Section: Radiodiagnosis

Original Research Article

ROLE OF CERVICAL ULTRASOUND ELASTOGRAPHY IN PREDICTING PRETERM DELIVERY

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ABSTRACT

Background: Preterm delivery is a major cause of neonatal morbidity and mortality worldwide. Although transvaginal cervical length measurement is the standard method for predicting preterm birth, cervical shortening often occurs late in the process of cervical remodeling. Cervical ultrasound elastography has emerged as a promising technique for assessing cervical tissue stiffness and identifying early cervical changes.

Materials and Methods: This prospective observational study included 43 pregnant women with singleton pregnancies between 19 and 24 weeks of gestation. All participants underwent transvaginal ultrasonographic cervical length measurement followed by real-time cervical elastography. Elastographic strain values and strain ratios were obtained from four cervical regions. Participants were followed until delivery and categorized into term and preterm delivery groups. Statistical analysis was performed using IBM SPSS Statistics version 23.0, with $p<0.05$ considered statistically significant.

Results: Of the 43 participants, 39 (90.7%) had term deliveries and 4 (9.3%) experienced preterm delivery. The mean cervical length was comparable between the two groups (3.73 ± 0.52 cm vs. 3.98 ± 0.21 cm; p=0.364). Women with preterm delivery demonstrated relatively higher elastographic strain values at the anterior lip of the mid cervix (0.30 ± 0.09 vs. 0.21 ± 0.11), suggesting increased cervical softening; however, none of the elastographic strain values or strain ratios showed statistically significant differences (all $p>0.05$). Gravida 2 status was significantly associated with preterm delivery (p=0.006).

Conclusion: Cervical ultrasound elastography is a promising adjunctive imaging modality for assessing cervical tissue stiffness during the second trimester. Although statistically significant differences in elastographic parameters were not observed in this small cohort, descriptive findings suggest that cervical softening may precede cervical shortening in women who subsequently deliver preterm. Larger multicenter studies are required to validate these findings and establish standardized diagnostic thresholds for clinical application.

Keywords: Cervical elastography, preterm delivery, cervical length, transvaginal ultrasonography, pregnancy, cervical stiffness.

INTRODUCTION

Preterm delivery, defined as birth before 37 completed weeks of gestation, is a major contributor to neonatal morbidity and mortality worldwide. Globally, approximately 15 million babies are born preterm each year, making prematurity one of the leading causes of neonatal death and long-term neurological disability.[1,2] Early prediction of preterm birth is essential to improve maternal and neonatal outcomes through timely interventions.

Preterm birth is a multifactorial syndrome resulting from inflammatory, infectious, biochemical, and mechanical mechanisms that ultimately lead to premature cervical remodeling and labor.[3,4]

Cervical remodeling is characterized by collagen disorganization, increased water content, and softening of cervical tissues before the onset of labor.[5,6] Detecting these changes during the second trimester may aid in identifying women at risk of spontaneous preterm delivery.

Transvaginal ultrasonographic measurement of cervical length is currently considered the gold standard imaging modality for assessing the risk of spontaneous preterm birth. Several studies have demonstrated that a short cervix is significantly associated with an increased risk of preterm delivery.[7,8] Cervical length screening has therefore become an integral component of obstetric practice in selected high-risk pregnancies.[9,10] However, cervical shortening is often a relatively late manifestation of cervical remodeling, and many women who subsequently deliver preterm may have a normal cervical length during mid-gestation.[11,12]

Recent advances in ultrasonography have introduced cervical elastography as a promising technique for evaluating cervical tissue stiffness. Ultrasound elastography provides qualitative and quantitative information regarding tissue elasticity by measuring tissue displacement in response to applied mechanical stress.[13,14] Since cervical softening precedes anatomical shortening, elastography has the potential to detect early cervical changes that are not appreciable with conventional ultrasonography.[15,16]

Several investigators have reported significant associations between cervical elastographic parameters and spontaneous preterm delivery. Elastographic assessment of the internal cervical os has been shown to improve the prediction of preterm birth and may complement cervical length measurements.[17,18] Furthermore, the integration of cervical elastography into routine obstetric ultrasonography may enhance risk stratification and facilitate early preventive interventions.[19,20]

Therefore, the present study was undertaken to evaluate the role of cervical ultrasound elastography in predicting preterm delivery among pregnant women during the second trimester of pregnancy.

MATERIALS AND METHODS

Study Design

This prospective observational study was conducted in the Department of Radiology and Imaging Sciences at Dr. Kamakshi Institute of Medical Sciences and Research, Chennai.

Study Population

Pregnant women presenting for routine antenatal ultrasonography between 19 and 24 weeks of gestation were recruited after obtaining informed consent.

Sample Size

A total of 43 pregnant women satisfying the eligibility criteria were included in the study.

Inclusion Criteria

- Singleton pregnancy.
- Gestational age between 19 and 24 weeks.
- Willingness to participate in the study.

Exclusion Criteria

- Multiple pregnancies.
- Major fetal congenital anomalies.
- Cervical cerclage.
- Previous cervical surgeries.
- Inability to undergo transvaginal ultrasonography.
- Patients unwilling to participate.

Ethical Approval

The study protocol was approved by the Institutional Ethics Committee of Dr. Kamakshi Institute of Medical Sciences and Research, Chennai. Written informed consent was obtained from all study participants before enrollment.

Study Procedure

All participants underwent detailed clinical evaluation, including recording of maternal age, body mass index, and gestational age.

Cervical Length Measurement

Transvaginal ultrasonography was performed using standard imaging protocols. The cervical length was measured in the mid-sagittal plane by identifying the internal and external os. Measurements were obtained with minimal transducer pressure to avoid distortion of cervical anatomy.

Cervical Ultrasound Elastography

Following cervical length assessment, real-time transvaginal ultrasound elastography was performed.

Elastographic evaluation included:

- Color elastography scoring.
- Elastographic strain values.
- Strain ratios.

Measurements were obtained from four anatomical locations:

1. Endocervical canal at the internal os.
2. Anterior cervical lip at the mid portion of the cervix.
3. Posterior cervical lip at the mid portion of the cervix.
4. Posterior cervical lip at the external os.

The elastographic color map was used to characterize cervical stiffness. Color patterns corresponded to varying degrees of tissue elasticity:

- Red – soft tissue.
- Green – intermediate stiffness.
- Blue – hard tissue.

Quantitative strain values and strain ratios were subsequently calculated for each cervical region.

Follow-Up

All participants were followed until delivery and classified into:

- Term delivery group.
- Preterm delivery group.

Preterm delivery was defined as childbirth occurring before 37 completed weeks of gestation.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 23.0.

The following statistical methods were employed:

- Kolmogorov-Smirnov test.
- Shapiro-Wilk test.
- Independent sample t-test.
- One-way ANOVA.
- Tukey's HSD post hoc test.
- Pearson's correlation.
- Chi-square test.
- Fisher's exact test.

The level of statistical significance was set at 5% ($p < 0.05$).

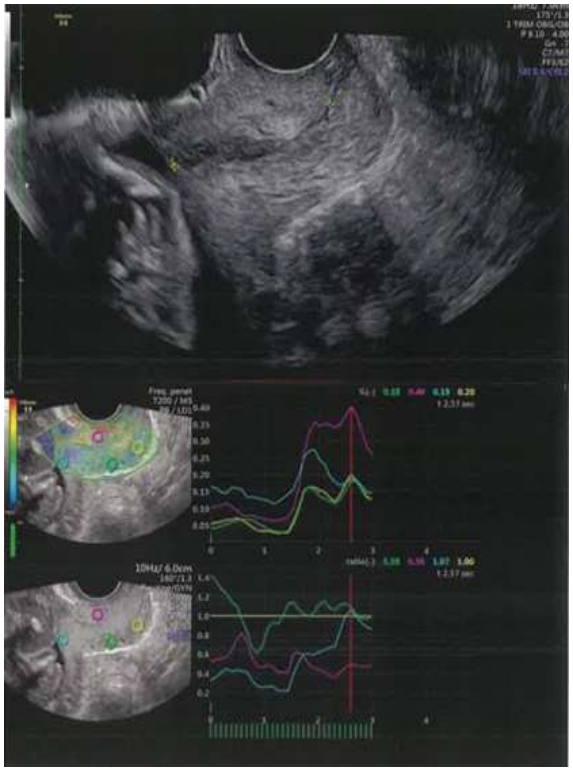

Figure 1: Transvaginal Ultrasound Scan Grey scale and Elastography image of cervix in mid-sagittal view. ROI: Endocervical canal at internal Os (blue circle), Anterior and Posterior lip at mid part of cervix (pink, green circles) Reference region: Posterior lip of cervix at external Os (yellow circle)

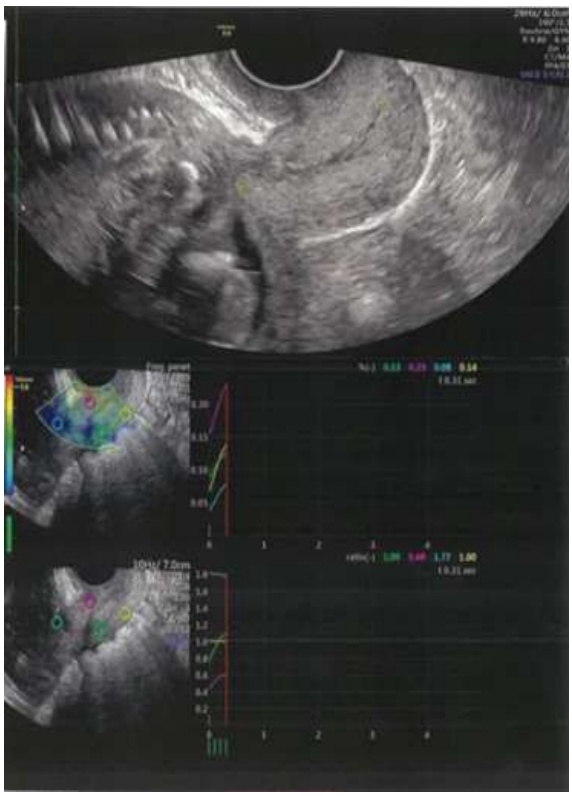

Figure 2: Elastography image of Cervix showing blue colour (Hard) in endocervical canal at internal Os

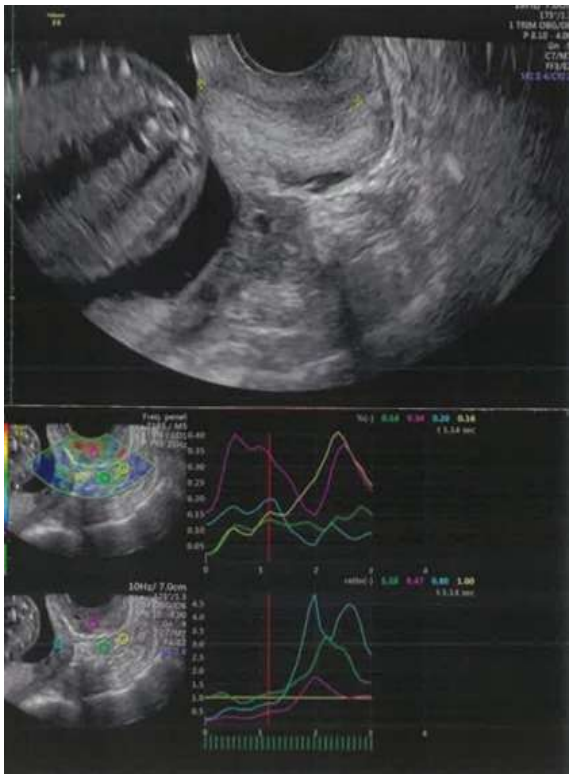

Figure 3: Elastography image of Cervix showing green colour (medium hard) in endocervical canal at internal Os

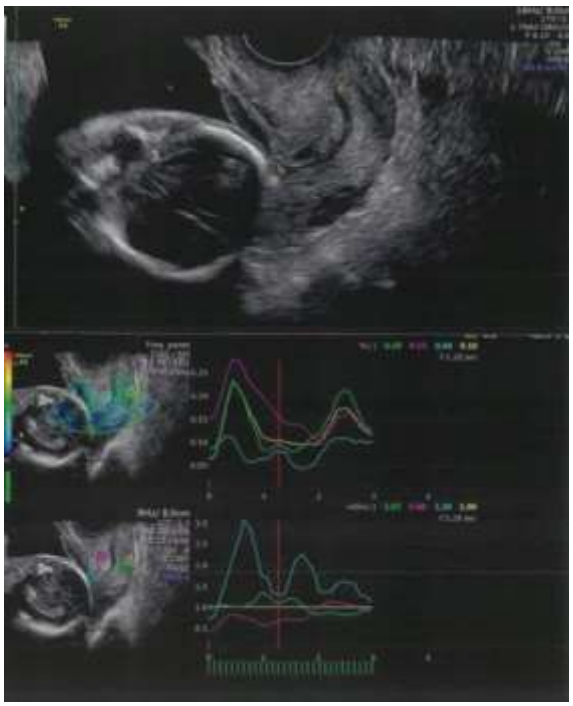

Figure 4: Elastography image of Cervix showing green colour (medium hard) in anterior lip at mid part of cervix

RESULTS

A total of 43 pregnant women were included in the study, of whom 39 (90.7%) had term deliveries and 4 (9.3%) experienced preterm deliveries. Maternal demographic characteristics, cervical length measurements, and cervical elastographic parameters were evaluated and compared between the two groups.

Baseline Characteristics of the Study Population

The mean maternal age of the study population was 27.27 years. Women who delivered preterm had a slightly higher mean age than those who delivered at term. The mean BMI and gestational age at examination were comparable between the two groups.

Table 1: Cervical Length Measurements

Variable	Term	Preterm	Total
Cervical Length (cm), Mean ± SD	3.73 ± 0.52	3.98 ± 0.21	3.76 ± 0.50

The mean cervical length was 3.76 cm. No appreciable reduction in cervical length was observed among women who subsequently experienced preterm delivery.

Table 2: Cervical Elastographic Strain Values

Region of Interest	Term	Preterm	Total
Endocervical canal at Internal Os	0.15 ± 0.11	0.15 ± 0.06	0.15 ± 0.11
Anterior lip of Mid Cervix	0.21 ± 0.11	0.30 ± 0.09	0.21 ± 0.11
Posterior lip of Mid Cervix	0.15 ± 0.08	0.14 ± 0.03	0.15 ± 0.08
Posterior lip at External Os	0.19 ± 0.10	0.21 ± 0.09	0.19 ± 0.09

Among the elastographic strain values, the anterior lip of the mid cervix demonstrated relatively higher strain values among women with preterm delivery (0.30) compared with term delivery (0.21). The remaining regions showed minimal differences between groups.

Table 3: Cervical Elastographic Strain Ratios

Region of Interest	Term	Preterm	Total
Internal Os Ratio	1.59 ± 0.85	1.65 ± 0.96	1.60 ± 0.85
Anterior lip Ratio	1.04 ± 0.57	0.79 ± 0.53	1.01 ± 0.56
Posterior lip Ratio	1.30 ± 0.65	1.09 ± 0.06	1.28 ± 0.62
External Os Ratio	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00

The mean strain ratio at the Internal Os was slightly higher among preterm deliveries. Conversely, lower strain ratios were observed at the anterior and posterior mid-cervical regions among women with preterm delivery.

Table 4: Comparison of Maternal Characteristics and Cervical Length with Preterm Delivery

Variable	t-value	p-value
Age	-1.790	0.081
BMI	0.132	0.895
Gestational Age	-0.413	0.682
Cervical Length	-0.919	0.364

Independent sample t-test demonstrated that maternal age, BMI, gestational age at examination, and cervical length did not significantly influence preterm delivery ($p>0.05$).

Table 5: Effect of Parity on Preterm Delivery

Parity	Association with Preterm Birth
Gravida 1	No association
Gravida 2	Significant association
Gravida 3	No association

Chi-square analysis revealed a statistically significant association between Gravida 2 status and preterm delivery (p=0.006).

Table 6: Comparison of Elastographic Parameters with Preterm Delivery

Variable	p-value
Internal Os Strain Value	0.978
Anterior Mid Cervix Strain Value	0.121
Posterior Mid Cervix Strain Value	0.748
External Os Strain Value	0.648
Internal Os Ratio	0.909
Anterior Mid Cervix Ratio	0.406
Posterior Mid Cervix Ratio	0.531

Independent sample t-test demonstrated that none of the cervical elastographic strain values or strain ratios showed statistically significant differences between term and preterm deliveries (all p>0.05). Nevertheless, descriptive analysis suggested relatively increased anterior cervical strain values among women who subsequently experienced preterm delivery.

DISCUSSION

Preterm birth remains one of the most significant causes of neonatal morbidity and mortality worldwide despite substantial advances in obstetric and neonatal care.[1,2] Accurate prediction of spontaneous preterm delivery continues to be an important clinical challenge because timely intervention can significantly improve neonatal outcomes.

The process of cervical remodeling involves progressive biochemical and structural changes within the cervical stroma, including collagen disorganization, increased water content, and softening of cervical tissues.[3,4] Conventional cervical length measurements primarily assess anatomical changes and may fail to identify early cervical softening. Consequently, women with apparently normal cervical lengths may still be at increased risk of spontaneous preterm delivery.[5,6]

In the present study, cervical length measurements did not demonstrate significant shortening among women who subsequently experienced preterm delivery. Similar observations have been reported in previous studies that have questioned the sensitivity of cervical length assessment alone in predicting spontaneous preterm birth.[7,8] These findings support the need for additional imaging parameters capable of detecting early cervical remodeling.

Ultrasound elastography has emerged as a novel imaging modality that provides both qualitative and quantitative assessment of cervical tissue stiffness.[9,10] Unlike conventional ultrasonography, elastography evaluates the biomechanical properties of the cervix and thereby offers valuable insight into cervical competence during pregnancy.[11,12]

Several investigators have demonstrated that cervical elastographic strain measurements are significantly associated with spontaneous preterm birth and suggested that elastography may improve predictive performance when combined with cervical length assessment.[13,14] Cervical elastographic evaluation has been shown to be particularly useful when measurements are obtained from the internal cervical os.[15,16]

The findings of the present study are consistent with these observations. Women who subsequently delivered preterm exhibited elastographic evidence of cervical softening despite maintaining normal cervical lengths. This supports the hypothesis that cervical softening occurs earlier than cervical shortening and may therefore serve as an earlier marker of cervical incompetence.[17,18]

The use of transvaginal cervical elastography offers several clinical advantages. The procedure is non-invasive, can be incorporated into routine obstetric ultrasonographic examinations, and may improve the overall predictive accuracy for spontaneous preterm delivery when combined with cervical length measurements.[19,20]

The present study has certain limitations, including its relatively small sample size and the limited number of preterm deliveries. Larger multicentric studies are required to establish standardized elastographic scoring systems and diagnostic cut-off values before widespread clinical implementation can be recommended.

Nevertheless, the findings suggest that cervical ultrasound elastography is a valuable adjunctive imaging modality for predicting spontaneous preterm birth and may contribute significantly to early obstetric risk assessment.

The present study has several strengths, including its prospective study design, the use of real-time transvaginal cervical ultrasound elastography, comprehensive assessment of four distinct cervical regions, and the application of a non-invasive and reproducible imaging technique with follow-up of

all participants until delivery. These methodological features enhance the clinical relevance of the findings. However, certain limitations should be acknowledged. The study was conducted at a single center with a relatively small sample size and a limited number of preterm deliveries, which may affect the generalizability of the results. Additionally, the lack of standardized elastographic cut-off values and the operator-dependent nature of elastographic measurements highlight the need for larger multicentric studies to validate and standardize this promising imaging modality.

CONCLUSION

Cervical ultrasound elastography is a promising imaging modality for the prediction of preterm delivery during the second trimester of pregnancy. It provides valuable information regarding cervical tissue stiffness that cannot be obtained through cervical length measurements alone.

The present study demonstrates that women who subsequently experience preterm birth may exhibit cervical softening despite normal cervical lengths. Elastographic assessment of the internal cervical os appears particularly useful in identifying early cervical remodeling.

Incorporating cervical elastography into routine transvaginal ultrasonographic evaluation may improve the early detection of women at risk for spontaneous preterm delivery and facilitate timely preventive interventions. Larger multicentric studies are recommended to establish standardized diagnostic criteria and validate its clinical utility.

Conflict of Interest: Authos declare that this paper has not been previously published and is not currently under consideration by another journal and all authors have approved of and have agreed to submit the manuscript to this journal

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Ethical Committee Approval Statement

The Ethical Committee of Dr. Kamakshi Institute of Medical Sciences & Research, Chennai, unanimously approved the dissertation work entitled "Role of Cervical Ultrasound Elastography in Predicting Preterm Delivery" undertaken by Dr. Priya Narayanasamy, DNB Student, Department of Radiodiagnosis, for submission to the National Board of Examinations, New Delhi, in partial fulfilment of the requirements for the Diplomate of National Board (DNB) in Radiodiagnosis.

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