI: 1.03–3.96, $p = 0.041$). Each one mm increase in the total uterine length reduced IUD displacement by 0.52-fold (95% CI: 0.28–0.99, $p = 0.045$). Each one $cm^3$ increase in the uterine volume increased IUD displacement by 2.32-fold (95% CI: 1.29–4.19, $p = 0.005$). Each one degree increase in the UCA increased IUD displacement by 1.31-fold (95% CI: 1.06–1.63, $p = 0.012$).

### *3.3 Determination of the Cut-off Value for the UCA*

As shown in Fig. 4, ROC analysis revealed the UCA had significant predictive value for IUD displacement (area under the curve (AUC): 0.865, 95% CI: 0.80–0.93, sample entropy (SE): 0.032, $p < 0.001$). The optimal UCA was found to be 139.5°, giving a sensitivity of 58%, specificity of 94.7%, positive predictive value of 90.7%, and negative predictive value of 72%.

## 4. Discussion

We performed a prospective cohort study to evaluate whether anterior UCA measurement was a predictor of IUD displacement. Our goal was to determine whether copper IUDs could be easily expelled by uterine contractions due to the flattened endometrial cavity and cervical line in the axial plane. The UCA was found to be significantly wider in women with displaced IUDs compared to those with a normal IUD position. Examination of secondary parameters revealed that endometrial cavity length, total uterine length, uterine volume, and vaginal bleeding were all positively correlated with IUD displacement.

Several previous studies have investigated the relationship between uterine sonographic measurements and IUD displacement [5,14,15]. There is still no consensus

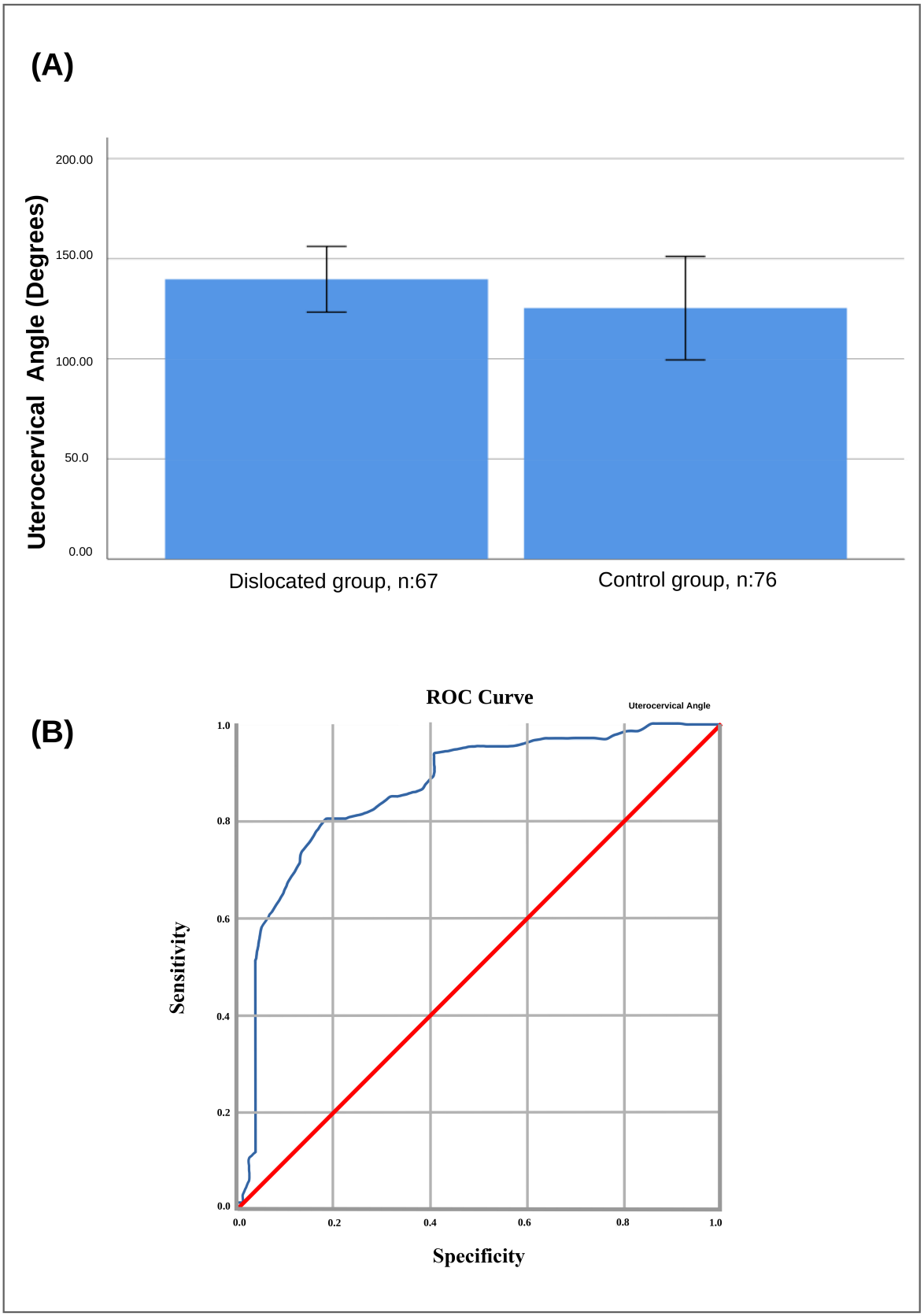


**Fig. 4. Receiver operator characteristic curve and UCA degree averages for patients who underwent copper IUD insertion.** (A) The receiver operator characteristic (ROC) area under the curve was 0.865 with a 95% confidence interval of 0.80–0.93, standard error of the mean (SEM) of 0.032 ($p < 0.001$) and optimal cut-off value for the UCA of 139.5 degrees ($p = 0.007$). (B) Means of the UCA for the two groups. Error bars represent standard errors.

on whether the endometrial cavity length can impact IUD displacement. No statistically significant correlation was found between endometrial cavity length and IUD displacement [5,6,16,17]. In contrast, a study by Castro *et al*. [15] on 970 patients with Multiload (MLCu375) IUD found that pregnancy rates were higher in women with an endometrial cavity length >45 mm. In agreement with the findings of Castro *et al*. [15], we also found an association between longer endometrial cavity length and IUD displacement. We determined that each one mm increase in endometrial cavity length increased IUD displacement by approximately 2.02-fold. The Food and Drug Administration (FDA)-approved copper IUDs are 36 mm in length. This is shorter than the patient's cavity length, hence the IUDs may slide towards the cervix and result in low lying, partial, or total expulsion due to contraction of the uterus. Moreover, the cornual regions and the uterine endometrial cavity do not form a complete "T" shape. The transition in that region may thus vary between patients, resulting in IUD displacement. Three-dimensional ultrasonography of the coronal section and MR imaging methods are crucial for assessing uterine cavity shapes, the embedment of IUD arms, and IUD displacement [17]. As there is still no agreement on this subject, additional comprehensive and randomized controlled prospective trials are needed.

Contradictory data has been published on the correlation between uterine volume and the displacement of IUDs [14,18,19]. Although Moshesh *et al*. [19] found no association between uterine volume and low-lying IUDs, their study was limited by the small sample size. In contrast, another study reported a higher discontinuation rate for levonorgestrel-releasing intrauterine devices (LNG-RIA) in patients with adenomyosis and a larger uterine volume (>150 mL) [14]. Although patients with uterine pathologies were excluded from the present study, we found that each one $cm^3$ increase in uterine volume increased IUD displacement 2.32-fold. These results require confirmation in large prospective cohorts and using different ultrasonographic modalities, such as 3-D ultrasonography or shear-wave elastography methods.

Abnormal vaginal bleeding has been consistently reported as the most frequent presenting symptom in patients with a displaced IUD [19,20]. We found that women presenting with vaginal bleeding during examination had an 86.9-fold increased risk of IUD displacement. The reason for this very high risk is that pathologies causing abnormal bleeding were excluded before enrollment and the outpatient clinic administrations of patients outside of their standard period.

UCA can be used as an ultrasonographic parameter and also appears to be an important anatomical factor in IUD displacement. Our results support the hypothesis that as UCA gets wider, more IUD displacement occurs. Multivariate logistic regression showed that a UCA >139.50 degrees was positively correlated with IUD displacement. The risk of IUD displacement increased 1.31-fold for each additional degree above a UCA of 139.50 degrees. Our results indicate that UCA is a reliable ultrasonographic parameter that can be used by gynecologists for predicting copper IUD displacement.

To our knowledge, the efficacy of UCA in predicting IUD displacement has yet to be reported in the literature. Major strengths of the present study include the comparison with several demographic and ultrasonographic variables, as well as the use of a single sonographer with a standardized protocol for the measurement of uterine dimensions and of all UCA measurements. Our study also has several limitations. First, the Coronavirus disease worldwide affected the number of patients attending their control visits which extended the time of the study. We tried to minimize this risk by using predetermined inclusion and exclusion criteria to screen the participants in our study. Secondly, we could not evaluate embedment as a type of displacement due to the absence of 3-D ultrasonography in our institution.

## 5. Conclusions

In conclusion, UCA measurement with ultrasonography before IUD insertion can be used as a screening tool for predicting the displacement of copper IUDs. UCA can be measured with a simple 2-D ultrasonography device on a standard mid-sagittal transvaginal cervical image. Our results suggest that patients with a UCA >139.5° should be counseled to consider other contraceptive methods, and should be informed about the risk of displacement before IUD insertion. However, further prospective studies with a larger number of patients are required to confirm our findings before reaching a more precise and definitive conclusion.

## Availability of Data and Materials

The datasets used and/or analyzed during the current study ara available from the corresponding author on reasonable request.

## Author Contributions

OK: Project development, Data Collection, Manuscript writing, Supervision; GNKK: Manuscript writing, Data collection; BY: Data collection, processed the images; IY: Data collection, Manuscript writing; AB: Made substantial contributions to conception and design, analyzed the data and interpreted data; IO: been involved in drafting the manuscript/reviewing it critically for important intellectual content, analyzed the data, final approval. All authors contributed to editorial changes in the manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work. All authors read and approved the final manuscript.

## Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Health Sciences University, Istanbul Kanuni Sultan Suleyman Training and Research Hospital (approval number 2020-198). The study followed the ethics standards recommended by the Declaration of Helsinki. All patients gave written informed consent before enrollment.


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## Conflict of Interest

The authors declare no conflict of interest.

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