

Research Article

The Self-Locking and Interlocking Mechanism: A Force-Based Theoretical Framework for Female Stress Urinary Incontinence

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Female stress urinary incontinence (SUI) is often approached through the anatomy of pelvic floor support and the position of the urethra and pelvic organs. These factors are important, but they do not always explain why continence is preserved in some women and lost in others with apparently similar anatomical findings. The difference may lie, at least in part, in how the pelvic floor behaves when it is exposed to a changing mechanical load.

We propose a pelvic floor self-locking and interlocking mechanism to consider this problem from a biomechanical standpoint. The central idea is that continence requires more than an appropriate anatomical position. As intra-abdominal pressure rises, the tissues need to move toward an effective configuration, establish sufficient contact, and maintain that configuration despite the continuing load. Two theoretical variables are introduced to describe this process. The functional closure gap (W) refers to the geometric separation that has to be accommodated for effective closure to occur, while closure capacity refers to the ability of the pelvic floor to establish and sustain closure during loading. Several familiar mechanical principles provide different ways of examining this process. Friction is relevant to resistance between contacting tissue surfaces; the Poisson effect illustrates coupled deformation; Laplace-type relationships draw attention to changes in local load distribution as geometry changes; and the Hagen–Poiseuille relationship illustrates the nonlinear effect that a change in urethral lumen radius may have on fluid transport. These principles are not combined into a complete mathematical model. Rather, they are used to develop a mechanical interpretation of how geometry, tissue interaction, force transmission, and urethral closure may be related.

Within this interpretation, SUI may occur when the mechanical demand generated by increased intra-abdominal pressure exceeds the capacity of the pelvic floor closure system at that moment. The

concept is intended to complement existing anatomical theories rather than replace them. W and closure capacity remain theoretical constructs, and their clinical meaning will depend on whether they can be defined, measured, and shown to relate consistently to continence in future studies.

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1. Introduction

Female stress urinary incontinence (SUI) is usually recognized by a familiar clinical event: urine leakage occurs when intra-abdominal pressure rises, such as during coughing, sneezing, or physical exertion^[1]^[2]. The mechanisms underlying this event, however, are considerably more complex than the clinical presentation suggests. Over the years, several major theories have provided different explanations for the role of pelvic floor support, including the Three Levels of Support Theory, the Hammock Hypothesis, and the Integral Theory^[3]^[4]^[5]. Together, these concepts have established much of the anatomical basis on which current understanding and reconstructive surgery are built.

The difficulty arises when continence is considered under dynamic rather than resting conditions. Knowing where the pelvic organs are located does not necessarily tell us what the tissues will do when intra-abdominal pressure changes rapidly. Nor does the presence of an anatomical defect, by itself, determine the degree of functional impairment that will result. The mechanical behavior of the tissues during loading is therefore an important part of the problem, but one that is less readily captured by static anatomical descriptions^[6].

There are several clinical observations that make this distinction worth considering. Pelvic floor abnormalities of similar apparent severity may be associated with different functional manifestations. Conversely, correction of an anatomical abnormality does not always lead to an equivalent improvement in function^[7]^[8]. In women with pelvic organ prolapse, for example, levator ani defects have been associated with reduced vaginal closure force^[8]^[9]. Other work has likewise emphasized that pelvic floor function depends on the interaction among supporting tissues rather than on the integrity of any single structure^[10]. Such findings do not invalidate the importance of anatomy. Instead, they suggest that anatomy may represent the initial condition of a mechanical system rather than its complete functional description.

The question can thus be stated more simply. When abdominal pressure rises, what allows the pelvic floor to remain closed?

At that moment, the tissues are not simply being displaced as a whole. Their relative positions change, tissue surfaces may come into contact, deformation occurs, and forces are transmitted between structures. The configuration reached during loading may be stable or unstable. A static measurement taken before the load is applied cannot, by itself, distinguish between these possibilities.

This is the point at which the idea of a mechanical closure system becomes useful. The terms self-locking and interlocking are used in this article as conceptual mechanical analogies. They do not imply that the pelvic floor functions like an engineered seal. Biological tissues are deformable, heterogeneous, viscoelastic, and actively controlled, and their behavior depends on continuously changing muscular activity and boundary conditions. The analogy is narrower: once tissue surfaces come into an appropriate relationship, their geometry and the forces acting between them may contribute to the stability of that configuration; at the same time, several anatomically connected structures may influence one another through shared deformation and force transmission.

This view leads to a distinction between support and closure. Support determines, in part, the anatomical conditions in which the pelvic floor operates. Closure concerns what the system actually accomplishes when it is challenged by a changing load. The two are related, but they are not necessarily interchangeable.

The present work develops this distinction into a proposed pelvic floor self-locking and interlocking mechanism. Two concepts are used to describe different parts of the process. The functional closure gap (W) represents a geometric condition relevant to tissue approximation and the formation of closure. Closure capacity describes the functional ability of the pelvic floor to establish, maintain, and recover an effective closed state while loading changes. The distinction is intentional: a geometric condition does not necessarily tell us how much mechanical reserve the system has.

Four established physical principles are then considered to explore different aspects of this proposed behavior. Coulomb friction is relevant once tissue contact has been established. The Poisson effect provides a way of considering coupled deformation rather than movement in a single direction. Laplace-type mechanics offers a conceptual basis for considering how altered geometry may redistribute mechanical loading. The Hagen–Poiseuille relationship illustrates the possibility that a relatively small change in urethral lumen geometry may produce a much larger functional effect under idealized flow conditions.

None of these principles, individually or collectively, constitutes a complete description of pelvic floor mechanics. Their purpose here is more limited: to ask whether familiar mechanical relationships can help connect an anatomical starting state with the dynamic closure behavior observed clinically.

The resulting hypothesis is that SUI may not be adequately described as a problem of anatomical displacement alone. It may also represent a failure of mechanical adaptation, in which the demand imposed by increased intra-abdominal pressure exceeds the closure capacity available under those conditions. This hypothesis does not compete with established anatomical theories. It adds another question to them: how is anatomical support converted into effective closure when the pelvic floor is actually loaded?

2. Theoretical Framework

2.1. From “Support” to “Closure”: Reconsidering Pelvic Floor Function

Most established models describe the female pelvic floor primarily as a support system^{[3][4][5]}. Their central concern is how anatomical structures maintain the position of the pelvic organs and resist downward displacement. This anatomical perspective has been fundamental to the development of pelvic floor surgery. Yet the presence of structural support does not, by itself, establish that the system is functionally competent.

Anatomical support describes the relationships that help keep the pelvic organs in position. Functional performance becomes evident under conditions in which those relationships are challenged by changing loads. A structure may therefore remain anatomically supportive while the overall system responds inadequately to the mechanical demands placed on it. A pelvic floor may therefore retain apparently adequate anatomical support while exhibiting functional impairment if its mechanical response to loading is insufficient.

From this perspective, maintaining a stable geometric closure during changes in intra-abdominal pressure may be regarded as a fundamental function of the female pelvic floor. Such closure may help limit downward displacement of the pelvic organs while also contributing to urethral closure and the transmission of intra-abdominal pressure. The pelvic floor can consequently be viewed not only as a supporting structure, but also as a dynamic geometric closure system.

2.2. The Functional Closure Gap (W): A Theoretical Variable of Pelvic Floor Geometry

The genital hiatus is routinely considered in clinical assessment of pelvic floor support. Its width, however, can also be considered in mechanical terms. It represents, at least in part, the spatial separation between opposing structures that need to come closer together before effective closure can occur. As intra-abdominal pressure increases, this geometric separation has to be accommodated before sufficient contact between the anterior and posterior vaginal surfaces can develop.

We therefore use the term functional closure gap (W) for this component of the closure problem. W is not proposed as a new anatomical structure. It is a theoretical variable intended to describe the initial spatial relationship between the structures involved in closure. When W is smaller, approximation of the opposing vaginal surfaces should require less tissue displacement. With a larger W, greater displacement and/or greater normal force may be needed to establish effective contact. If the gap becomes too large for the surrounding tissues to accommodate under the available mechanical conditions, closure may fail despite the persistence of some anatomical support.

The point of introducing W is therefore not simply to add another anatomical measurement. It is to describe the geometric starting condition from which the subsequent mechanical response of the pelvic floor takes place.

2.3. Closure Capacity: A Functional Property of the Pelvic Floor

We use closure capacity to describe the ability of the pelvic floor to respond effectively when intra-abdominal pressure increases. In practical terms, the concept concerns whether the system can achieve closure, maintain it while the load persists, and regain an effective configuration as the loading condition changes.

Closure capacity is unlikely to arise from any single mechanical factor. The initial geometry, including W, may affect how easily opposing tissues can approximate. Once contact is established, however, the tissues must generate and sustain coordinated forces, and sufficient normal pressure must develop at the contact surfaces for the closed configuration to remain stable.

The relationship among these factors is therefore not simply anatomical. The starting geometry influences how the tissues interact under load, while the resulting mechanical behavior determines whether effective closure can be maintained. Continence, in this sense, represents the functional consequence of a closure system that remains sufficiently stable during pressure changes. This also

suggests that future assessment of pelvic floor function should consider dynamic closure behavior alongside conventional measurements of organ position.

2.4. Self-Locking and Interlocking: Two Components of the Closure System

The term self-locking is used here to describe local mechanical stability that can persist once a tissue configuration has been established, with stability arising from the geometry of the configuration together with normal pressure and friction at the tissue interface. Continuous active contraction is therefore not necessarily required to maintain every aspect of the closed state. When the anterior and posterior vaginal walls are brought into sufficient contact, their interaction may help stabilize the configuration against relative displacement. This is analogous, at a conceptual level, to self-locking behavior in mechanical systems.

Interlocking refers to stability that is not generated by one tissue alone, but emerges from the interaction of several mechanically connected structures. The pelvic floor is better considered as a network than as a collection of independent parts. The levator plate, bladder base, vaginal walls, urethra, and surrounding connective tissues are mechanically coupled, so a change in one component can alter the loading and deformation of others.

In this setting, continence should be regarded as a property of the system as a whole rather than of any single anatomical component. The relevant issue is whether the individual structures can accommodate deformation and transmit forces in a coordinated manner when the system is loaded. Self-locking describes the local stabilization that occurs at tissue contact sites, whereas interlocking describes the additional stability arising from mechanical coupling between different parts of the pelvic floor. These two levels may operate simultaneously and together contribute to maintenance of functional closure.

2.5. Closure Failure: A Mechanical Interpretation of SUI

Within this framework, SUI represents a condition in which the pelvic floor is unable to preserve an effective closure state during loading. Degenerative changes in supporting tissues or impaired levator plate function may reduce the ability to generate and sustain coordinated forces. As a consequence, tissue contact and the normal pressure developed between contacting surfaces may become insufficient, with a corresponding reduction in closure capacity.

Leakage would be expected when the mechanical load imposed by an increase in intra-abdominal pressure exceeds what the closure system can accommodate at that time. The transition may not be

gradual. Once the available mechanical compensation is exhausted, a previously stable configuration may become unstable, and effective urethral closure may be lost.

This view places SUI within a chain of mechanically related events rather than assigning it to a single anatomical lesion. Changes in tissue structure may modify the geometry of the pelvic floor; the altered geometry may change tissue contact and force transmission; and these changes may ultimately determine whether closure can be maintained during loading. Anatomical position is therefore one part of the process, but does not necessarily describe its functional endpoint.

3. First-Principles Mechanical Analysis

The proposed model can be approached through several basic mechanical questions. How does pelvic floor closure remain stable as intra-abdominal pressure increases? Why can women with apparently similar anatomical configurations show different functional outcomes? What mechanical process might underlie the progressive deterioration seen with compromised pelvic floor support? And why can a relatively small change in urethral caliber have a marked effect on continence?

To explore these questions, we consider four established principles from mechanics and fluid mechanics: Coulomb friction, the Poisson effect, Laplace-type mechanics, and the Hagen–Poiseuille relationship. These principles are not presented as a complete mathematical description of the pelvic floor. Instead, they are used selectively to examine different parts of the proposed mechanism, including tissue contact, deformation, redistribution of mechanical loading, and the nonlinear effect of changes in urethral lumen geometry.

3.1. Coulomb Friction: Normal Pressure as a Component of Closure Capacity

When the anterior and posterior vaginal walls come into effective contact, the contacting surfaces can develop normal pressure and, with it, resistance to relative sliding. Assuming broadly similar contact conditions, a greater normal force at the interface would be expected to increase this resistance.

This mechanical relationship offers one explanation for the contribution of tissue contact to closure stability. With impaired levator plate function, the pelvic floor may be less able to bring the opposing vaginal walls together or to sustain the forces required to keep them in contact. As the contact becomes less secure, resistance to relative movement would be expected to diminish as well.

There is, however, an important qualification. Friction can contribute to stability only after an effective contact interface has been established. Its effect will also depend on the properties and condition of the contacting tissues. Normal pressure should therefore not be equated with closure capacity as a whole. It is better regarded as one component of the mechanical stability of an already established closure.

This distinction matters to the present model. Closure capacity is intended as a property of the whole system. Contact pressure and friction may help preserve closure, but they do not explain how the tissues first come into an effective configuration. The geometric conditions represented by W and the ability of the surrounding structures to generate coordinated forces remain necessary parts of that process.

3.2. The Poisson Effect: Coupled Tissue Deformation Under Loading

Anatomical position provides only the starting configuration of the pelvic floor. Its functional behavior depends on what happens to that configuration when the system is loaded. In the proposed model, a relatively small W may favor approximation of the anterior and posterior vaginal walls as intra-abdominal pressure increases. When the available mechanical compensation becomes insufficient, the same loading may instead result in greater tissue separation and loss of effective closure.

Pelvic floor tissue cannot be treated as a simple homogeneous material. Differences in tissue composition, anisotropic behavior, attachments to surrounding structures, and changing boundary conditions all affect how deformation occurs. Movement in one direction may consequently be accompanied by deformation in another, rather than the two occurring independently.

The Poisson effect offers a simple mechanical perspective on this coupling. In the present model, the initial geometry represented by W may influence how the tissues subsequently deform under load. Changes in W could modify the contact relationships and boundary conditions before loading, with possible effects on both the direction and extent of tissue movement as intra-abdominal pressure increases.

This should not be interpreted as a constitutive description of pelvic floor tissue. Pelvic floor tissues are nonlinear, heterogeneous, anisotropic, and subject to active muscular control, all of which are beyond the scope of the Poisson effect alone. Here, the principle is used more narrowly to emphasize that tissue deformation may occur in a coupled manner, rather than being determined solely by changes in anatomical position.

3.3. Laplace-Type Mechanics: Closure Failure and Redistribution of Mechanical Stress

Mechanical loading in a biological system is not necessarily distributed evenly after its geometry changes. If the configuration of the pelvic floor changes during closure failure, local curvature and tissue orientation may change with it. Some regions may consequently become exposed to a greater share of the mechanical load, particularly where the supporting tissues are already less capable of resisting deformation.

This raises the possibility of a progressive process. Once local deformation occurs, the geometry of the system is altered. The altered geometry may then change how subsequent loads are transmitted. If this process repeatedly favors the same mechanically vulnerable regions, further deformation could occur and closure capacity could decline.

Laplace-type relationships offer a familiar mechanical way of thinking about the relationship among pressure, curvature, and wall tension. They should not, however, be applied directly to the pelvic floor as though it were a simple thin-walled vessel. The pelvic floor has an irregular geometry, heterogeneous tissue properties, multiple attachments, and continuously changing boundary conditions.

For that reason, the role of Laplace-type mechanics in this article is deliberately limited. It is used to illustrate the possibility that a change in local geometry may alter load distribution within the system. Whether this occurs to a clinically meaningful degree in the pelvic floor, and whether it contributes to progressive functional deterioration, remains to be demonstrated experimentally.

3.4. The Hagen–Poiseuille Relationship: Functional Amplification of Small Changes in Urethral Lumen Geometry

The Hagen–Poiseuille relationship illustrates how strongly fluid transport can depend on lumen radius under idealized conditions. In a tubular system, a relatively small change in radius can therefore produce a much larger change in fluid conductance. This nonlinear relationship is relevant to the present discussion because the functional consequence of a change in urethral lumen size need not be proportional to the magnitude of the anatomical change.

A small alteration in the effective closing dimension of the urethra could, in principle, produce a marked change in the resistance to urine flow. Such an effect could help explain why a relatively subtle change in urethral closure might have a clinically important consequence, particularly when the continence mechanism is already operating close to its functional limit.

The analogy has clear limitations. The female urethra is deformable and non-cylindrical, and urinary flow is transient and influenced by the interaction between the urethral wall and the fluid. The assumptions of steady laminar flow through a rigid cylindrical tube are therefore not fully met under physiological conditions.

A more realistic description of this process will require experimental measurements and fluid–structure interaction models that account for the deformable geometry and physiological conditions of the urethra. For the present theoretical framework, the Hagen–Poiseuille relationship is used only to make a narrower point: a small geometric change can have a disproportionately large functional consequence when the underlying structure–flow relationship is nonlinear.

4. Theoretical Predictions and Testable Hypotheses

A useful theory should do more than provide an explanation for observations that are already known. It should also lead to predictions that can be examined in clinical or experimental studies and, importantly, could prove to be wrong. The self-locking and interlocking mechanism therefore leads to several hypotheses that can be evaluated independently.

Prediction 1: Dynamic pressure may be more informative than static position

After adjustment for age, body mass index, parity, urethral mobility, and other relevant confounders, measures related to dynamic vaginal pressure may show a stronger relationship with SUI severity and continence outcomes than static measures of organ position.

The rationale is that closure capacity in the proposed model depends partly on the forces developed between opposing tissue surfaces during loading. A pressure measurement obtained under dynamic conditions may therefore capture an aspect of pelvic floor behavior that cannot be inferred from where the pelvic organs are located at rest.

This prediction can be tested using clinical datasets in which dynamic pressure measurements and conventional anatomical measurements are available from the same participants. Their respective relationships with symptom severity, objective measures of urinary leakage, and postoperative continence could then be examined after adjustment for relevant covariates.

Prediction 2: The relationship between W and closure capacity may be nonlinear

W and closure capacity describe related but distinct aspects of pelvic floor function. W refers primarily to the geometric state of the closure system, whereas closure capacity reflects how effectively that system can respond to loading and maintain functional closure.

An increase in W does not, by itself, imply that closure will immediately fail. The functional consequence of a larger gap is likely to depend on the mechanical reserve of the surrounding tissues and their ability to compensate for the increased separation.

When W remains within a relatively small range, the pelvic floor may still compensate through tissue displacement, deformation, and force generation, with little apparent loss of function. With further widening of the gap, however, this compensatory reserve may become increasingly constrained. At some point, a small additional increase in W could produce a disproportionate change in closure stability.

Accordingly, the proposed model does not assume a simple linear relationship between W and closure function. Instead, it suggests that the effect of W may become more pronounced once the available mechanical reserve is approached or exceeded. This possibility could be investigated by combining dynamic measurements of W with an independent assessment of closure function.

Prediction 3: Anatomical repositioning and functional recovery may diverge

Restoration of anatomical position should not necessarily be expected to produce proportional restoration of continence function. Anatomical repositioning may improve the geometric conditions required for closure, but functional recovery would also depend on whether the surrounding tissues can generate and maintain the mechanical interactions required for a stable closed state.

This distinction could be investigated in longitudinal studies of patients undergoing pelvic floor surgery or other interventions. Changes in anatomical measurements could be compared with changes in dynamic functional parameters and continence outcomes over time.

A clinically relevant finding would be a persistent discrepancy between the degree of anatomical correction and the degree of functional recovery. Such a finding would be consistent with the proposed distinction between anatomical restoration and mechanical functional restoration, although it would not, by itself, establish the self-locking and interlocking mechanism.

Prediction 4: The mechanical effect of an intervention may influence long-term continence beyond anatomical correction

The proposed framework also leads to a surgical prediction. If continence depends partly on coordinated mechanical interactions rather than anatomical position alone, interventions that restore these interactions may produce functional benefits that cannot be explained entirely by the degree of anatomical repositioning.

Procedures that improve tissue coordination, restore sustained force transmission, or facilitate dynamic closure should therefore be expected to perform differently from procedures that primarily alter local anatomy, particularly when the resulting anatomical correction is comparable.

This hypothesis could be tested by comparing interventions with similar anatomical outcomes but different effects on pelvic floor mechanics. Dynamic pressure measurements, imaging during loading, and longitudinal continence outcomes could be used to determine whether differences in functional recovery persist after the extent of anatomical correction has been taken into account.

Prediction 5: Pelvic floor assessment may require integration of structure, geometry, and function

The proposed mechanism implies that the mechanical state of the continence system is unlikely to be captured adequately by a single anatomical measurement. Structural integrity, spatial configuration, and dynamic mechanical behavior describe different aspects of the same system and may therefore need to be considered together.

We propose a Structure–Geometry–Function (SGF) framework comprising three complementary domains:

- Structure — anatomical integrity and supporting structures;
- Geometry — spatial relationships and their dynamic changes, including W;
- Function — pressure generation, tissue interaction, and closure behavior.

The clinical value of this framework could be assessed by determining whether the combination of these domains improves prediction of SUI severity, treatment response, or long-term continence compared with conventional anatomical assessment alone.

Falsifiability of the Proposed Framework

The proposed mechanism is deliberately open to empirical testing. Its central assumptions should be considered unsupported if the predicted relationships repeatedly fail to appear.

For example, if dynamic vaginal pressure measures show no meaningful relationship with continence function after appropriate adjustment for relevant confounders, if W proves unrelated to the functional state of the pelvic floor, or if objectively improved closure capacity does not accompany or predict better continence, important elements of the model would need to be reconsidered. Consistent failure of several independent predictions would provide grounds for substantial revision of the framework and, ultimately, for rejecting it.

5. Clinical Implications, Future Research, and Theoretical Limitations

5.1. Clinical Implications

The self-locking and interlocking mechanism may have implications for how pelvic floor function is assessed in clinical practice. Anatomical position remains an important part of this assessment, but it may not provide a complete picture of functional behavior. Information on tissue structure, pelvic floor geometry, and dynamic function could therefore be considered together. In particular, a structure that appears anatomically intact, or has been successfully repositioned, may still respond abnormally when subjected to increased intra-abdominal pressure.

A similar issue arises in reconstructive surgery. Restoring the position of the pelvic organs is an established objective of pelvic floor reconstruction, but anatomical correction alone may not capture the mechanical behavior of the reconstructed system. The present framework places additional emphasis on whether the reconstructed tissues can establish effective contact, transmit forces appropriately, and maintain a stable configuration when intra-abdominal pressure changes. These features may be relevant when assessing functional recovery and the durability of the surgical result.

This does not diminish the importance of anatomical reconstruction. Instead, it points to a distinction between where the pelvic organs are positioned and how the reconstructed pelvic floor functions under load. Anatomical restoration and restoration of mechanical function may occur together, but they should not necessarily be regarded as equivalent outcomes.

5.2. Future Research

The framework can be taken forward only if its theoretical variables can be translated into measurable quantities. Several lines of investigation follow directly from this requirement.

A first step would be to establish whether closure capacity can be measured objectively. Dynamic vaginal pressure recording and multi-point pressure mapping are two possible approaches. These measurements could be obtained during standardized loading conditions and compared with established clinical and objective measures of SUI. The key issue would not simply be whether pressure differs between individuals, but whether its pattern of change during loading carries information about continence.

The second issue concerns W. Before W can be considered a useful clinical variable, its anatomical definition and measurement procedure will need to be specified. Dynamic pelvic floor ultrasonography and MRI could be used to examine how W changes with loading and whether different observers obtain comparable measurements. It would also be important to determine whether the observed variation in W corresponds to differences in continence or other measures of pelvic floor function. Such analyses should take conventional anatomical measurements and relevant patient characteristics into account, since W may otherwise simply reflect differences that are already captured by established clinical variables. An important question will be whether W remains informative after conventional anatomical parameters and other relevant confounders have been taken into account.

Biomechanical modeling may offer a complementary way to explore the proposed mechanism. Rather than treating the pelvic floor as a fixed anatomical configuration, finite element models could examine how changes in tissue geometry, material properties, and attachment conditions alter deformation and force transmission. Digital twin approaches could eventually extend this work to patient-specific simulations. At present, however, such applications remain dependent on measurements of tissue properties and boundary conditions that are not routinely available in clinical practice.

Prospective longitudinal studies would provide a further test of the framework. Following the same patients over time would allow anatomical changes, dynamic pressure responses, W, and functional measures to be considered in relation to one another rather than as isolated observations. Of particular interest would be the temporal relationship between these variables: whether a change in geometry precedes a change in mechanical function, whether both change together, or whether functional deterioration can occur despite relatively little change in static anatomy. Long-term clinical outcomes

would provide the necessary reference against which these mechanical observations could be interpreted.

An important methodological point is that these measurements should ideally be obtained under comparable loading conditions. Resting measurements alone would not be sufficient to test a theory that is fundamentally concerned with the behavior of the pelvic floor during changes in intra-abdominal pressure. Repeated measurements during standardized maneuvers may therefore be necessary to distinguish a reproducible mechanical response from simple variation in resting anatomy.

5.3. Theoretical Limitations

The proposed mechanism should be interpreted within the limits of its current stage of development. At present, the self-locking and interlocking mechanism is a conceptual framework rather than a validated biomechanical model. W and closure capacity have not yet been assigned universally accepted operational definitions, and their measurement reliability and normal reference ranges remain unknown.

There are also inherent limitations in applying classical mechanical concepts to the pelvic floor. The tissues involved are heterogeneous and anisotropic, exhibit viscoelastic behavior, and are subject to active muscular control. Their attachments, material properties, and boundary conditions are not fixed during loading. The four physical principles discussed above consequently cannot be expected to reproduce the full behavior of the pelvic floor. Their role in this article is narrower: they provide different mechanical perspectives from which the proposed closure process can be considered.

Another limitation concerns the scope of the present theory. The framework was developed primarily to address the mechanics of female SUI. It should therefore not be assumed that the same variables or mechanical relationships will explain pelvic organ prolapse or other pelvic floor disorders. Extension of the model to these conditions would require separate theoretical development and empirical testing.

Finally, the present work contains no original physiological measurements or clinical outcome data. The proposed relationships among W, closure capacity, dynamic pressure, and continence consequently remain hypotheses. Whether these variables can be measured reliably, whether they are independently associated with continence, and whether changing them alters clinical outcomes are questions that can only be answered by subsequent experimental and clinical studies.

6. Conclusion

The clinical definition of SUI is straightforward, but the mechanical event behind it is not. Urine leakage occurs when abdominal pressure rises, yet the presence or degree of an anatomical abnormality does not always predict how well continence will be maintained. This leaves an important part of the problem between anatomy and clinical function: what happens to the pelvic floor once it is subjected to load?

The self-locking and interlocking mechanism proposed in this article addresses that part of the problem. It considers the pelvic floor as a deformable system whose tissues continuously adjust their positions and mechanical relationships as intra-abdominal pressure changes. Effective continence, in this view, depends on whether those changes lead to a sufficiently stable closure and whether that closure can withstand the mechanical demand imposed on the system.

The distinction between W and closure capacity is central to this interpretation. W describes the geometric problem that must be accommodated before effective approximation can occur. Closure capacity describes the functional reserve available to deal with that problem once the system is loaded. A larger W does not, in itself, establish that continence will fail. Its consequence depends on the ability of the surrounding tissues and supporting structures to compensate for the associated geometric and mechanical demands.

The four mechanical principles discussed in this article serve different purposes within this reasoning. Friction provides one explanation for how contact between tissue surfaces may contribute to local stability. The Poisson effect draws attention to the fact that tissue deformation is coupled rather than purely positional. Laplace-type mechanics raises the possibility that changes in geometry may influence where mechanical loads are concentrated. The Hagen–Poiseuille relationship shows, under idealized conditions, why a relatively small alteration in urethral lumen radius may have a disproportionate effect on fluid transport. None should be interpreted as a complete mechanical model of the pelvic floor.

The proposed mechanism is consequently not intended to displace the established anatomical theories of female continence. Its contribution is narrower. It places dynamic geometry and mechanical behavior between anatomical structure and functional outcome, and it suggests that this intermediate level may contain information that is missed when assessment is restricted to static position.

Whether this additional mechanical layer is useful remains an empirical question. W needs a reproducible anatomical definition; closure capacity requires an objective functional measure; and both need to be tested against established measures of continence. The predicted relationships between

geometry, pressure, tissue interaction, and functional outcome must likewise be examined in prospective clinical and experimental studies.

For now, the value of the self-locking and interlocking mechanism lies not in claiming a definitive explanation for SUI, but in providing a testable way of asking why anatomical findings and continence function do not always change in parallel. If subsequent evidence supports these relationships, the framework may offer a useful complement to anatomical assessment. If the predictions are not supported, the mechanism will need to be revised. Its ultimate strength should therefore be judged by its ability to withstand measurement and experimental testing rather than by its conceptual appeal alone.

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No potential competing interests to declare.

Use of Generative AI

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) for language editing and improvement of readability. The authors reviewed and approved all AI-assisted modifications and take full responsibility for the accuracy, integrity, originality, and scientific content of the manuscript.

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