Accuracy of Transvaginal Ultrasound Parameters and Bishop Score as Predictors of Successful Induction of Labor in Term High-Risk Pregnancy

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ABSTRACT

Background

Induction is one of the most common interventions in obstetrics practice, accounting for 1.4-35%. Cervical favorability is crucial for successful induction. The Bishop score is simple and assesses preinduction cervical favorability based on five components. However, it has high inter- and intra-observer variability. Alternative objective methods are transvaginal ultrasound parameters (e.g., cervical length, width, and funneling).

Objective

To assess and compare the predictive value of transvaginal ultrasound and bishop score for vaginal delivery. In addition, the time interval from induction to delivery in women undergoing induction of labor.

Method

This prospective cross-sectional study included 342 pregnant women, in whom induction of labor was performed at 38-42 weeks of gestation. Cervical length, funneling, and width from transvaginal sonography and bishop scores by digital examination are assessed prior to induction in high-risk cases according to standard protocol.

Result

In our study, both transvaginal cervical length and bishop score showed similar predictors of successful labor induction, i.e., vaginal delivery. The ROC curve for cervical length showed an optimal cut-off value of ≤ 32 mm, corresponding to a sensitivity of 64.2% and a specificity of 60.0%, whereas the optimal cut-off value for Bishop score was ≥ 5, with a sensitivity of 65.1% and a specificity of 62.0%. However, cervical width and the presence of cervical funneling did not correlate. Both cervical length and Bishop score had a significant correlation as predictors of successful induction, with an OR of 0.93 (95% CI 0.91-0.96), an AOR of 0.96 (955 CI 0.9-0.99), and an OR of 1.41 (95% CI 1.2-1.6) and an AOR 1.2 (95% CI 1.1-1.5), respectively.

Conclusion

Cervical length and bishop score are both good and equally predict of successful induction of labor.

KEY WORDS

Bishop score, Cervical length measurement, Labor induction, Obstetric delivery

INTRODUCTION

Induction implies the stimulation of contractions before the spontaneous onset of labor. It is indicated when the benefits to either the mother or fetus outweigh those of pregnancy continuation. Induction of labor is increasingly being carried out in obstetric units for varying indications.[1] Worldwide, roughly 1.4-35% of all deliveries occur after the induction of labor.[2-4] Several factors affect the ability of labor induction to achieve vaginal delivery.[5,6] Among them, cervical changes are a significant component, since some desirable characteristics of the uterine cervix at the time of labor induction would easily advance into labor and then result in vaginal birth.[7-9]

The traditional method of predicting whether an induced labor will result in successful vaginal delivery is based on the preinduction favorability of the cervix as assessed by bishop score. Professor Emeritus of Obstetrics and Gynecology, Edward Bishop, first published the bishop score in August 1964.[10] Manual vaginal examination is done to assess the five components. The maximum score of 13 and more than 8 is favorable for induction of labor, such that over 90% of women gave birth vaginally.[1,4] However, despite its simplicity and ease of performance, there are concerns about its accuracy due to its subjective nature and its high inter- and intra-observer variability.[11-13]

In women undergoing total hysterectomy, Jackson et al. measured cervical length preoperatively, both digitally and by transvaginal ultrasound. After surgery, for comparison purposes, cervical length was measured with a ruler; it appeared that digital examination significantly underestimated cervical length by an average of 13.6 mm compared with the ruler measurement.[14] This has led researchers to search for alternative methods that may be more objective.

Recently Transvaginal ultrasound parameters such as cervical length, cervical width, and funneling are reported to be better than the bishop score to predict the success of induction of labor. Unlike the bishop score, transvaginal ultrasound allows visualization of the cervix and measures the cervical length quantitatively without much inter-observer variation.[14,15] The supra-vaginal portion of the cervix represents 50% of the cervical length.[16] Also, studies have shown that cervical effacement begins in the internal os and progresses downward to the external os. Hence, the assessment of bishop score in the closed cervix is difficult digitally.[17]

This study was designed to evaluate and compare the predictive value of transvaginal ultrasound and bishop score for vaginal delivery and the time interval from induction to delivery in women undergoing induction of labor. If such evidence becomes available, clinicians will be guided appropriately in order to optimize the outcome of labor induction and counsel patients regarding the process and the success or failure of vaginal delivery.

METHODS

This is a prospective cross-sectional study that was carried out from September 2023 to March 2024 at the Dhulikhel Hospital's high-risk pregnancy obstetric department. The institutional review committee of Kathmandu University School of Medical Sciences (IRC, KUSMS) has obtained ethical approval for it, and it is registered under research ID IRC-KUSMS:155/23.

The sample size was determined by using the Wan Nor Arifin sample size calculator.[18] Based on research by Abdullah et al., which acquired a 70% incidence of vaginal deliveries following labor induction, transvaginal sonographic assessment of cervical length demonstrated accuracy with 69.1% sensitivity, 60.9% specificity with a 10% expected drop, 10% precision, and a 95% confidence interval.[19] The final sample size was 308, and after expecting a 10% dropout, the sample size was 343. However, we successfully recruited 342 patients with no dropouts.

The inclusion criteria for the study were meticulously designed to include a wide range of pregnant women. It included those of any age or parity, at 38 to 42 weeks of gestation, with a single fetus in cephalic presentation, intact membranes, and an adequate pelvis. The obstetric indications are: low normal amniotic fluid levels, polyhydramnios, gestational diabetes, and gestational hypertension. Maternal medical conditions such as pregestational hypertension, diabetes, and hypothyroidism. Fetal indications: intrauterine growth restriction without doppler abnormalities.

The exclusion criteria listed are: a gestational age of less than 38 weeks, a patient already in the latent phase of labor, maternal fetal complications (cephalopelvic disproportion, placenta previa, vasa previa), maternal (a previous cesarean or any history of hysterotomy, active genital herpes, invasive cervical cancer, cardiac, renal, respiratory, autoimmune, and hematological disease, known allergy to prostaglandins), fetal (multifetal pregnancies, malpresentations, extreme low birth weight < 1500 gm or macrosomia > 4000 gm, fetal anomaly, intrauterine fetal death)

Both verbal and written informed consent were obtained by the primary investigator. Printed pro-forma was used to collect patient characteristics.

The primary investigator performed all transvaginal ultrasonography for cervical measures prior to induction of labor. The vaginal examination for bishop scoring (Table.1) was done by resident doctors who were blinded to the results of transvaginal ultrasound assessments.

After emptying the bladder, participants were examined in the dorsal lithotomy position. The cervical canal and surrounding cervical mucosa were identified. We made sure the pressure from the probe on the cervix was as little as possible. The image was magnified so that the cervix

Table 1. Bishop score

	0	1	2	3
Position	Posterior	Middle	Anterior	-
Consistency	Firm	Intermediate	Soft	-
Effacement	0-30%	40-50%	60-70%	≥ 80%
Dilatation	0 cm	1-2 cm	3-4 cm	≥ 5 cm
Station	-3	-2	-1,0	+1, +2

occupied approximately 50-75% of the image. In a sagittal plane, the length of the cervix was measured from the outer to the inner cervical os as a straight line. In a curved cervix, measurements were obtained in two or more added segments. Three measurements of cervical length were taken over a period of three minutes, and the best and shortest measurement was recorded. The cervical width (A-P) was measured midway between the length of the cervix and the internal os. (Fig. 1) The presence of funneling was also documented, which was a funnel-shaped appearance at the internal cervical os due to internal os dilatation, measuring at least 5 mm (Fig. 2).

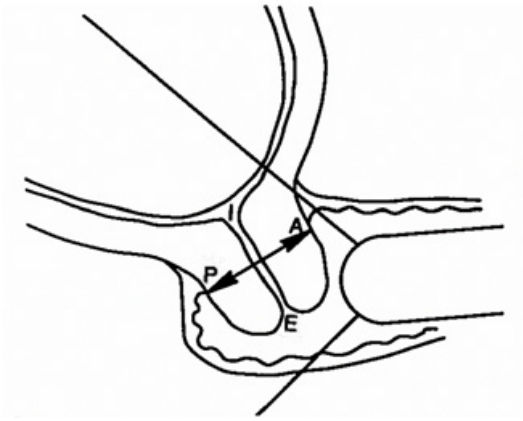

Figure 1. Transvaginal ultrasound method of measurement of cervical width.

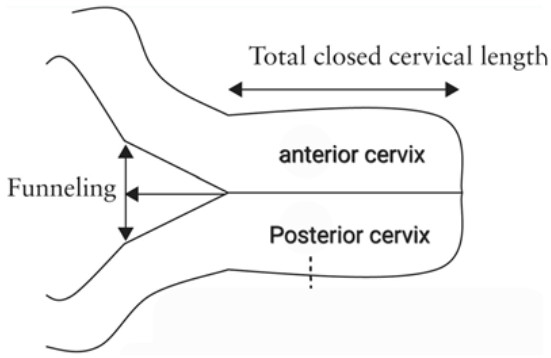

Figure 2. Transvaginal ultrasound measurement for cervical length and funneling

Induction drugs were administered in according with Dhulikhel Hospital protocol: Tab misoprostol 25 mcg with a maximum of three doses six hours apart per vagina, followed by either a Foley catheter (40 cc inflated with sterile water) or Inj syntocin 1-2 mIU/min, increased at intervals of 30 min, aiming for four to five contractions in ten minutes. The induction with Foley's was only done if the cervical os dilatation was less than two centimeters. Amniotomy was done if it was needed. The primary outcome evaluated the association of the cervical length by transvaginal ultrasound scan and bishop score in predicting successful vaginal delivery. The reason for the Caesarean delivery was either fetal distress (abnormal fetal heart rate, moderate to thick meconium stain liquor) or the failure of induction of labor, which is defined as the inability to achieve the active phase of labor (cervical dilatation of > 4 cm) after 24 hours of prostaglandin administration ± 12 hours of oxytocin infusion, or the non-progress of labor, which is defined as less than two centimeter of cervical dilatation after four hours of oxytocin, and prolong second stage of labor (two hours for primigravida and one hour of multigravida)

The secondary outcomes evaluated were the variables associated with successful vaginal delivery and induction to delivery time.

Data was analyzed using statistical software SPSS (Version 27.0; Armonk, NY: IBM Corp.). For descriptive analysis, the means, standard deviation, median, and interquartile range (IQR) were calculated. The Shapiro-Wilk test was used to evaluate the normality of the data variables. Inferential analysis was done using the Independent Samples t-test for continuous parametric variables, the Mann-Whitney -U test for non-parametric variables, and Fisher's exact test for categorical data. An analysis via the Receiver Operator Characteristics (ROC) curve was performed to evaluate the optimal threshold value for cervical length measurement and Bishop score in predicting the success of induction of labor, i.e., vaginal delivery. The area under the curve (AUC) and the respective confidence intervals (CI) were obtained. A p-value of < 0.05 was considered statistically significant. Univariate and multivariate logistic regression analyses were performed to determine the relationship between successful induction of labor and various variables.

RESULTS

A total of 342 women were recruited and analyzed. Among them, 180 (52.63%) were nulliparous, and 162 (47.37%) were multiparous. The mean age was 26.8±4.8 years, and the mean gestational age was 39.1±1.8 weeks. The indications for induction of labor in descending order were: post-dated 108 (31.7%), hypothyroidism 103 (30.2%), low normal AFI 51 (15.0%), gestational hypertension 35 (10.2%), gestational diabetes mellitus 23 (6.7%), decreased fetal movement 18 (5.2%), intrauterine growth restriction 19 (5.5%), Rh negative 15 (4.4%), bad obstetric history 9 (2.6%), chronic hypertension 7 (2.0%), intrahepatic cholestasis of pregnancy 4 (1.1%), oligohydramnios 2 (0.5%), and preeclampsia 2 (0.5%).

Table 2. Maternal demographic characteristics between vaginal delivery and cesarean section

Variables	Vaginal delivery n= 232	Cesarean section n=110	p-value
Age, in years old (Mean, SD)	26.5 ± 4.8	27.5 ± 4.7	0.08
< 20 n (%)	10 (4.3%)	8 (7.3%)	0.28
20-34 n (%)	208 (89.7%)	92 (83.6%)	
≥ 35 n (%)	14 (6.0%)	10(9.1%)	
Height in cm (Mean, SD)	153.1 ± 6.1	153.4 ± 5.6	0.78
≤ 145 n (%)	18 (7.76%)	8 (7.34%)	0.88
> 145 n (%)	214 (92%)	101 (92.6%)	
BMI (Mean, SD)	24.2 ± 4.1	25.5 ± 4.8	0.01
Current weight (Mean, SD)	68.8 ± 11.2	71.5 ± 12.8	0.04
Parity (Median, IQR)	0.7± 0.8	0.4±0.8	0.005
Gestational weeks	274.25±14.296	274.42±7.884	0.906
Expected fetal weight by scan in grams	2970.83+/-422.6	3103 ±406.7	0.007

Analysis was done by independent t-test for continuous parametric variables, Mann-Whitney U test for non-parametric variables, Fisher's exact test for categorical data.
Standard deviation (SD)
Interquartile range (IQR)

Table 2 displays the maternal demographic differences between vaginal births and cesarean sections. There was no statistically significant difference among the vaginal and cesarean section delivery groups in terms of mean maternal age and height. Women who underwent cesarean section had a higher mean BMI (25.5 ± 4.8 vs. 24.2 ± 4.1 kg/m^2, p = 0.01). Higher parity resulted in successful vaginal delivery, with a median parity of 0.7 (IQR: 0.8) for vaginal delivery and 0.4 (IQR: 0.8) for cesarean section (p = 0.005). In all the indications for induction of labor (Table 3), there was no statistically significant difference except for a decrease in fetal movement (9 vs. 10 numbers, p = 0.04).

Out of the 342 women, 232 (67.8%) had a vaginal delivery due to successful induction of labor; the remaining 110 (32.2%) had cesarean sections for a variety of reasons, such as fetal distress 47 (42.7%), failed induction of labor 45 (40.9%), non-progress of labor 7 (6.6%), cephalopelvic disproportion 4 (3.6%), prolonged second stage of labor 6 (5.5%), and impending eclampsia (Table 4).

When comparing the transvaginal measurements for the correlation between normal delivery and cesarean section, there was a significant degree of relationship between the bishop score and cervical length. Cervical width and the presence of cervical funneling, however, did not correlate. (Table 5).

While there was no significant difference in the total amount of inj syntocin and misoprostol dosages, a smaller number of women with vaginal delivery were induced using foleys. Both the fetus's weight and the induction to delivery duration were noticeably short in vaginal birth. (Table 6 and Table 7).

Table 3. Indication of induction of labor between vaginal delivery and cesarean section

Indications	Vaginal delivery n (%)	Cesarean section n (%)	p-value
Post dated	77 (33.1)	31 (28.1)	0.35
Hypothyroidism	70 (30.2)	33 (30.0)	0.97
Low normal AFI	36 (15.5)	16 (14.6)	0.81
Gestational hypertension	26 (11.2)	9 (8.2)	0.38
Gestational diabetes mellitus	14 (6.03)	9 (8.2)	0.45
Intrauterine growth restriction	13 (5.6)	7 (6.3)	0.76
Decrease fetal movement	9 (3.9)	10 (9.1)	0.04
Rh negative	10 (4.3)	5 (4.5)	0.92
Bad obstetric history	5 (2.6)	4 (3.2)	0.43
Chronic hypertension	5 (2.2)	3 (2.7)	0.74
Intrahepatic cholestasis of pregnancy	1 (0.4)	3 (2.7)	0.15
Oligohydramnios	1 (0.4)	1 (0.9)	0.58
Preeclampsia	1 (0.4)	1 (0.9)	0.27

Table 4. Indication for cesarean sections

Indications	Number (110)	%	Stage of labor	Number	%
Fetal distress	47	42.7	LPOL	33	70.2
			APOL	13	27.7
			Fully dilated	1	2.1
Failed induction of labor	45	40.9	LPOL	45	
Non progress of labor	7	6.4	LPOL	3	42.9
			APOL	4	57.1
Cephalopelvic disproportion	4	3.6	LPOL	2	50.0
			APOL	2	50.0
Prolonged second stage of labor	6	5.5	Fully dilated	6	
Impending eclampsia	1	0.9	LPOL	1	

Latent phase of labor (LPOL), active phase of labor (APOL)

The ROC curves were constructed to determine the optimal cut-off value of cervical length and Bishop score to predict a successful induction of labor (Fig. 3 and 4). There was a significant relationship between these variables and the prediction of vaginal delivery, as both curves were above the 45˚ line. The curve for cervical length showed an optimal cut-off value of ≤ 32 mm, corresponding to a sensitivity of 64.2% and a specificity of 60.0%, whereas

Table 5. **Correlation between bishop score and cervical parameters with mode of delivery**

		Vaginal delivery	Cesarean section	p-value
BISHOP score (Median, IQR)		5(2)	4(2)	0.000
Cervical length in mm (Mean,SD)		29.6±8.7	35.2±9.6	0.000
Cervical funneling	Present n (%)	33 (14.2)	11 (10)	0.276
	Absent n (%)	199 (85.8)	99 (90)	
Cervical width in mm (Mean, SD)		35.9±6.1	36.2 ±5.8	0.690

Table 6. **Method of induction**

Method of inductions	Vaginal delivery	Cesarean section	p-value
Misoprostol doses 25 mcg n (%)			0.23
0	1 (0.43)	0 (0)	
1	121 (52.16)	52 (47.2)	
2	107 (46.12)	53 (48.18)	
3	3 (1.29)	5 (4.55)	
Foleys induction n (%)	24 (10.39)	27 (24.55)	0.001
Syntocin augmentation pint (Mean, SD)	1.1±0.8	1.1±0.9	0.609

Table 7. **Induction and delivery parameters between groups.**

	Vaginal	Cesarean	p-value
Induction to delivery time hours (Mean SD)	16.9 ± 6.3	19.7 ± 7.4	0.000
Baby weight in gms (Mean, SD)	3034.6 ± 427.6	3156 ± 481.3	0.01

the optimal cut-off value for Bishop score was ≥ 5, with a sensitivity of 65.1% and a specificity of 62.0% (Table 8). The area under the curve (AUC) for cervical length and Bishop score were similar at 0.663 (95% CI 0.600-0.726) and 0.667 (0.608-0.727), respectively, and both were highly significant with a p-value of < 0.001.

A multivariate logistic regression analysis was performed to evaluate the relationship between various variables and the successful induction of labor (Table 9). The degree of the association was determined by the p-value for the odds ratio (OR) and the adjusted odd ratio (AOR). OR and AOR > 1 demonstrate a positive association, such that an increase in value would result in higher success of induction of labor, whereas an OR and AOR < 1 indicate a negative correlation, meaning a decrease in value would result in lower success of induction of labor. Both cervical length and Bishop score had a significant correlation as predictors of successful induction, with an OR of 0.93 (95% CI 0.91-0.96), an AOR of 0.96 (955 CI 0.9-0.99), and an OR of 1.41 (95% CI 1.2-1.6) and an AOR 1.2 (95% CI 1.1-1.5), respectively. Other significant factors for predicting vaginal delivery included BMI, induction, and delivery duration.

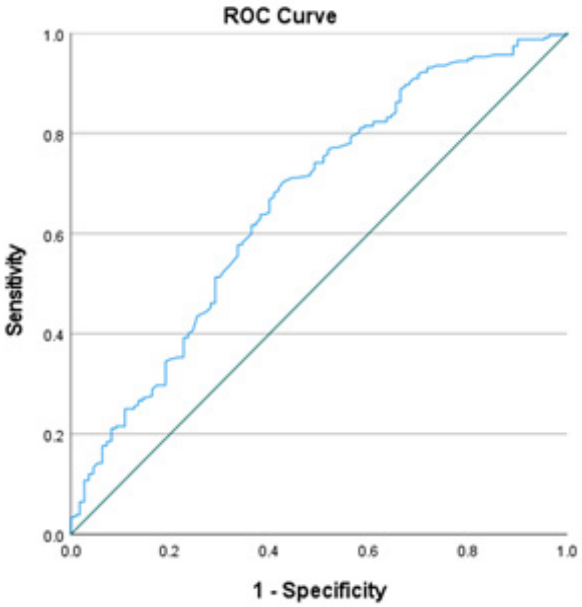

Figure 3. **Receiver operating curves for cervical length**

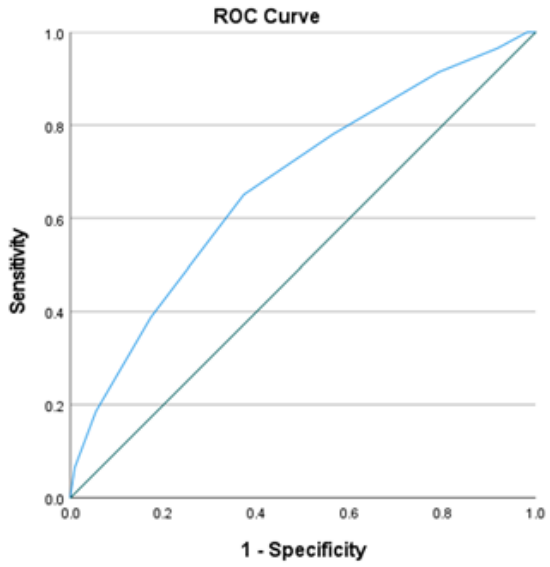

Figure 4. **Receiver operating curves for bishop score**

DISCUSSION

Our research demonstrated that the bishop score and transvaginal cervical length are equally good predictors of the success of labor post-induction, i.e., vaginal delivery. Based on the analysis obtained from the ROC curves, a threshold value ≤ 32 mm of cervical length measured by transvaginal ultrasound and Bishop score ≥ 5 was associated with successful induction of labor (p < 0.001) with similar AUCs of 0.663 and 0.667, respectively. This is consistent with earlier research that revealed a comparable prediction (Table 10). However, each study's cut-off values are different. In our study, the cervical length was the longest in comparison to previous studies. The cause of it might be different. The inclusion weeks of gestation in our

Table 8. ROC corresponding, AUC, sensitivity, specificity and significance

		Sensitivity	specificity	Area under curve (95%CI)	Standard error	P value
Cervical length (mm)	≤20	14.7	93.6	0.663 (0.600-0.726)	0.032	0.000
	≤25	27.6	83.6			
	≤26	32.3	80.9			
	≤27	35.3	77.3			
	≤28	43.5	74.5			
	≤29	48.7	70.9			
	≤30	55.6	66.4			
	≤31	59.9	63.6			
	≤32	64.2	60.0			
	≤33	68.5	58.2			
	≤34	72.8	50.9			
	≤35	75.4	49.1			
Bishop score	≥2	96.6	6.5	0.667 (0.608-0.727)	0.034	0.000
	≥3	91.4	19.4			
	≥4	78.0	42.6			
	≥5	65.1	62.0			
	≥6	38.8	82.4			
	≥7	18.5	94.4			
	≥8	6.5	99.9			

Table 9. Relationship between various variables and vaginal delivery

Variables	OR	95% CI	P value	AOR	95% CI	P value
Bishop score	**1.4**	**1.2,1.6**	**0.001**	**1.2**	**1.1,1.5**	**0.002**
Age	0.95	0.91,1.0	0.08	0.97	0.91, 1.03	0.42
BMI	**0.93**	**0.88,0.98**	**0.01**	0.96	0.9,1.02	0.25
Parity	1.1	0.6,2.3	0.64	1.2	0.53,2.8	0.61
TVS cervical length	**0.93**	**0.91,0.96**	**0.001**	**0.96**	**0.9,0.99**	**0.01**
Funneling	1.4	0.72,3.0	0.27	0.81	0.33,1.9	0.65
Induction to delivery duration	**0.94**	**0.90,0.97**	**0.001**	**0.95**	**0.91,0.99**	**0.02**

study were 38 weeks of gestation. The medicine protocol we used for induction of labor is different from other studies. Some studies have found cervical length to be a better predictor than the Bishop score.[15,16,20-28] and three studies have shown bishop score to be a better predictor.[29-31]

While doing a per-vaginal digital examination of a patient with closed cervical os, the effacement is difficult to measure. The sonographic research has shown that the cervical effacement begins at the internal os and proceeds downwards, subsequently allowing the protrusion of the fetal membrane into the upper cervical canal, i.e., funneling. Funneling was seen in 44 patients. However, our

Table 10. Comparable of cut off value of similar studies.

Name of author and year	N	Weeks of gestation	Medication used for IOL	Cut-off value
Abdullah et al.[19]	294	37-42	NA	Bishop score ≥ 4 Cervical length ≤ 26 mm
Alanwar et al.[32]	320	37-42	Misoprostol 50 mcg 4 doses maximum with injection oxytocin	Bishop score mean 5 Cervical length 23 mm
Bastani et al.[33]	200	37-42	NA	Bishop score ≥ 4 Cervical length 19 mm
Ware et al.[16]	77	≥ 37	Misoprostol 25 mcg 4doses max with injection oxytocin	Bishop score > 4 Cervical length < 30 mm

study failed to show any correlation with the presence of funneling to predict vaginal delivery with an OR of 1.4, a 95% CI of 0.72-3.00, and a p value of 0.27. Keepanasseril et al. demonstrated a lack of association between funneling and successful vaginal birth (OR 1.018, 95% CI 0.975-1.063; p = 0.415).[34]

Since the results of both methods were comparable. Both approaches can be used independently, depending on the settings and availability of the ultrasound machine. With the growth of urbanization and all the modern amenities, ultrasound plays a major role. It provides an objective assessment of cervical length. Images obtained through transvaginal ultrasound can serve as visual aids during patient counseling. Showing the patient the cervical status and explaining the implications can enhance their understanding and facilitate shared decision-making. The images can be saved digitally or printed for documentation purposes in the future and add value in medicolegal situations. Additionally, medical students, midwives, and other healthcare professionals who might not have much expertise doing the Bishop cervical scoring might utilize these photographs as a teaching aid.

Nevertheless, not all health centers have access to transvaginal ultrasounds. It requires trained expertise and is costly. In such situations, the Bishop scoring system remains a reliable method for assessing cervical readiness for labor induction.

The limitation of our study was that it's a single center-based study that included all high-risk pregnant women only. Hence, the findings may not apply universally. Patient populations, local practices, and resources can vary significantly across centers. The Bishop score was calculated by multiple doctors. The medication for induction of labor differs from what other institutes use.

CONCLUSION

In a setting where transvaginal ultrasound is available, we suggest utilizing transvaginal ultrasonographic measurement of cervical length as an adjunct or even alternative to bishop score. This is more so in cases where in cervical os is closed. However, where transvaginal sonography and skilled personnel are unavailable Bishop score is as effective to predict success of induction of labor. Hence, prior to general recommendation of this approach, cost effectiveness studies will be necessary.

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