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Review of Tuberous Breast Deformity: Developments over the Last 20 Years

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Background: Tuberous breast (TB) deformity is a condition characterized by alterations in breast morphology and tissue structure with high prevalence in the general population. The literature provides sparse descriptions of TB, as not many investigations on the condition have been conducted. The aim of this review was to analyze and provide a holistic overview on the morphological characteristics of the TB.

Methods: A review of current literature was performed using the PubMed database from 2001 to 2021. The key words used for the review included "tuberous breast," "constricted breast," and "stenotic breast." We included articles that analyzed the anatomic and histologic characteristics of TB.

Results: From 213 articles, only 42 met the inclusion criteria. A total of 171 articles were excluded, as they were letters, not related to the condition, or were written in a foreign language. The studies in this review drew on hypothesis on the embryological origin of TB and analyzed the composition of TB tissues, consisting in a constricting fibrous ring, made of longitudinally arranged collagen and elastic fibers. Furthermore, the review reports the different anatomical and surgical classifications, as well as the various surgical corrective procedures developed throughout history up to 2021.

Conclusion: The review describes all etiological, epidemiologic, anatomical, histological, and surgical characteristics of tuberous breast. *(Plast Reconstr Surg Glob Open 2022;10:e4355; doi: 10.1097/GOX.0000000000004355; Published online 26 May 2022.)*

INTRODUCTION

Tuberous breast (TB) deformity is a condition characterized by alterations in breast morphology and tissue structure with a high prevalence in the general population. The condition was first described by Ress and Aston in 1976.[1] It arises during puberty and it is generally characterized by a range of gross alterations, such as contracted skin envelope (horizontally and vertically), constricted breast base, breast parenchyma volume reduction, abnormal elevation of the inframammary fold, areolar herniation of the breast parenchyma, and nipple-areolar complex (NAC) herniation associated with a normal breast base.[2]

The literature provides sparse descriptions of TB because not many investigations on the condition have been conducted. The aim of this review was to analyze and provide a holistic overview on the morphological characteristics of the TB.

METHODS

A review of the current literature was performed using the PubMed database (from 2001 to 2021). The keywords used for the review included "tuberous breast," "constricted breast," "stenotic breast." We included articles that analyzed the anatomic and histologic characteristics of TB. Only original articles written in English were included. All non–subject-related articles, commentaries, and letters were excluded.

RESULTS

From 213 articles, only 42 met our inclusion criteria. The remaining 171 articles were excluded because they were letters, not related to the condition, or were written in a foreign language.

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ETIOLOGY, GENETICS, AND HISTOLOGIC CHARACTERISTICS

The exact etiology of TB is still controversial; however, it is generally accepted that it has an embryological origin. In 1962, Tanner described normal breast development.[3] During the 10th to 14th week of gestation, the developing breast bud (ectodermal origin) invaginates into the underlying mesenchyme and becomes enclosed within the superficial fascia, which is a continuous layer of the Camper's fascia. The superficial fascia is made by two layers, covering respectively the breast parenchyma and its posterior boundary. The deeper layer of the fascia is separated from the underlying pectoralis major and serratus anterior muscles by the loose areolar space of Chassaignac.[4–6] The superficial layer of the fascia, however, is absent in the area underneath the areola. Within the NAC, there is also a subareolar smooth muscle layer with circular fibers (muscle of Sappey) and radial fibers (muscle of Meyerholtz).

The areolar projection is first noted in the prepubertal phase, followed by the glandular development in a semispherical fashion. At puberty, the breast assumes a conical shape with a net nipple-areola projection.[5]

Many theories have been formulated to explain the development of TB. Phylogenetic relapse was suggested in 1930. Later, it was postulated that the deformity is due to a failure of tissue differentiation in a limited zone of the fetal thorax.[7]

The anomaly of the areolar fascia is the main theory in the TB development. Some authors suggest an anomaly in the quality of the skin of the areola with a deficiency of areolar fascial support. Another possible cause is the presence of a constricting fibrous ring, made up of longitudinally arranged collagen and elastic fibers. Some authors describe the ring at the level of areola, impeding both horizontal and vertical growth of the breast parenchyma.[4,5,7,8] Other authors supported the hypothesis of strong adherence between the dermis and the deeper muscle layer and presence of the constricting fibrous ring at the glandular base, preventing radial expansion and promoting a more protuberant and tubular shape of the glands.[9,10]

Another theory suggests an implication of hormonal action, which normally promotes breast enlargement during puberty. In particular, estrogenic hormones normally induce horizontal growth of the galactophorous ducts with a horizontal widening of the NAC. If the breast is not able to spread radially, the developing glandular tissue projects anteriorly. Progesterone normally induces lobular development with a vertical thrust. If this process is rapid and is not paralleled by expansion of the skin envelope, the glandular element will herniate through the areola.[11,12]

These theories, despite being vastly described, have not been confirmed by strong histopathological evidence in the literature. Histological studies support the theory behind the presence of the superficial fascia fibrous ring. A case-control study was performed to describe the differences of breast parenchyma components between TB and normal patients. TB patients showed histological evidence of a disorder deposition and concentrations of collagen fibers and dispositional abnormalities involving all the stromal components (derma, gland, adipose tissue, and fascia) compared with normal breasts. During the surgical experience, they never found ring-like fascia constriction.[13] Furthermore, other histological studies reported the presence of large concentrations of collagen and elastic fibers on the periphery in the constrictive ring of the superficial fascia and within the central portion of the glandular structure.[14–16]

The genetic implication has been investigated in a few studies, showing a correlation among homozygous twins and consanguineous.[13,17] One study recruited six patients with positive family history: the first family was formed by three first degree and second cousins, and the second family was formed by two sisters and their mother. There was a correlation in the presence of TB among those lineages, thus presuming a possible genetic role in transmission of TB.

Despite the results found in the literature, a definite consensus on the histopathological and genetic characterization of the condition has not been proposed. As the literature focuses more on the surgical correction of the deformity, further research is needed for a more detailed description of TB.

Takeaways

Question: What are the etiological, epidemiologic, anatomical, histological, and surgical characteristics of tuberous breast (TB)?

Findings: The exact etiology of TB is still controversial. Many classification criteria have been created, yet they mainly revolve around the macroscopic characteristics and the types of surgical correction for the condition. The histological findings regard higher concentrations of collagen fibers and dispositional abnormalities involving all the stromal components.

Meaning: TB presents findings that differ from normal breasts. More evidence is needed to make a consensus on the condition's etiological, epidemiologic, anatomical, histological, and surgical characteristics.

TUBEROUS BREAST CLASSIFICATION SYSTEMS

In 1996, von Heimburg et al[7] proposed a classification system that is routinely employed in clinical practice (used in 9/41 articles), based on four main types of tuberous breast:

- Type I: hypoplasia of the lower medial quadrant;
- Type II: type I with sufficient skin in the subareolar region;
- Type III: type I with no sufficient skin in the subareolar region; and
- Type IV: severe breast constriction with minimal breast base.[7]

The most accredited classification (15/41 articles) was proposed in 1999 by Grolleau. The classification is based on the defects on the mammary base: type I (minor

form)—only the lower medial quadrant is deficient; type II—both lower quadrants are deficient and type III —all four quadrants are deficient.[10]

More recently, a further type of TB has been introduced by Costagliola et al.[8] It is characterized by NAC herniation, either permanent or intermittent, with a normal breast base observed mostly in patients with normal or hypertrophic breast that can be evaluated through manual compression or mammostat. They indicated that the classification of TB should additionally include a fourth type (type 0) to describe the isolated simple areola protrusion. Currently, protuberant NAC does not fit appropriately in either classification, but is a real clinical entity with typical morphological characteristics.[18] The main classification systems, nevertheless, are based on a subjective clinical assessment of the deformity and inevitably results in substantial interobserver variability.

In 2005, another classification was made by Persichetti et al, rating the degree of asymmetry based on breast volume, the details of which are as follows[19]:

- Grade A: mild (<200 g)
- Grade B: moderate (between 200 and 400 g)
- Grade C: severe (>400 g).

In 2007, Pacifico and Kang[20] proposed the Northwood index, a standardized assessment tool, representing the relationship between the areola's diameter and herniation measured on the lateral view. In tuberous breasts, the Northwood index is greater than 0.4.

In 2015, Adam and colleagues decided to use a three-tier classification system that facilitated their qualification of the anatomical considerations and severity of TB deformities[21]:

- Type I: minor base constriction; normal laterally and minor elevation medially of the inframammary fold; sufficient skin envelope; minimal/no deficiency or hypertrophy of the breast volume; mild/moderate/severe ptosis; enlargement of areola.
- Type II: moderate base constriction; medial and lateral elevation of the inframammary fold; inferior insufficiency of the skin envelope; moderate deficiency of the breast volume; none or mild ptosis; normal/mild/moderate herniation of the areola.
- Type III: severe base constriction; elevation of entire inframammary fold or fold absence; global skin envelope insufficiency; severe breast volume deficiency; mild/moderate ptosis; severe herniation of areola.

In 2017, Klinger et al[16] considered the anatomical feature of breast stenosis as the main aspect to be assessed. They identified two groups: vertical stenotic gland and vertical–horizontal stenotic gland. Moreover, they analyzed glandular parenchymal trophism (hypoplastic defined as insufficient glandular tissue or not hypoplastic) and ptosis (considered as areolar positioning under the inframammary fold). Accordingly, eight different groups were obtained:

1) Vertical stenosis, hypoplastic, non-ptotic
2) Vertical stenosis, hypoplastic, ptotic
3) Vertical stenosis, non-hypoplastic, non-ptotic
4) Vertical stenosis, non-hypoplastic, ptotic
5) Vertical–horizontal stenosis, hypoplastic, non-ptotic
6) Vertical–horizontal stenosis, hypoplastic, ptotic
7) Vertical–horizontal stenosis, non-hypoplastic, non-ptotic
8) Vertical–horizontal stenosis, non-hypoplastic, ptotic

The author highlights the importance of this classification also for the choice of the surgical procedures to be used. For each group, in fact, specific techniques and procedures are suggested.

In 2018, Innocenti et al[15] proposed a new classification including minor forms, also considering the breast volume and tissue quality. Based on the volume, they identified two types of breasts: hypoplastic and normoplastic TB. Based on the consistency of the tissue, they distinguished soft and solid TB.

- Hypoplastic:
  - The soft hypoplastic TB represent the most severe form of the deformity: its skin cover is extremely thin and easily pinched in folds (because of the poor presence of suspending ligaments);
  - on the contrary, solid hypoplastic TB has a wider mammary base, a smaller areola and a thicker skin cover firmly connected to the parenchyma through compact connections by Cooper ligaments, the inferior mammary pole is generally flat or concave, whereas the inframammary fold is absent.
- Normoplastic:
  - Type I–II: deficit of breast volume in the lower pole, only medial quadrant (type I) or both the medial and lateral quadrants (type II). Both types I and II have upper pole fullness because most part of the parenchyma is displaced upward by the sulcus and the deficiency of skin cover in the lower pole. They usually appear with a different grade of ptosis and their NAC, placed at a shorter distance than normal from the inframammary fold, points downward.
  - Type III: permanent or intermittent glandular protrusion inside the areola on a normal mammary plate introduced by Costagliola et al. All the mentioned classifications are summarized in Table 1.

PREVALENCE

The exact incidence of TB is unknown and underestimated as many women with mild degrees of deformity may not seek help. Patients usually ask for a surgical consultation if they present with unilateral TB (increasing the asymmetry to the contralateral breast) or in case of a severe bilateral presentation, as it may cause major psychological distress.[15]

Only one study was specifically focused on prevalence of TB: a 5-year retrospective analysis on standard preoperative photographs of White female patients reported that the presence of at least one of the typical features characterizing TB is extremely common among the general population (27.6%). The high prevalence of TB is particularly common among women seeking breast augmentation and breast reduction (about 50%).[2]

Table 1. Summary of the Different Classifications of TB

Author	Year	Classification of Tuberous Breast
Von Heimburg et al[7]	1996	• Type I: hypoplasia of the lower medial quadrant; • Type II: type I with sufficient skin in the subareolar region; • Type III: type I with no sufficient skin in the subareolar region; • Type IV: severe breast constriction with minimal breast base.
Grolleau et al[10]	1999	• Type I (minor form): only the lower medial quadrant is deficient; • Type II: both lower quadrants are deficient • Type III: all four quadrants are deficient
Persichetti et al[19]	2005	Asymmetry level: • Grade A: mild (<200 g) • Grade B: moderate (between 200 and 400 g) • Grade C: severe (>400 g).
Pacifico and Kang[20]	2007	Northwood index (N/D index): relationship between the areola's diameter and herniation measured on the lateral view.
Costagliola et al[8]	2013	• Type 0: normal mammary base; isolated areolar complex herniation sometimes intermittent • Type I: defect of inferior medial part of mammary base, S italics aspect • Type II: defect of lower pole • Type III: defect of total base, extremely narrow-based breast. Tubular Snoopy deformity
Kolker and Collins[21]	2015	• Type I: minor base constriction; minor elevation on medial inframammary fold; minimal hypertrophy; mild/moderate/severe ptosis; enlargement of areola. • Type II: moderate base constriction; medial and lateral elevation of the inframammary fold; inferior insufficiency of the skin envelope; moderate deficiency of the breast volume; none or mild ptosis; normal/mild/moderate herniation of the areola. • Type III: severe base constriction; elevation of entire inframammary fold or fold absence; global skin envelope insufficiency; severe breast volume deficiency; mild/moderate ptosis; severe herniation of areola.
Klinger et al[16]	2017	1) Vertical stenosis, hypoplastic, non-ptotic 2) Vertical stenosis, hypoplastic, ptotic 3) Vertical stenosis, non-hypoplastic, non-ptotic 4) Vertical stenosis, non-hypoplastic, ptotic 5) Vertical–horizontal stenosis, hypoplastic, non-ptotic 6) Vertical–horizontal Stenosis, hypoplastic, ptotic 7) Vertical–horizontal stenosis, non-hypoplastic, non-ptotic 8) Vertical–horizontal stenosis, non-hypoplastic, ptotic
Innocenti et al[15]	2018	• Hypoplastic: • Soft: most severe form; skin cover is extremely thin and easily pinched in folds • Solid: wider mammary base, a smaller areola and a thicker skin cover, flat or concave inferior mammary pole, absent the inframammary fold. • Normoplastic: • Type I–II: deficit of breast volume in the lower pole, only medial quadrant (type I) or both the medial and lateral quadrants (type II); upper pole fullness; deficiency of skin cover in the lower pole; different grade of ptosis; shorter inframammary fold – NAC distance, downward pointing NAC. • Type III: permanent or intermittent glandular protrusion inside the areola

In the 42 articles, 2094 patients (age range: between 12 and 65 years) were studied, mostly White women with bilateral TB presentation. Male tuberous breast was poorly investigated and lacks a classification system in the current literature.[22]

SURGICAL CORRECTION PROCEDURES

The type of surgical procedure is determined by specific factors which must be considered by both the surgeon and the patient. The patient must express their preference regarding breast volume, which has to be compatible with the surgeon's chosen procedure, materials and goals in breast reconstruction.

The goals in TB reconstructive procedures are to release the constricted base both vertically and horizontally, restore the correct nipple-inframammary fold distance, avoid the double bubble, correction of ptosis and hypertrophy, and restoration of both volume and asymmetry (Figs. 1, 2).[23]

Different approaches to TB correction have been described in the literature. Although many encompassed the use of well-known reconstructive procedures, some authors chose personalized techniques.

The periareolar surgical incision was the most common approach used by authors. Depending on the aim of TB surgical correction, an inferior hemi-periareolar or a complete periareolar incision was made. This surgical access was usually chosen due to the easy visibility of the whole breast gland and wider vision of the operative field. Furthermore, a complete periareolar incision allows for nipple-areolar-complex reshaping, repositioning and breast mastopexy.[2,14,16,21,24–26]

Glandular detachment procedure was also greatly employed in the literature. The procedure involved the complete interruption of retractile fibers connecting muscular and glandular tissue. This maneuver is greatly important because it allows for the whole gland tissue to be reshaped and homogeneously redistributed through flaps in all four breast poles. This also allows the correction of both vertical and horizontal stenosis, by respectively lowering the inframammary fold and by obtaining a breast base enlargement.[14,22,25,27,28]

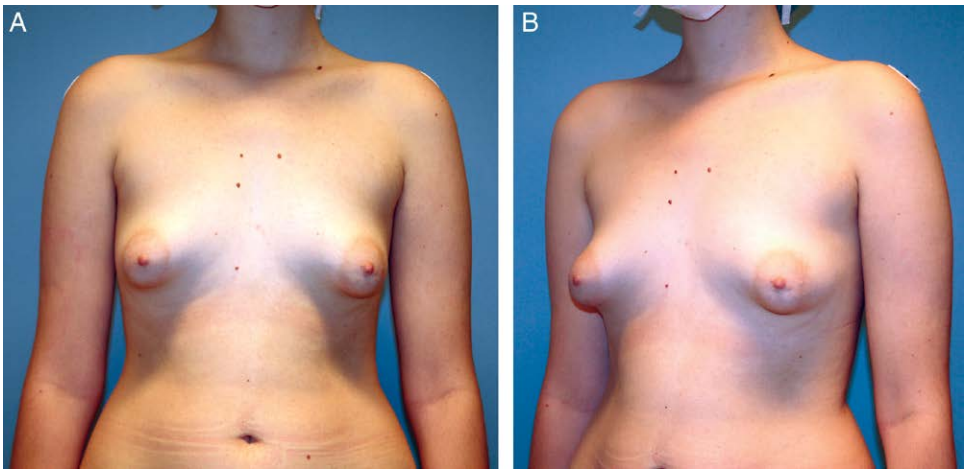

Fig. 1. Preoperative stenotic characteristics of TB in a young woman seen in our practice. Preoperative tuberous breast frontal (A) and oblique (B) views.

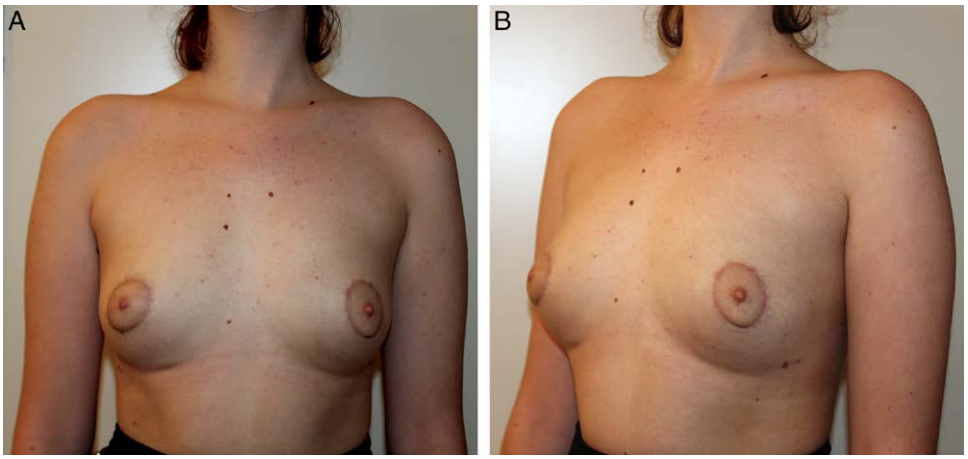

Fig. 2. Postoperative results of the same patient, surgically corrected using a periareolar approach, glandular detachment, tissue scoring, breast implant placement and fat grafting procedures. Postoperative tuberous breast frontal (A) and oblique (B) views.

Tissue scoring is a common technique used to release the glandular tissue from the stenotic fascia, to allow expansion, and to minimize the anesthetic postsurgical defects such as glandular retractions. This is done by performing parallel vertical and horizontal surgical incisions directly on the fascia or by percutaneous 18-gauge V-shaped fasciotomies.[14,29,30]

Periareolar mastopexy was used to elevate and centralize the NAC. This allows the correction of asymmetries between the NAC in terms of position and diameter. It also made it possible to reduce the excessive distance between the inframammary fold and the areolar border. The marking for mastopexy can be described as an eccentric oval around the circumference of the areola with higher diameter placed in the direction of planned NAC displacement. Both a skin-only donut mastopexy and Benelli mastopexy were utilized.[14,29]

Inverted T mastopexy was also employed in cases of severe ptotic breasts with no constricted base. The technique was greatly used with breast reduction surgeries in bigger breasts or to balance out the contralateral breast volumes.[21,26,31]

Breast implants have been vastly employed in different procedures for TB correction. In particular, they were used to adapt the breast volume and to provide the correct conical shape when absent.[16,21,25,30,32–41]

Implants were mostly placed in subpectoral (double-plane) position. This procedure involves the pectoralis major muscle dissection and the creation of a pocket where to place the chosen breast implant. Partial submuscular coverage of breast implants is usually employed. This adds supporting tissue coverage to the implant, especially when the skin is thin.[21] When the pectoralis major costal insertion is excessively cranial or when the pectoralis muscle does not provide adequate covering, the implants are inserted in the subglandular plane.[16]

Furthermore, both single-stage or two-stage breast correction procedures were used depending on the level of breast hypotrophy. Hypotrophic breasts did not allow a direct implant insertion, but required the use of tissue expanders before the insertion of a breast implant.[21] The lower amount of breast parenchyma due to hypotrophy,

in fact, obliges surgeons to first create a subpectoral space in a gradual time period to allow the tissue adaptation to increasing volumes.

Fat grafts were used in combination with augmentation techniques to help in perfecting breast remodeling. Lipofilling is, in fact, helpful in reshaping tissue depression and correcting the "tissue memory" caused by the high fibrosis characteristic of TB. Lipofilling overall improved tissue release and breast pole filling.[2,16,29,30,34,36,37,40–47]

Fat graft was usually obtained from the periumbilical region through Coleman technique. The fat delivery was performed in a multiplanar, multidirectional fan-shaped technique to maximize the surface area of the graft.[41] The fat transfer was also performed with the use of needles, as they allow both graft deposit and needle-induced fibrosis release by needleotomy.[16]

Fat grafts were also employed as the sole procedure for the correction of asymmetrical or unilateral TB, to volumetrically match the contralateral breast. The fat was grafted in multiple layers and the volume overcorrected due to future fat reabsorption.[48]

Less recurrent in literature were the personalized approaches to TB correction. Among these, Muti's technique describes the transferring of glandular tissue from the upper glandular quadrants to the inferior ones.[17,32]

Other techniques were the Puckett's technique for remodeling the glandular flap, Lejour's method of breast reduction, pedicled transverse rectus abdominis myocutaneous (TRAM), and latissimus dorsi muscle flap.[40,49,50] Puckett's and Lejour techniques are preferred in cases of higher breast volumes, which can be reshaped by autologous pedunculated flaps. The transverse rectus abdominis myocutaneous and latissimus dorsi muscle flap are employed in case of smaller breast volumes and in case of the patient's preferring autologous tissue reconstruction rather than an implant-based procedure, as well as based on the surgeon's experience and preference.

The "compass rose" suture technique was another personalized approach applied to the reduction of the nipple-areolar complex.[51] Procedures for the correction of TB in men were also depicted. Particular relevance regarded mastectomy procedures,[24] parenchymal debulking techniques,[21,26] and NAC reduction procedures.[52,53]

POSTOPERATIVE COMPLICATIONS

The literature describes some postoperative complications, the occurrence rate of which varies depending on the type of surgical correction employed. Common complications seen after implant insertion were listed from the most to the least recurrent and involve the double-bubble deformity, capsular contracture, implant mispositioning and displacement, infections, seroma, hematomas, and implant rupture. In contrast, the most common complication observed in procedures involving autologous fat grafting involve the formation of cysts.[14,16]

CONCLUSIONS

TB is relevant to clinical practice, as it is encountered quite frequently. Despite the high prevalence, only a few studies have been performed, and more information is needed on the pathophysiological mechanisms, etiology, and histological characteristics of this condition. In particular, a better knowledge of the condition can aid the development of specific medical, biomolecular, or mechanical tools to prevent or correct this condition with decreasing complication rates and more satisfying aesthetic results.

Another problem encountered during the revision of all the articles was the diversity in the classification used to assess and grade TB. Future goals would be to unify the classification methods, so as to obtain a general consensus on therapeutic strategy to apply, according to the degree of deformity.

Additionally, studies on the correlation of TB with other medical pathologies should be made. As histological findings show higher collagen densities, TB can be found to be associated with other diseases with abnormalities in the extracellular matrix. Being macroscopically visible, if associated with other medical conditions, the presence of TB can become an easy-to-assess sign for the diagnosis of extracellular matrix syndromes.

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