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Original Article

Comparison of Transvaginal Ultrasound Cervical Length with Bishop Score in Predicting Cesarean Section after Labor Induction

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ABSTRACT

A critical aspect of obstetric care aimed at initiating or augmenting childbirth when natural processes are deemed insufficient or unsafe, employing various methods to ensure maternal and fetal well-being **Objective:** To compare the transvaginal ultrasound cervical length with bishop score in predicting cesarean section after labor induction. **Methods:** A comparative cross-sectional study was conducted at the Department of Gynecology and Obstetrics Azad Jammu Kashmir Medical College (AJKMC), Muzaffarabad from January 2023 to June 2023. A total of 110 pregnant women aged 18 to 35 years having gestational age ≤ 40 weeks were included who underwent transvaginal ultrasound (TVS) for measuring cervical length (CL) measurement and Bishop Score assessment before labor induction. Primary outcomes included cesarean section rates post-induction, with secondary outcomes covering maternal and neonatal variables. **Results:** The study involved 110 participants, with a mean age of 25.9 ± 4.00 years. Mean Bishop Score was 4.53 ± 2.06, and the mean cervical length measured by transvaginal ultrasound was 26.6 ± 7.37 mm. Misoprostol was the primary induction method (65.5%), with an overall Cesarean Section rate of 35.5%. Comparing CS and VD groups, BS was lower in CS (3.74 ± 2.20 vs. 4.96 ± 1.86, p = 0.005), while CL was higher (31.1 ± 6.70 mm vs. 24.1 ± 6.53 mm, p < 0.001). **Conclusions:** Our study found that transvaginal ultrasound (TVUS) measurement of cervical length (CL)>27 mm demonstrated superior predictive ability for cesarean section (CS) following labor induction compared to the Bishop Score (BS)≤5.

INTRODUCTION

Induction of labor, a medical intervention to initiate uterine contractions artificially, has become increasingly common in contemporary obstetric practice [1]. It is used where there is a delayed onset of the natural labor process or where a medical condition requires that the baby be delivered before actual labor. Bennett's case highlights several critical aspects of labor induction: the associated risks for both the mother and fetus, revised calculations according to the gestational age, and the unique conditions of the patient [2, 3]. Induction of labor should be attempted when there are risks associated with continued pregnancy for the mother or fetus. Some of the most frequent indications of a maternal kind include preeclampsia, gestational diabetes, cholestasis, and post-term pregnancy. Fetal indications may include small for gestational age, poor weight gain, range of movement restriction, reduced fluid, and placental dysfunction [4]. In general, induction of labor is nowadays considered safe but as is always the case with any medical procedure, there are not without risks and possible complications. The risks

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may affect the mother and include uterine hyperstimulation. This condition is characterized by the excessive and forceful contraction of the uterus following the administration of a drug or injection. Uterine rupture refers to a tear that occurs in the uterine wall. Postpartum hemorrhage is defined as excessive bleeding that occurs after childbirth. Maternal risks may be further categorized into short-term and long-term risks and include; Pregnancy-induced hypertension, placenta abruption, preterm labor, anemia, mode of delivery, and death. Fetal risks include birth trauma, fetal distress, and NICU admission [5]. Originally, performing cervical length examination has posed some concerns due to its invasiveness; however, with the advancement of transvaginal ultrasound (TVS), assessing cervical length has become much more effective and accurate before labor induction. The non-stiff cervix can be measured accurately with the help of TVS. Short cervical length and poor perinatal outcomes have also been found to be linked to the risk of Cesarean section and hence cervical length measurements using TVS are useful in obstetric practice [6, 7]. The Bishop Score, first introduced in the mid-1960s is a cervical scoring system employed to evaluate the cervix in preparation for artificial rupture of membranes (ARM). The Bishop Score is a tool used in evaluating cervical ripeness, with a higher score being an indication of increased inducibility and successful vaginal birth [9]. This research aims to address the challenge of effectively combining the Bishop Score with transvaginal ultrasound assessment of cervical length (CL) to improve the accuracy of predicting cesarean sections (CS) after labor induction (LI). Detailed data on this cumulative assessment and its predictive value are scarce, particularly in countries like Pakistan, where the risks of cesarean sections are high. Thus, this study is well-positioned to fill this research gap. The findings of this research are useful for clinicians and might help to enhance existing programs thereby improving safety in childbirth as well as the use of resources.

This study aimed to comparison of transvaginal ultrasound cervical length with bishop score in predicting cesarean section after labor induction.

METHODS

The current cross-sectional comparative study was conducted in the Department of Gynecology and Obstetrics of Azad Jammu Kashmir Medical College, Muzaffarabad after getting permission from the respective ethical review board of the hospital (AJKMC/IRB/86) from January to June 2023. Written informed consent to participate in the study was taken from each patient. Pregnant women with age between 18 and 35 years, pregnant with a single baby, and those with gestational age not exceeding 40 weeks formed the target study group under the Inclusion criteria. Exclusion criteria involved multiple pregnancies (twins, triplets), known fetal anomalies incompatible with vaginal delivery, a history of uterine surgery (cesarean section, myomectomy), pre-existing medical conditions complicating labor induction (placenta previa, severe preeclampsia), and an inability to undergo transvaginal ultrasound examination or Bishop Score assessment. The sample size of 110 women was calculated using the WHO calculator taking cesarean section rates post-labor induction based on prior research, a significance level (α) of 0.05, and a power of 80%. Data encompassing demographic and clinical information such as maternal age, gestational age, parity, medical history, and obstetric history were gathered from the medical records of patients. Bishop Score and cervical length (CL) were measured by transvaginal ultrasonography before labor induction. TVS was conducted by experienced sonographers using a high-resolution ultrasound machine (GE Voluson E10, 7.5 MHz). CL was measured in millimeters from the inside to the outside, with the participant in the lithotomy position. The average of three consecutive measurements was recorded. The induction methods included the administration of Misoprostol (25 mcg every 4 hours up to 200 mcg total) for cervical ripening and Oxytocin (starting at 1-2 mU/min, titrated based on response) for labor stimulation. Delivery methods included Cesarean section for indications such as fetal distress or failed induction, and Vaginal delivery for successful inductions or spontaneous labor. The indications for labor induction were determined through a comprehensive review of patient records, including gestational diabetes, antepartum hemorrhage, fetal growth restriction, intra-hepatic cholestasis, intra-uterine demise, oligohydramnios, polyhydramnios, post maturity, preeclampsia, and Rh-negative grade through isoimmunization. Bishop Score assessment was performed by obstetricians using standard criteria, evaluating cervical dilation, effacement, consistency, position, and fetal station. Each parameter in the Bishop Score is scored on a scale from 0 to 3. This includes cervical dilation, effacement, consistency, position, and fetal station. Higher scores indicate increased cervical ripeness and a greater likelihood of successful labor induction. The primary outcome of this study is the rate of cesarean section following labor induction, as predicted by transvaginal ultrasound (TVS) measurement of cervical length (CL) and Bishop Score (BS). The secondary outcome was the determination of the predictive value of a cervical length cutoff of >27 mm compared to a Bishop Score of ≤5 for cesarean section following labor induction, as indicated by the superior predictive ability of CL. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated using standard 2x2 contingency tables comparing predicted outcomes (CS or VD) with actual outcomes. Sensitivity was

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the ratio of true positives to the sum of true positives and false negatives, specificity was the ratio of true negatives to the sum of true negatives and false positives, PPV was the ratio of true positives to the sum of true positives and false positives, NPV was the ratio of true negatives to the sum of true negatives and false negatives, and accuracy was the ratio of the sum of true positives and true negatives to the total number of cases. Statistical analysis was done with IBM SPSS 27. Continuous variables were shown as mean ± SD, whereas categorical variables were shown as frequencies and percentages. The Chi-square test compared categorical variables, while the Mann-Whitney U test examined continuous variables. The Kolmogorov-Smirnov Test determined data normality. To evaluate the predictive value of transvaginal ultrasound-measured cervical length for cesarean section after labor induction, we performed a Receiver Operating Characteristic (ROC) curve analysis. The ROC curve was generated using IBM SPSS version 27.0. The ROC curve plots sensitivity (true positive rate) against 1-specificity (false positive rate) at various threshold settings. The Area Under the Curve (AUC) was calculated to quantify the overall ability of the test to discriminate between those who would require a cesarean section and those who would not. An AUC of 1 represents perfect discrimination, whereas an AUC of 0.5 suggests no discriminative ability.

RESULTS

There were 110 participants in the study, with a mean age of 25.9 ± 4.00 years. Most of the participants were 18-25 years old (n=62, 56.4%), followed by 26-30 years (n=37, 33.6%) and 31-35 years (n=11, 10%). The average Bishop Score was 4.53 ± 2.06 and transvaginal ultrasonography indicated 26.6 ± 7.37 mm cervical length. The majority of participants (n=67, 60.9%) were multigravida and had gestational ages ≤ 40 weeks (n=71, 64.5%). Misoprostol induction predominated (n= 72, 65.5%). The overall prevalence of Cesarean Section was 35.5% (Table 1).

Table 1: Study Participant Characteristics and Outcomes (n = 110)

Variables	n (%) / Mean ± SD
Age Groups (Years)	
18-25	62 (56.4%)
26-30	37 (33.6%)
31-35	11 (10.0%)
Age (Years)	25.9 ± 4.00
Bishop Score	4.53 ± 2.06
Cervical Length (mm)	26.6 ± 7.37
Gravida Status	
Multigravida	67 (60.9%)
Primigravida	43 (39.1%)
Duration of Pregnancy	
≤40 Weeks	71 (64.5%)
>40 Weeks	39 (35.5%)
Period of Gestation (Weeks)	
Mean ± SD	39.5 ± 1.69
Method of Induction	
Misoprostol	72 (65.5%)
Oxytocin	38 (34.55)

Out of all the grounds for induction, the most common ones were foetal growth restriction (9.1%), oligohydramnios (10.9%), intrahepatic cholestasis (14.5%), post-maturity (28.2%), and pre-eclampsia (17.3%). Table 2 showed that less common reasons included factors such as intrauterine death (5.5%), Rh-negative status with isoimmunization (5.5%), antepartum haemorrhage (4.5%), polyhydramnios (0.9%) and gestational diabetes mellitus (3.6%) (Table 2).

Table 2: Reasons for Labor Induction among Study Participants

Indications	n (%)
Gestational Diabetes (GDM)	4 (3.6%)
Antepartum Hemorrhage	5 (4.5%)
Fetal Growth Restriction (FGR)	10 (9.1%)
Intra-Hepatic Cholestasis of Pregnancy	16 (14.55)
Intra-Uterine Demise	6 (5.5%)
Oligohydramnios	12 (10.9%)
Polyhydramnios	1 (0.9%)
Post Maturity	31 (28.2%)
Preeclampsia	19 (17.3%)
Rh-Negative Grade Through Isoimmunization	6 (5.5%)

The majority of scores (55.5%) were in the 4-6 range, with 29.1% scoring above 6. With an average BS of 4.53 ± 2.06, fifteen cases (15.5% of the total) had a BS less than four. The cervical length varied between 15 and 44 mm, with 50.9 percent having a CL less than 25 mm, 25.5 percent between 25 and 30 mm, and 23.6 percent greater than 30 mm. The average CL, as shown in Table 3, was 26.6 ± 7.37 mm (Table 3).

Table 3: Distribution of participants according to Bishop score and TVS measurement of cervical length

Variables	n (%)
Bishop Score	
<4	17 (15.5%)
4-6	61 (55.5%)
>6	32 (29.1%)
Cervical Length	
≤25 mm	56 (50.9%)
25.1 to 30 mm	28 (25.5%)
>30 mm	26 (23.6%)

The average ages of women having a caesarean section (CS) and those having a vaginal delivery (VD) were 25.3 ± 4.02 and 26.23 ± 3.98 years, respectively, with a p-value of 0.312. Compared to the VD group, the CS group had a lower Bishop Score (BS) (3.74 ± 2.20 vs. 4.96 ± 1.86, p = 0.005) and higher cervical length (31.1 ± 6.70 mm vs. 24.1 ± 6.53 mm, p < 0.001). The CS group had 53.8% primigravida compared to 31% in the VD group (p = 0.019). The two groups did not differ

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in gestation period (39.3 ± 1.56 weeks vs. 39.6 ± 1.76 weeks, p = 0.355) or induction method (p > 0.05) (Table 4).

Table 4: Comparison of demographic and clinical parameters between cesarean section (CS) and vaginal delivery (VD) groups

Variables	CS (n=39) n (%)	VD (n=71) n (%)	p-value
Age (Mean ± SD)	25.3 ± 4.02	26.23 ± 3.98	0.312[a]
Bishop Score (Mean ± SD)	3.74 ± 2.20	4.96 ± 1.86	0.005[a]
Cervical Length (mm) (Mean ± SD)	31.1 ± 6.70	24.13 ± 6.53	< 0.001[a]
Gravida Status			
Multigravida	18 (46.2%)	49 (69.0%)	0.019[b]
Primigravida	21 (53.8%)	22 (31.0%)	-
Pregnancy Duration			
≤40 weeks	27 (69.2%)	44 (62.0%)	0.446[b]
>40 weeks	12 (30.8%)	27 (38.0%)	-
Weeks of Gestation (Mean ± SD)	39.3 ± 1.56	39.65 ± 1.76	0.355[a]
Method of Induction			
Misoprostol	26 (66.7%)	46 (64.8%)	0.843[b]
Oxytocin	13 (33.3%)	25 (35.2%)	-

[a] Mann-Whitney U test; [b] Chi-square test.

Table 5 presents the cross-tabulation of mode of delivery with Bishop scores of ≤ 5, indicating 32 (29%) true positive cases and 26 (23.6%) true negative cases. Additionally, the table illustrates that a cervical length cutoff of > 27 mm identified 31 (28.2%) true positive participants and 58 (52.7%) true negative participants.

Table 5: Cross-tabulation of the mode of delivery with Bishop score and Cervical length

Variables		Mode of Delivery	
		Cesarian Section (n=39)	Vaginal Delivery (n=71)
Bishop Score (≤5)	Yes	32	45
	No	7	26
Cervical Length (>27 mm)	Yes	31	13
	No	8	58

The strong predictive ability was indicated by the ROC curve analysis for cervical length (CL), which produced an AUC of 0.797 (95% CI = 0.712-0.881, p < 0.001). The overall accuracy was 80.9% with a sensitivity of 79.5% and a specificity of 81.7% when the CL cutoff was > 27 mm. In contrast, Following IOL, the Bishop Score (BS) showed less predictive power for CS, with an area under the curve (AUC) of 0.347 (95% CI = 0.238-0.456, p = 0.008). Comparison of the AUC of both ROC curves highlighted cervical length (CL) as the superior predictor of Cesarean Section (CS) post-induction of Labor (IOL). CL demonstrated higher specificity (81.7% vs. 36.6%), a greater PPV (70.5% vs. 41.6%), and increased overall accuracy (80.9% vs. 52.7%) compared to the Bishop Score (BS). Comparing the two predictors, we found no statistically significant variations in sensitivities (79.5% vs. 82.1%) or NPV (87.9% vs. 78.8%) (Table 6).

Table 6: Comparison of accuracy of bishop score and cervical length for predicting likelihood of cesarean section

Parameters	Formula	Cervical Length (>27 mm)	Bishop Score (≤5)
Sensitivity	$\frac{TP}{TP+FN} \times 100$	79.5%	82.1%
Specificity	$\frac{TN}{TN+FP} \times 100$	81.7%	36.6%
PPV	$\frac{TP}{TP+FP} \times 100$	70.5%	41.6%
NPV	$\frac{TN}{TN+FN} \times 100$	87.9%	78.8%
Accuracy	$\frac{TP+TN}{TP+TN+FP+FN} \times 100$	80.9%	52.7%

Where: TP = True Positives, TN = True Negatives, FP = False Positive, FN = False Negatives

Figure 3 ROC curve illustrates the diagnostic performance of cervical length measurement in predicting cesarean section after labor induction. The y-axis represents sensitivity (true positive rate), and the x-axis represents 1-specificity (false positive rate). The Area Under the Curve (AUC) is 0.797 (95% CI: 0.712-0.881) with a p-value of <0.001, indicating a significant predictive value (Figure 1).

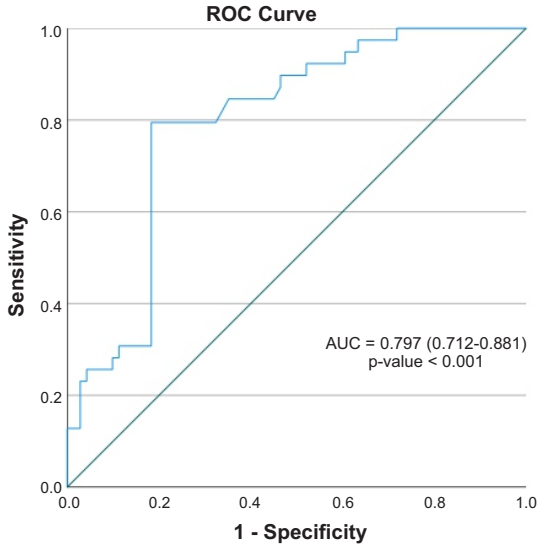

Figure 1: ROC Curve for Predicting Cesarean Section Based on Transvaginal Ultrasound Measured Cervical Length

The ROC curve for the Bishop score-predicted cesarean section is shown in Figure 4. The curve demonstrates the trade-off between sensitivity and specificity for different threshold values. The AUC of 0.347 (95% CI: 0.238-0.466) indicates that the model has limited discriminative ability. The p-value of 0.008 suggests that the model's performance is significantly different from random guessing, although the overall performance is poor. The x-axis represents 1–Specificity1–Specificity (also known as the False Positive Rate). The y-axis represents Sensitivity (also known as the True Positive Rate). Both axes are unitless as they represent proportions or probabilities ranging from 0 to 1 (Figure 2).

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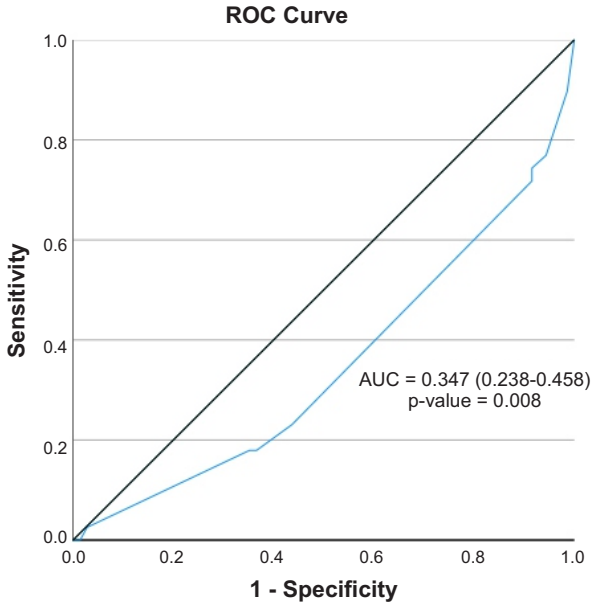

Figure 2: Bishop Score-Predicted Cesarean Section ROC Curve

DISCUSSION

In Cesarean sections following induction of labor, TVS (transvaginal ultrasound) of cervical length (CL) provides crucial insights into cervical readiness, aiding in assessing the feasibility of vaginal delivery. Adding CL measurements to the Bishop Score improves the accuracy of the decisions to be taken to get the best deliveries possible [10]. In the primary findings of our study, the average age of the respondents was 25 years. 60% of them are within the ages of 18-25 years, whereas the rest is equally distributed within the remaining age bracket of the next three decades. This stands in agreement with what Sinha *et al.*, conducted, which stated that the mean age was 25 years. Years of work was 56 years and the majority of them were in the age group of 20-25 years (56.7%) [11]. Nikbakht *et al.*, however, reported a slightly lower mean age of 25.5±4.4 years among their participants. Regarding gravidity, our study predominantly included multigravida participants (60.9%), which is consistent with the findings of Nikbakht *et al.*, where 59.5% of the participants were nulliparous [12]. Sinha *et al.*, reported a higher proportion of multigravida participants (57.5%) compared to primigravida and grand multigravida individuals. Interestingly, our study had a higher percentage of participants with a gestational age of ≤ 40 weeks (64.5%) compared to Sinha *et al.*, findings. The prevalent use of misoprostol for induction in our study (65.5%) aligns with their observation of 65.8%. In our analysis, 28.2% of inductions were for post-maturity, which is consistent with Sinha *et al.*, findings (28.3%). Additionally, our study's mean cervical length of 26.6 ± 7.37 mm is comparable to Nikbakht *et al.*, median cervical length of 24.5 ± 7.9 mm among pregnant women undergoing pregnancy termination [11, 12]. Both our study and Sinha *et al.*, found a predominant proportion of cases with a Bishop score falling within the moderate range (55.5% and 55.8%, respectively), indicating moderate cervical readiness. Similarly, a comparable percentage of cases had a cervical length of 25 mm or less (50.9% in our study, 51.7% in Sinha *et al.*, suggesting potential challenges in induction[11,12]. In our study, mean ages were comparable between Cesarean Section (CS) and Vaginal Delivery (VD) groups (25.3 ± 4.02 years vs. 26.23 ± 3.98 years, p = 0.312), whereas Kamran *et al.*, found a significant higher mean age in the CS group (30.21 ± 4.55 years) compared to the VD group (28.32 ± 4.87 years). Additionally, our CS group had a significantly lower Bishop Score (BS) compared to the VD group (3.74 ± 2.20 vs. 4.96 ± 1.86, p = 0.005), contrasting with Kamran *et al.*, findings of a higher mean cervical length in the CS group (27.95 ± 7.24 mm) compared to the VD group (24.85 ± 7.68 mm). Both studies reported a higher proportion of primigravida in the CS group, reflecting potential obstetric risk factors [13]. The findings of the current study align with Kamran *et al.*, who reported 48% true positive and 13.74% true negative patients using a Bishop Score > 5. In contrast, cervical length with a cutoff of < 27 mm showed higher true positives (53.43%) and true negatives (22.14%). Similarly, our study found cervical length (CL) to be a better predictor, with an AUC of 0.797, 79.5% sensitivity, 81.7% specificity, 70.5% PPV, and 87.9% NPV, compared to the Bishop Score (BS) with lower predictive power (AUC of 0.347). Kamran et al., also noted higher sensitivity (87.5% vs. 80.0%) and specificity (56.86% vs. 35.29%) for CL, reinforcing that CL is more accurate for predicting successful labor induction [13]. Our study's findings regarding cervical length corroborate those of the Al-Adwy *et al.*, study where the mean cervical length was significantly lower in women with successful induction of labor (28.76 ± 3.93 mm) compared to those with unsuccessful induction (34.67 ± 2.40 mm). This consistency underscores the clinical significance of cervical length as a predictive factor in labor induction outcomes [14]. Current study found no significant associations between maternal age, gestational duration, or induction method with delivery mode. However, a notably higher cesarean rate was observed in primigravida (48.9%) compared to multigravida (27.4%), consistent with findings by Cubal *et al.* This underscores parity's influential role in determining delivery mode, warranting further investigation for tailored obstetric management strategies [15]. Using a Bishop Score (BS) cutoff of ≤ 5, we observed 82.1% sensitivity, 36.6% specificity, 41.6% PPV, 78.8% NPV, and 52.7% accuracy. In comparison to Hafeez *et al.*, our study demonstrated higher specificity (81.7% vs. 59%) and NPV (87.9% vs. 80%) for CL, indicating its enhanced ability to correctly identify cases not requiring CS following IOL [16]. Agrawal *et al.*, reported lower sensitivity (67.57%) and specificity (65.38%) for BS, contrasting with our findings

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for both predictors [17]. Similarly, Wajid *et al.*, showed inferior specificity (58.9%) and PPV (76%) for CL compared to our study, suggesting variations in predictive performance across different populations [18]. Our study supports findings from Iftikhar *et al.*, who noted that TVS outperforms the Bishop Score in predicting successful labor induction, with TVS showing higher accuracy and F1 Score. Similarly, Chauhan *et al.*, reported that cervical length is more predictive of successful induction compared to the Bishop Score, a result consistent with our higher sensitivity and specificity for cervical length [19, 20]. In contrast to Bahadori *et al.*, who found the Bishop Score to have higher sensitivity (77%) and lower specificity (56%) compared to cervical length (66% sensitivity, 76% specificity), our study found cervical length to be superior overall, with an accuracy of 80.9%, sensitivity of 79.5%, and specificity of 81.7% [21]. Study strengths include the robust sample size, precise methodology adhering to standardized protocols, and comprehensive analysis employing receiver operating characteristic (ROC) curve assessment. Study limitations involve the lack of diversity in the study population and limited generalizability to different healthcare settings.

CONCLUSIONS

Our study found that transvaginal ultrasound (TVUS) measurement of cervical length (CL) >27 mm demonstrated superior predictive ability for cesarean section (CS) following labor induction compared to the Bishop Score (BS) ≤5. This highlights the potential of CL measurement as an objective, reliable tool for better predicting CS likelihood and optimizing labor induction decisions.

Authors Contribution

Conceptualization: NS

Methodology: HP, NS, RA, SK

Formal analysis: IA, SH

Writing review and editing: HP

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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