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Ultrasound-Derived Cervical Volume Outperforms Bishop Score in Predicting Successful Labour Induction at Term: A Prospective Observational Study

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ABSTRACT

Background: Accurate prediction of successful labour induction remains a major challenge in obstetric practice. Although the Bishop score is widely used for pre-induction cervical assessment, its predictive value is limited by subjectivity and interobserver variability. Ultrasound-derived cervical parameters, particularly cervical length and cervical volume, may provide more objective and reproducible measures of cervical readiness. This study evaluated the predictive performance of cervical volume for successful labour induction at term and compared it with cervical length and the Bishop score.

Methods: This prospective observational study was conducted in the Department of Obstetrics and Gynaecology, Tata Main Hospital, Jamshedpur, India, between May 2023 and May 2024. Seventy-eight term pregnant women undergoing induction of labour were enrolled consecutively. Pre-induction assessment included modified Bishop score and transvaginalultrasonographic measurement of cervical length and cervical diameter.

Results: Successful induction resulting in vaginal delivery was achieved in 57 women (73.1%), whereas 21 women (26.9%) underwent caesarean delivery following failed induction. Women with successful induction had significantly higher Bishop scores (3.07 ± 1.08 vs. 2.29 ± 0.95; $p=0.004$), shorter cervical lengths (3.09 ± 0.41 cm vs. 3.61 ± 0.39 cm; $p<0.001$), and smaller cervical volumes (18.79 ± 6.49 cm³ vs. 26.06 ± 6.25 cm³; $p<0.001$) than those with failed induction.

Conclusions: Ultrasound-derived cervical parameters outperform the Bishop score in predicting successful labour induction at term. Cervical length demonstrated the highest overall predictive accuracy, while cervical volume emerged as an independent predictor with excellent specificity.

Keywords*: Labour induction; Cervical volume; Cervical length; Bishop score; Transvaginal ultrasonography; Vaginal delivery; Prediction; Obstetrics.*

INTRODUCTION

Labour induction is one of the most frequently performed interventions in contemporary obstetric practice and accounts for a substantial proportion of deliveries worldwide. Over the past two decades, the rate of induction of labour (IOL) has increased steadily owing to expanding maternal and fetal indications, improved fetal surveillance, and growing evidence supporting planned delivery in selected high-risk pregnancies. Current estimates indicate that labour induction is performed in approximately 20–30% of pregnancies in many developed countries, making it one of the most common obstetric procedures globally [1,2]. Induction is recommended when the risks associated with continuation of pregnancy outweigh those of delivery, including conditions such as post-term pregnancy, hypertensive disorders of pregnancy, diabetes mellitus, oligohydramnios, fetal growth restriction, and premature rupture of membranes [3,4]. Despite advances

in induction protocols and cervical ripening agents, the success of induction remains highly variable and continues to represent a major clinical challenge.

Accurate prediction of induction success is clinically important because failed induction is associated with prolonged labour, increased maternal discomfort, higher healthcare costs, increased use of oxytocin and analgesia, operative vaginal delivery, and a greater likelihood of caesarean section [5,6]. Caesarean delivery following unsuccessful induction is further associated with increased maternal morbidity, longer hospital stay, and adverse implications for future pregnancies [7]. Therefore, reliable pre-induction assessment of cervical readiness is essential for identifying women who are most likely to achieve vaginal delivery and for optimizing individualized labour management strategies. An ideal predictive tool should be objective, reproducible, non-invasive, and capable of accurately discriminating between successful and unsuccessful induction outcomes.

For more than five decades, the Bishop score has remained the standard clinical method for assessing cervical favourability before labour induction [8]. The scoring system incorporates cervical dilatation, effacement, consistency, position, and fetal station to estimate the likelihood of successful vaginal delivery. Although widely used, the Bishop score has several important limitations. Assessment is based on digital vaginal examination and is therefore inherently subjective, resulting in considerable interobserver and intraobserver variability [9,10]. Furthermore, evaluation of the supravaginal component of the cervix is difficult during digital examination, particularly when the cervix is closed or minimally dilated [11]. Several studies have reported only modest predictive performance of the Bishop score, with variable sensitivity and specificity across different patient populations [12,13]. These limitations have prompted investigators to explore more objective methods of cervical assessment.

Transvaginal ultrasonography (TVS) has emerged as a promising alternative for evaluating cervical status before labour induction. Unlike digital examination, TVS provides direct visualization of the entire cervical canal, including the internal os, thereby allowing objective and reproducible measurement of cervical characteristics [14,15]. The technique is well tolerated by patients and minimizes observer-dependent variability. Ultrasound assessment can accurately quantify cervical morphology and identify early cervical changes that may not be detectable during clinical examination [16]. Consequently, ultrasound-based cervical parameters have attracted increasing attention as potential predictors of labour induction outcomes.

Among the various sonographic markers, cervical length has been the most extensively investigated. Numerous studies have demonstrated that a shorter cervical length is associated with a higher probability of successful induction and vaginal delivery [17–19]. Pandis et al. reported that transvaginalsonographic cervical length was a useful predictor of successful labour induction and showed superior reproducibility compared with the Bishop score [20]. Similar findings have been reported by Rane et al., Gabriel et al., and Yang et al., who observed significant associations between shorter cervical length and favourable induction outcomes [21–23]. Nevertheless, the evidence remains inconsistent. Some investigators have found cervical length to be only modestly predictive and not significantly superior to traditional clinical assessment, highlighting the need for more comprehensive cervical evaluation strategies [24,25].

Recently, cervical volume has emerged as a novel ultrasound-derived parameter that may provide a more comprehensive assessment of cervical readiness. Unlike cervical length alone, cervical volume incorporates both cervical length and diameter, thereby reflecting the overall cervical architecture and tissue characteristics more accurately. Theoretically, cervical volume may better represent the structural remodeling that precedes labour and cervical ripening. However, evidence regarding its clinical utility remains limited and controversial. While some studies have suggested that smaller cervical volumes are associated with successful induction and vaginal delivery, others have reported limited predictive value and inconsistent diagnostic performance. Variations in study design, sample size, ultrasound methodology, and population characteristics have contributed to the heterogeneity of findings. Consequently, the role of cervical volume in predicting induction success remains incompletely understood.

The available literature on cervical volume is particularly sparse in low- and middle-income countries, including India, where obstetric populations often differ substantially from those reported in Western studies with respect to parity, maternal characteristics, obstetric risk factors, and labour management practices. Most published investigations evaluating cervical volume have been conducted in relatively small cohorts and predominantly outside the Indian subcontinent. As a result, there is limited evidence regarding the applicability and predictive performance of cervical volume in Indian women undergoing induction of labour at term. Given the increasing utilization of labour induction in India, establishing reliable and objective predictors of induction success is of considerable clinical importance.

In view of these considerations, the present prospective observational study was undertaken to evaluate the utility of ultrasound-derived cervical volume in predicting successful labour induction among term pregnant women undergoing induction of labour. We further compared the predictive performance of cervical volume with established pre-induction assessment tools, including cervical length and the Bishop score. We hypothesized that cervical volume, by integrating multiple dimensions of cervical anatomy, would demonstrate superior predictive accuracy for successful vaginal delivery following induction of labour and could serve as a more objective and clinically useful marker of cervical favourability.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of Obstetrics and Gynaecology, Tata Main Hospital, Jamshedpur, Jharkhand, India, a tertiary care teaching hospital providing comprehensive obstetric services. The study was undertaken over a one-year period from May 2023 to May 2024 after obtaining approval from the Institutional Ethics Committee. The study was designed in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational research.

Study Population and Sample Size

Pregnant women admitted for induction of labour at term were screened for eligibility. A total of 78 women meeting the predefined eligibility criteria were enrolled consecutively during the study period.

The sample size was calculated based on previous literature evaluating ultrasonographic cervical parameters for prediction of successful induction of labour, considering a confidence level of 95%, statistical power of 80%, and anticipated difference in predictive performance between cervical volume and conventional cervical assessment methods. Consecutive sampling was employed to minimize selection bias and ensure representative recruitment of eligible participants.

Eligibility Criteria

Inclusion Criteria

Women fulfilling all of the following criteria were included:

- Singleton pregnancy.
- Cephalic presentation.
- Gestational age ≥37 completed weeks.
- Intact membranes.
- Planned induction of labour for standard obstetric or medical indications.
- Reactive fetal heart rate tracing before induction.
- Willingness to participate and provide written informed consent.

Exclusion Criteria

Women with any of the following conditions were excluded:

- Multiple pregnancy.
- Non-cephalic fetal presentation.
- Previous uterine scar including previous caesarean section or myomectomy.
- Placenta previa or unexplained antepartum haemorrhage.
- Premature rupture of membranes.
- Active labour at admission.
- Known fetal congenital anomalies.
- Intrauterine fetal demise.
- Contraindications to vaginal delivery.
- Refusal to participate.

Recruitment and Baseline Assessment

Eligible women admitted for induction of labour were identified by the attending obstetric team. After obtaining written informed consent, detailed demographic, obstetric, and clinical information was recorded using a structured case record form.

Baseline variables included maternal age, parity, gestational age, indication for induction of labour, body mass index, obstetric history, and relevant antenatal complications. All participants underwent clinical examination, fetal assessment, and ultrasonographic cervical evaluation before initiation of induction.

Clinical Cervical Assessment

Prior to induction, cervical favourability was assessed by digital vaginal examination using the modified Bishop scoring system. The examination was performed by experienced obstetricians trained in cervical assessment.

The modified Bishop score included evaluation of:

- Cervical dilatation.
- Cervical length.
- Cervical consistency.
- Cervical position.
- Fetal station.

Scores ranged from 0 to 13, with higher scores indicating greater cervical favourability and increased likelihood of successful induction.

Ultrasonographic Cervical Assessment
Equipment and Technique
Transvaginal ultrasonography (TVS) was performed before initiation of induction using a high-resolution ultrasound machine equipped with a transvaginal probe. Participants were examined in the lithotomy position with an empty urinary bladder to minimize distortion of cervical anatomy.

The transvaginal probe was introduced gently into the anterior vaginal fornix without exerting excessive pressure on the cervix. Sagittal visualization of the cervical canal was obtained, clearly identifying both the internal and external cervical os.

Cervical Length Measurement
Cervical length was measured as the linear distance between the internal os and external os along the endocervical canal. Three consecutive measurements were obtained, and the shortest technically acceptable measurement was recorded for analysis. Measurements were expressed in centimetres.

Cervical Diameter Measurement
The transverse diameter of the cervix was measured at the midpoint of the cervical canal in the sagittal plane. Care was taken to obtain measurements perpendicular to the cervical canal to improve reproducibility.

Cervical Volume Calculation
Cervical volume was calculated using the geometric formula for a cylinder:

Cervical Volume = $\pi \times (D/2)^2 \times L$
where:

- D = cervical diameter (cm)
- L = cervical length (cm)

The calculated volume was expressed in cubic centimetres (cm^3).

Operator Standardization
All ultrasound examinations were performed by trained operators following a standardized imaging protocol to minimize interobserver variability. Measurements were obtained before administration of induction agents and prior to digital cervical manipulation whenever feasible.

Labour Induction Protocol
The indication and method of labour induction were determined according to institutional protocols and standard obstetric guidelines.

Cervical Ripening
Women with an unfavourable cervix underwent cervical ripening using prostaglandin preparations according to hospital policy. The need for additional doses was assessed based on cervical response and uterine activity.

Oxytocin Augmentation
Intravenous oxytocin infusion was administered when clinically indicated to establish or augment effective uterine contractions. Oxytocin dosage was titrated according to uterine response and fetal well-being.

Artificial Rupture of Membranes
Artificial rupture of membranes (ARM) was performed when cervical conditions were favourable and fetal head engagement was adequate, as per institutional labour management protocols.

Throughout labour, maternal vital signs, uterine activity, fetal heart rate patterns, labour progression, and delivery outcomes were monitored and documented.

Outcome Measures
Primary Outcome
The primary outcome was successful induction of labour, defined as achievement of vaginal delivery following induction.

Secondary Outcomes
Secondary outcome measures included:

- Vaginal delivery within 24 hours of induction.
- Caesarean section following induction.
- Induction-to-delivery interval.
- Requirement for oxytocin augmentation.

- Additional cervical ripening requirements.
- Neonatal birth weight.

Statistical Analysis
Data were entered into Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) software version 25.0 (IBM Corp., Armonk, NY, USA).

Continuous variables were assessed for normality and presented as mean ± standard deviation (SD). Categorical variables were expressed as frequencies and percentages.

Comparisons between groups were performed using:
- Student's t-test for continuous variables.
- Chi-square test or Fisher's exact test for categorical variables, as appropriate.

Univariate logistic regression analysis was performed to evaluate the association between cervical parameters and successful induction of labour. Odds ratios (ORs) with corresponding 95% confidence intervals (CIs) were calculated.

Receiver operating characteristic (ROC) curve analysis was performed to determine the predictive performance of cervical length, cervical volume, and Bishop score for successful vaginal delivery. The area under the ROC curve (AUC) was calculated for each parameter.

Optimal cut-off values were identified using the Youden index. Diagnostic performance metrics including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated.

Comparative evaluation of AUC values was undertaken to determine the relative predictive ability of cervical volume, cervical length, and Bishop score.

A two-sided p-value <0.05 was considered statistically significant.

Ethical Considerations
The study protocol was reviewed and approved by the Institutional Ethics Committee of Tata Main Hospital, Jamshedpur (Approval No. TMH/IEC/MAY/094/2023). Written informed consent was obtained from all participants before enrolment. Confidentiality and anonymity of participant data were maintained throughout the study. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and subsequent amendments.

RESULTS
A total of 78 pregnant women undergoing induction of labour at term were included in the study. The majority of participants belonged to the age group of 26–30 years (51.3%), followed by 18–25 years (25.6%). The mean maternal age was approximately 27–28 years. Nulliparous women constituted the majority of the study population (75.6%), whereas 24.4% were multiparous. Most inductions were performed between 38 and 39 weeks of gestation. The common indications for induction included intrahepatic cholestasis of pregnancy (IHCP), gestational diabetes mellitus (GDM), gestational hypertension, oligohydramnios, and post-dated pregnancy.

Table 1. Demographic and Obstetric Characteristics of Study Participants (N=78)

Characteristic	Value
Maternal age, years	Majority 26–30 years (51.3%)
Nulliparous	59 (75.6%)
Parous	19 (24.4%)
Gestational age at induction	Predominantly 38–39 weeks
Common indication for induction	IHCP, GDM, Gestational HTN, Oligohydramnios, Post-dated pregnancy
Total participants	78

Table 1 summarizes the baseline demographic and obstetric characteristics of the 78 pregnant women included in the study. Most participants belonged to the age group of 26–30 years, and the majority were nulliparous. Induction of labour was predominantly performed between 38 and 39 weeks of gestation. The most common indications for induction included intrahepatic cholestasis of pregnancy, gestational diabetes mellitus, gestational hypertension, oligohydramnios, and post-dated pregnancy. These findings indicate that the study population was representative of women commonly undergoing induction of labour in routine obstetric practice.

Table 2. Cervical Parameters and Induction Characteristics

Parameter	Value
Bishop score	Predominantly ≤4

Cervical length	Assessed by TVS
Cervical volume	Calculated from cervical length and diameter
Need for oxytocin augmentation	51.3%
Need for multiple doses of dinoprostone	Common among nulliparous women
Method of cervical assessment	Modified Bishop score and TVS

Table 2 presents the pre-induction cervical assessment findings and induction-related characteristics. Most women had an unfavourable cervix at baseline, reflected by relatively low Bishop scores. Cervical length and cervical volume were assessed objectively using transvaginal ultrasonography before induction. More than half of the participants required oxytocin augmentation, and a substantial proportion required repeated doses of dinoprostone gel, indicating variable responsiveness to cervical ripening and induction protocols.

Table 3. Labour Outcomes Following Induction (N=78)

Outcome	**n (%)**
Successful induction (vaginal delivery)	57 (73.1)
Failed induction (caesarean section)	21 (26.9)
Vaginal delivery within 24 h	47 (60.3)
Mean induction-to-delivery interval (successful IOL)	17.5 ± 6.9 h
Mean induction-to-delivery interval (failed IOL)	28.5 ± 2.3 h

Table 3 illustrates the overall outcomes of labour induction. Successful induction, defined as vaginal delivery, was achieved in approximately three-fourths of participants, while one-fourth underwent caesarean delivery because of failed induction. More than 60% of women delivered vaginally within 24 hours of induction. Women with successful induction experienced a significantly shorter induction-to-delivery interval than those with failed induction, suggesting that favourable cervical characteristics are associated not only with successful vaginal delivery but also with a shorter labour duration.

Table 4. Comparison of Cervical Parameters According to Induction Outcome

Parameter	**Successful IOL (n=57)**	**Failed IOL (n=21)**	**p-value**
Bishop score	3.07 ± 1.08	2.29 ± 0.95	0.004
Cervical length (cm)	3.09 ± 0.41	3.61 ± 0.39	<0.001
Cervical volume (cm^3)	18.79 ± 6.49	26.06 ± 6.25	<0.001
Oxytocin augmentation	42.1%	76.2%	0.008
>1 dose Dinoprostone	56.1%	100%	<0.001

Table 4 compares cervical characteristics and induction-related parameters between women with successful and failed induction. Women who achieved vaginal delivery had significantly higher Bishop scores and significantly lower cervical length and cervical volume measurements than those who underwent caesarean delivery. Furthermore, failed induction was associated with increased requirements for oxytocin augmentation and repeat dinoprostone administration. These findings suggest that sonographic cervical parameters provide important information regarding cervical readiness and likelihood of successful induction.

Table 5. Logistic Regression Analysis for Predicting Successful Induction

Predictor	**Crude OR (95% CI)**	**p-value**	**Adjusted OR (95% CI)**	**p-value**
Bishop score	0.44 (0.23–0.78)	0.002	0.66 (0.31–1.14)	0.122
Cervical length	18.30 (7.45–46.41)	<0.001	13.82 (6.22–37.93)	<0.001
Cervical volume	1.28 (1.12–1.40)	<0.001	1.21 (1.06–1.70)	0.031

Table 5 presents the results of univariate and multivariable logistic regression analyses evaluating the predictive value of Bishop score, cervical length, and cervical volume. All three parameters demonstrated significant associations with successful induction in univariate analysis. However, after adjustment for potential confounding effects, cervical length emerged as the strongest independent predictor of successful vaginal delivery, while cervical volume also retained statistical significance. In contrast, Bishop score lost significance in the multivariable model, indicating inferior independent predictive ability compared with ultrasound-derived cervical measurements.

Table 6. ROC Analysis of Cervical Parameters

Parameter	AUC	95% CI	p-value
Bishop score	0.290	0.160–0.420	0.003
Cervical length	0.882	0.754–0.955	<0.001
Cervical volume	0.831	0.720–0.947	<0.001

Table 6 demonstrates the discriminative performance of Bishop score, cervical length, and cervical volume using receiver operating characteristic curve analysis. Cervical length exhibited the highest area under the curve (AUC), indicating excellent predictive performance for successful induction of labour. Cervical volume also demonstrated good diagnostic accuracy, whereas Bishop score showed poor predictive ability. These findings highlight the superiority of objective sonographic cervical assessment over conventional digital examination for predicting induction outcomes.

Table 7. Diagnostic Performance of Cervical Parameters

Parameter	Cut-off	Sensitivity (%)	Specificity (%)
Bishop score	≥4.5	66.7	47.6
Cervical length	<3.4 cm	82.4	76.2
Cervical volume	<25.6 cm³	75.4	80.9

Table 7 presents the optimal cut-off values and diagnostic performance characteristics of the evaluated cervical parameters. A cervical length of less than 3.4 cm provided the highest sensitivity for predicting successful vaginal delivery, while a cervical volume below 25.6 cm³ demonstrated the highest specificity. The Bishop score showed comparatively lower sensitivity and specificity. These results suggest that cervical length and cervical volume are clinically useful tools for identifying women who are likely to achieve successful induction and vaginal delivery.

Figure 1. Receiver Operating Characteristic (ROC) Curves for Prediction of Successful Induction of Labour

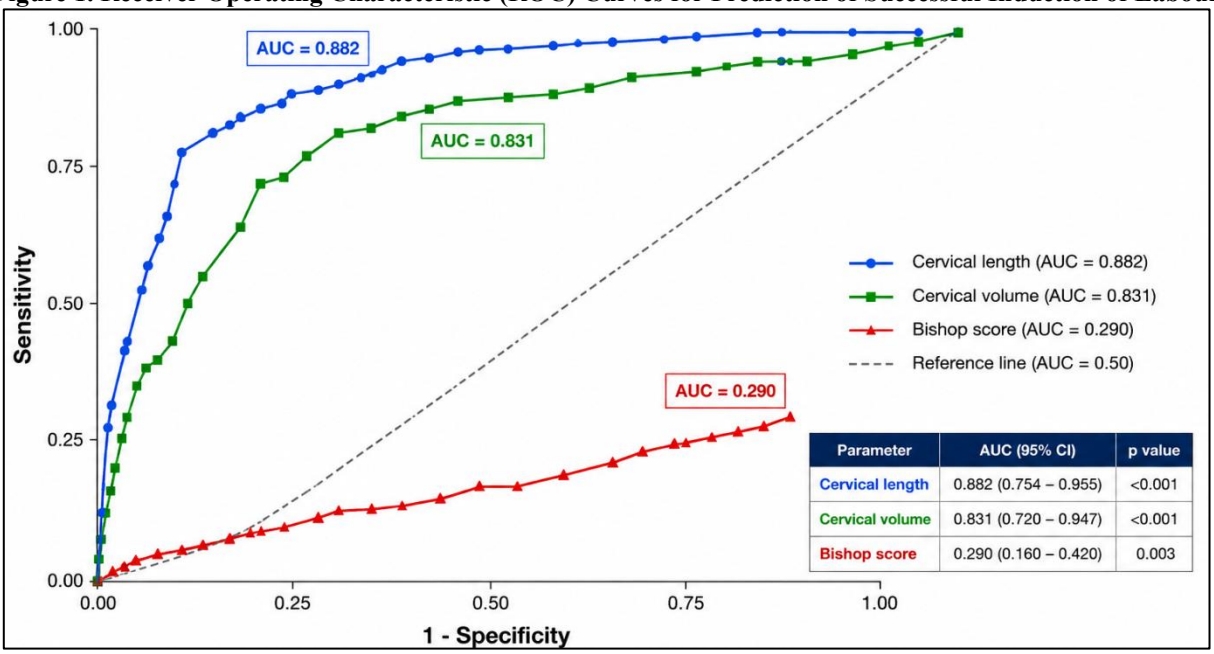

Figure 1. Receiver operating characteristic (ROC) curves comparing the predictive performance of Bishop score, cervical length, and cervical volume for successful induction of labour. Cervical length demonstrated the highest area under the curve (AUC=0.882), followed by cervical volume (AUC=0.831), whereas Bishop score showed poor discriminatory ability (AUC=0.290). The findings indicate superior predictive performance of ultrasound-derived cervical parameters compared with conventional digital cervical assessment.

Figure 2. Comparison of Mean Cervical Parameters According to Induction Outcome

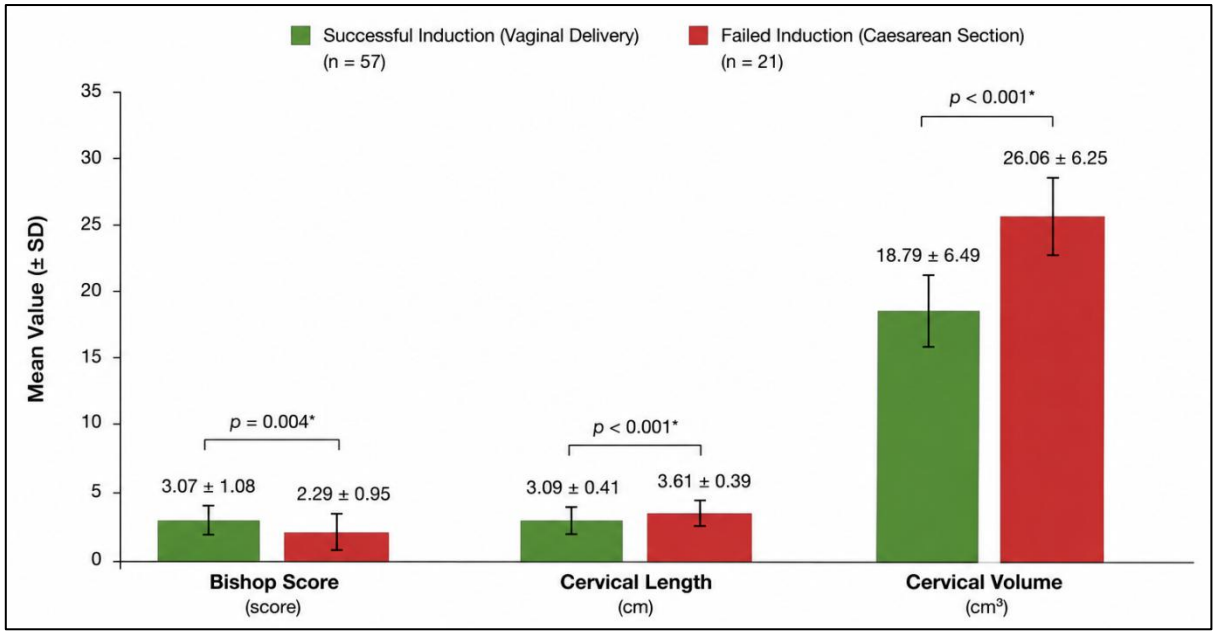

Figure 2.Comparison ofpre-induction cervical parameters between successful and failed induction groups. Women who achieved vaginal delivery had significantly higher Bishop scores and significantly lower cervical length and cervical volume compared with women who underwent caesarean delivery following failed induction. These findings suggest that favourable cervical characteristics are associated with successful labour induction.

Figure 3. Forest Plot of Logistic Regression Analysis

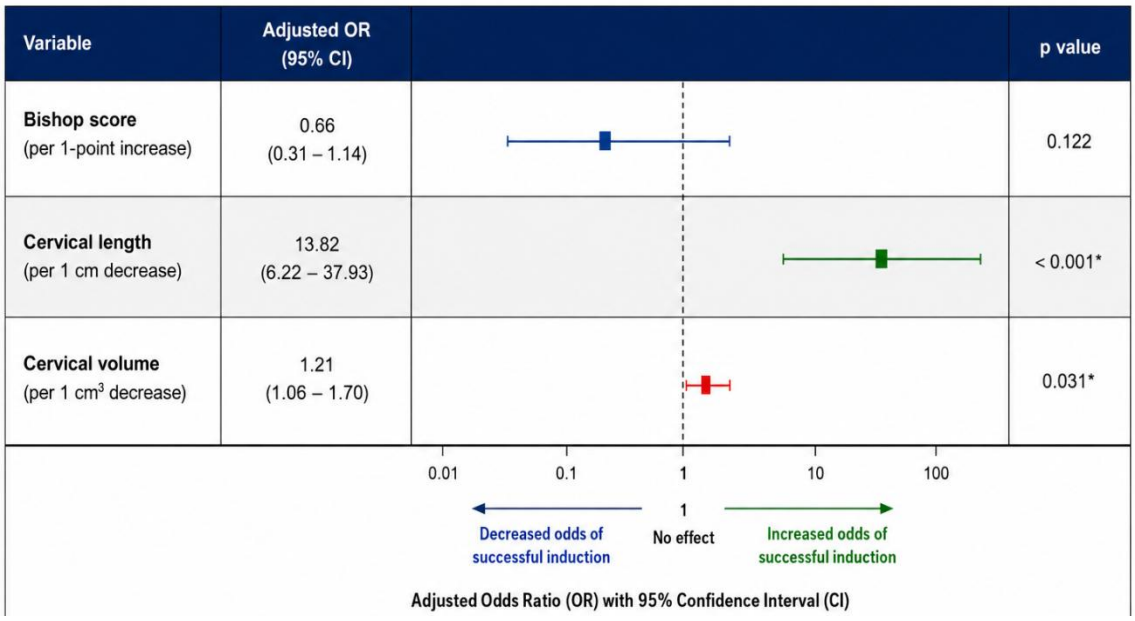

Figure 3.Forest plotdemonstrating adjusted odds ratios for predictors of successful induction of labour. Cervical length emerged as the strongest independent predictor of vaginal delivery, followed by cervical volume. Bishop score did not remain statistically significant after multivariable adjustment.

Figure 4. Diagnostic Accuracy Comparison of Cervical Parameters

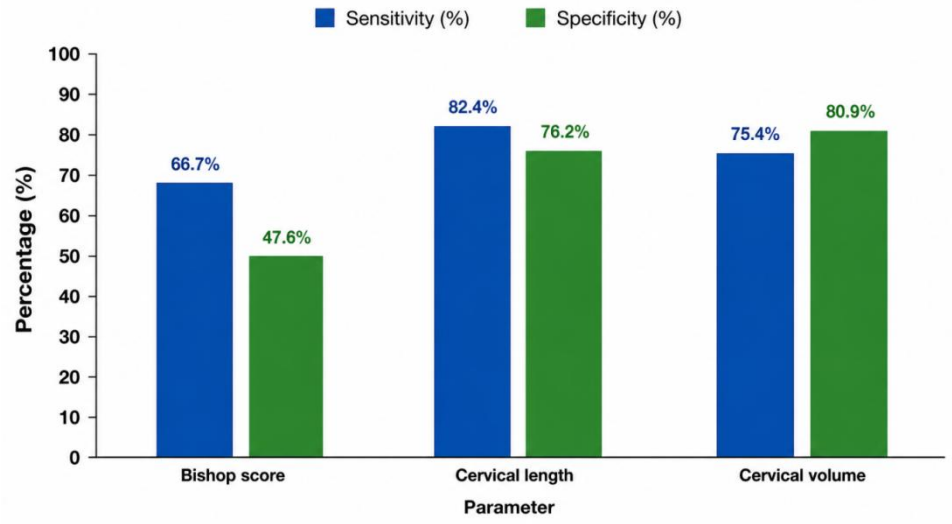

Figure 4. Comparison of sensitivity and specificity of Bishop score, cervical length, and cervical volume for predicting successful induction of labour. Cervical length demonstrated the highest sensitivity (82.4%), whereas cervical volume demonstrated the highest specificity (80.9%). Both ultrasound-derived cervical parameters showed superior diagnostic performance compared with the Bishop score, supporting their utility as objective predictors of successful labour induction.

DISCUSSION

The present prospective observational study evaluated the utility of ultrasound-derived cervical volume in predicting successful induction of labour at term and compared its predictive performance with cervical length and the conventional Bishop score. The principal findings demonstrate that women who achieved successful vaginal delivery had significantly lower cervical volume and cervical length measurements and significantly higher Bishop scores than women who underwent caesarean delivery following failed induction. Receiver operating characteristic analysis revealed that cervical length demonstrated the highest predictive performance (AUC=0.882), followed by cervical volume (AUC=0.831), whereas the Bishop score exhibited poor discriminatory ability (AUC=0.290). Furthermore, multivariable logistic regression identified cervical length and cervical volume as independent predictors of successful induction, while the Bishop score lost statistical significance after adjustment. Collectively, these findings support the superiority of objective ultrasound-derived cervical parameters over conventional clinical assessment.

One of the most important observations in the present study is the significant association between cervical volume and induction outcome. Cervical volume integrates cervical length and diameter into a single parameter and may therefore provide a more comprehensive assessment of cervical morphology than linear measurements alone. Women who achieved vaginal delivery demonstrated significantly smaller cervical volumes, suggesting advanced cervical remodeling before labour onset. Similar findings have been reported in studies evaluating volumetric cervical assessment, which proposed that cervical volume may better reflect the structural and biochemical changes associated with cervical ripening than digital examination alone [26,27]. The high specificity observed for cervical volume in the present study further suggests potential clinical utility in identifying women at increased risk of failed induction.

The findings regarding cervical length are consistent with substantial published evidence. Pandis et al. demonstrated that transvaginalsonographic cervical length was an effective predictor of successful induction and exhibited greater reproducibility than the Bishop score [15]. Ware and Raynor similarly reported that shorter cervical length was associated with increased rates of vaginal delivery following induction [16]. Rane et al. observed superior predictive performance of ultrasound assessment compared with digital examination [18], while Yang et al. reported that sonographic evaluation provided a more objective and reproducible assessment of cervical favourability [14]. Additional studies by Gabriel et al. [17], Gómez-Laencina et al. [19], Park et al. [20], Tan et al. [21], Keepanasseril et al. [22], Khazardoost et al. [23], and Abdullah et al. [24] consistently demonstrated the value of cervical length in predicting labour induction outcomes. The excellent predictive performance of cervical length observed in the present study is therefore highly consistent with existing evidence.

The predictive value of the Bishop score remains controversial. Although the Bishop score has served as the standard clinical tool for pre-induction assessment since its introduction in 1964 [8], numerous studies have highlighted substantial interobserver variability and limited reproducibility [9,10]. Rozenberg et al. [11] and Peregrine et al. [13] reported only modest predictive performance of digital cervical assessment. Gonen et al. demonstrated that the predictive value of the Bishop score was particularly limited among nulliparous women undergoing induction [28]. Similarly, Vrouenraets et al. reported a significant association between low Bishop scores and increased risk of caesarean delivery

but only moderate predictive accuracy overall [6]. In the present study, the Bishop score demonstrated inferior predictive performance and failed to retain significance in multivariable analysis, reinforcing concerns regarding its reliability as a standalone predictor.

Comparison with international studies reveals substantial agreement regarding the superiority of ultrasound-derived cervical assessment. Hatfield et al., in a systematic review and meta-analysis, concluded that sonographic cervical assessment provides clinically useful predictive information beyond conventional digital examination [26]. Studies from Europe, Asia, and North America have consistently shown that cervical length is either superior or at least equivalent to the Bishop score for predicting successful induction [15–24]. Nevertheless, some investigators have reported only modest differences between ultrasound and clinical assessment. Such discrepancies may be attributable to differences in study populations, parity distribution, gestational age, induction indications, cervical ripening methods, and definitions of successful induction. The predominance of nulliparous women in the present study may also partly explain the strong predictive performance observed for ultrasound-derived measurements.

The biological plausibility of these findings is supported by current understanding of cervical ripening. Before labour, the cervix undergoes extensive extracellular matrix remodeling characterized by collagen degradation, increased hydration, leukocyte infiltration, and alterations in glycosaminoglycan composition. These changes result in progressive shortening, softening, and widening of the cervix. Ultrasound-derived measurements are capable of objectively quantifying these structural changes. Cervical volume may be particularly informative because it reflects multidimensional changes in cervical anatomy rather than relying solely on linear shortening. Consequently, cervical volume may provide a more comprehensive representation of cervical readiness for labour.

The clinical implications of these findings are considerable. Failed induction is associated with prolonged labour, increased maternal morbidity, greater healthcare utilization, and higher caesarean section rates. Reliable prediction of induction outcomes could improve patient counselling, optimize allocation of healthcare resources, and facilitate individualized labour management. Women identified as having unfavourable ultrasound-derived cervical parameters may benefit from intensified cervical ripening protocols or closer intrapartum monitoring, whereas those with favourable measurements may proceed confidently with induction.

The integration of ultrasound-derived cervical assessment into routine labour induction protocols warrants serious consideration. Transvaginal ultrasonography is widely available, non-invasive, and relatively inexpensive. Standardized assessment of cervical length and cervical volume could readily be incorporated into pre-induction evaluation. Although cervical length demonstrated the highest predictive accuracy in the present study, cervical volume provided additional information and excellent specificity, suggesting that both parameters may be useful in clinical practice. Future predictive models combining cervical volume, cervical length, parity, maternal demographics, and biochemical markers may further improve individualized prediction of induction success.

The strengths of the present study include its prospective design, standardized ultrasound protocol, comprehensive evaluation of cervical parameters, and use of advanced statistical analyses including multivariable logistic regression and ROC curve analysis. The study also contributes valuable data from an Indian population, addressing a notable gap in the literature regarding cervical volume assessment in low- and middle-income settings.

Several limitations should be acknowledged. The study was conducted at a single tertiary care centre and included a relatively modest sample size, which may limit generalizability. Interobserver variability of ultrasound measurements was not formally assessed. Furthermore, the findings may not be directly applicable to women with previous caesarean delivery, multifetal gestation, or preterm induction. Cervical volume calculations were also based on geometric assumptions that may not fully capture individual anatomical variation.

Future multicentre studies involving larger populations are required to validate the predictive utility of cervical volume. Comparative studies incorporating three-dimensional ultrasound, cervical elastography, and biochemical markers of cervical ripening may further clarify the role of volumetric assessment. Development of integrated prediction models combining clinical and sonographic variables may ultimately facilitate precision-based approaches to labour induction.

CONCLUSION

The present study demonstrates that ultrasound-derived cervical parameters outperform the Bishop score in predicting successful induction of labour. Cervical length exhibited the highest predictive accuracy, while cervical volume emerged as an independent predictor with favourable diagnostic performance. These findings support the increasing role of objective ultrasound-based cervical assessment in modern obstetric practice and suggest that cervical volume may serve as a valuable adjunctive marker for optimizing pre-induction evaluation and improving prediction of labour induction outcomes.

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