






# Esthetic Rib Remodeling in Adults: A Systematic Review of Efficacy and Safety

## Remodelamento costal estético em adultos: Revisão sistemática de eficácia e segurança

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### Abstract

**Introduction** Esthetic rib remodeling reduces waist circumference, but available evidence remains scarce.

**Objective** To assess the efficacy, safety, and technical feasibility of esthetic rib remodeling in healthy adults.

**Materials and Methods** Systematic review of Public Medical Literature (PubMed)/ Medlars online (MEDLINE), Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS), and Cochrane Library on April 28, 2025. Two reviewers independently selected the studies. Eleven clinical studies met the inclusion criteria, covering rib-extension or Costari (RibXcar), ultrasound-assisted indentation surgery of the torso (UUAIST), rib osteosynthesis stabilization (RIBOSS), ultrasonic ostemodelling for body contouring (ORUS), waistline esthetic slimming by puncture (WASP) and parallel approach, greenstick fracture, and floating-rib resection.

**Results** Waist reduction ranged from 6 to 13 cm, being higher for RIBOSS. Reported complications included minor burns (n = 2), atelectasis (n = 2), pneumothorax (n = 2 [intraoperative] + 1 [delayed]), prolonged pleural effusion (n = 1), mild dehiscence (n = 1), and contour asymmetries (n = 3).

**Conclusion** Although these techniques provide short-term cosmetic benefit, the low methodological quality of the studies and absence of long-term functional outcomes prevent definitive conclusions regarding safety, durability, and ideal indications.

### Keywords

- ▶ plastic surgery
- ▶ cosmetic surgery
- ▶ thoracic surgery
- ▶ rib resection
- ▶ body contouring

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## Resumo

**Introdução** O remodelamento costal estético objetiva reduzir a circunferência da cintura e remodelar o arco costal, mas a evidência disponível permanece limitada.

**Objetivo** Avaliar a eficácia, segurança e viabilidade técnica do remodelamento costal estético em adultos saudáveis.

**Materiais e Métodos:** Revisão sistemática nas bases Public Medical Literature (PubMed)/Medlars online (MEDLINE), Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS) e Cochrane Library até 28 de abril de 2025. Dois revisores conduziram triagem independente. Onze estudos atenderam aos critérios de inclusão, contemplando *rib-extension or Costari (RibXcar)*, *ultrasound-assisted indentation surgery of the torso (UUAIST)*, *rib osteosynthesis stabilization (RIBOSS)*, *ultrasonic ostemodelling for body contouring (ORUS)*, *waistline esthetic slimming by puncture (WASP)* e abordagem paralela, fratura *greenstick* e ressecção de costelas flutuantes.

**Resultados** A redução documentada da cintura variou entre 6 e 13 cm, sendo a maior magnitude associada à RIBOSS. As complicações registradas incluíram queimaduras cutâneas (n = 2), atelectasias (n = 2), pneumotórax (n = 2 intraoperatórios + 1 tardio), derrame pleural prolongado (n = 1), deiscência leve (n = 1) e assimetrias (n = 3).

**Conclusão** As técnicas demonstram benefício estético de curto prazo; porém, a qualidade metodológica dos estudos é baixa e não há avaliação funcional em longo prazo, limitando conclusões sobre segurança, durabilidade e indicações ideais.

## Palavras-chave

- ▶ cirurgia plástica
- ▶ cirurgia estética
- ▶ cirurgia torácica
- ▶ ressecção de costela
- ▶ contorno corporal

## Introduction

Recently, rib remodeling has gained popularity as an esthetic body contouring technique, particularly among patients seeking slimmer waists, enhanced thoracic definition, and a harmonious overall silhouette. Notable techniques described include ultrasound-assisted indentation surgery of the torso (UUAIST), rib osteosynthesis stabilization (RIBOSS), and selective resection of the floating ribs.<sup>1-3</sup>

Beyond purely esthetic enhancement, a growing number of patients undergo these interventions for specific purposes, such as bodily feminization or aligning thoracic contour with gender identity. As such, rib reduction or remodeling techniques have been employed to reduce the waist-to-hip ratio (WHR) and accentuate traditional feminine features.<sup>4</sup> Despite the increasing clinical adoption of these techniques, literature remains scarce, consisting mainly of case series, with no integrated evaluation of the efficacy, safety, and functional impact in healthy adults undergoing procedures solely for esthetic purposes.<sup>2</sup>

Recent studies indicate that both patients and surgeons have a positive perception of these procedures, with high esthetic satisfaction and low rates of severe short-term events.<sup>1-3</sup> However, methodological heterogeneity and the lack of comparative controls and standardized clinical, functional, and esthetic outcomes limit the interpretation of available results and hinder the establishment of these techniques as evidence-based practices.<sup>1</sup> Aspects such as postoperative quality of life and subjective perception of improvement remain scarcely addressed, despite the existence of validated scales (e.g., BODY-Q) recommended for measuring psychosocial outcomes.<sup>5</sup> Additionally, objective

data on functional impact, such as long-term spirometric parameters, remain scarce.<sup>1</sup>

To the best of our knowledge, this systematic review is the first to exclusively synthesize evidence regarding rib remodeling performed solely for esthetic purposes in healthy adults, comparing techniques, presenting objective ranges of reduction (when reported), and organizing complications according to documented incidence. Unlike previous reviews that included heterogeneous populations or reconstructive contexts, the present study focuses solely on esthetic procedures, allowing a more precise assessment of efficacy and risks. We aim to fill a critical gap by providing a structured synthesis that supports clinical decision-making, guides surgical practice, and informs the development of future guidelines.

## Materials and Methods

The present systematic review of the literature adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)<sup>6</sup> and the guidelines set by the International Committee of Medical Journal Editors (ICMJE) for preparing scientific manuscripts.

The guiding question was structured using the population, intervention, comparison, outcome (PICO) framework.<sup>7</sup> The population (P) included adults with no thoracic disease; the intervention (I) comprised rib remodeling techniques performed for purely esthetic purposes; the comparison (C), when applicable, involved either no intervention or a comparison between different surgical approaches; and the outcomes (O) encompassed waist circumference reduction, WHR, esthetic satisfaction, surgical complications, and technical feasibility.

We conducted a systematic search of Public Medical Literature (PubMed)/Medlars online (MEDLINE), Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS), and the Cochrane Library, covering all available publications up to April 28, 2025. The search strategy combined free terms and descriptors using Boolean operators, including *rib remodeling*, *esthetic rib resection*, *floating rib removal*, *waist reduction surgery*, *rib contouring*, *body contouring surgery*, *greenstick fracture*, *rib osteotomy*, *rib reshaping*, and *thoracic feminization*. Supplementary Material 1 shows the complete search strategy, including detailed descriptors and Boolean operators for each database.

Inclusion criteria encompassed studies reporting procedures performed exclusively for esthetic purposes, involving adults ( $\geq 18$  years) of any gender or gender identity, with no history or diagnosis of thoracic disease. Eligible studies included those describing greenstick fractures, monocortical osteotomies, piezotomies, or selective resection of floating ribs, with study designs comprising clinical trials (randomized or non-randomized), prospective or retrospective cohorts, or case series with up to five patients.

We included articles reporting at least one of the following outcomes: waist circumference reduction, WHR change, assessment of body symmetry, patient satisfaction, or complication rates. We only considered articles published in English or Spanish that were available as full texts. Exclusion criteria comprised studies with reconstructive purposes, populations under 18 years, patients with thoracic or significant pulmonary disease, cases of functional thoracic reconstruction, series with fewer than five patients, and articles not accessible in full text.

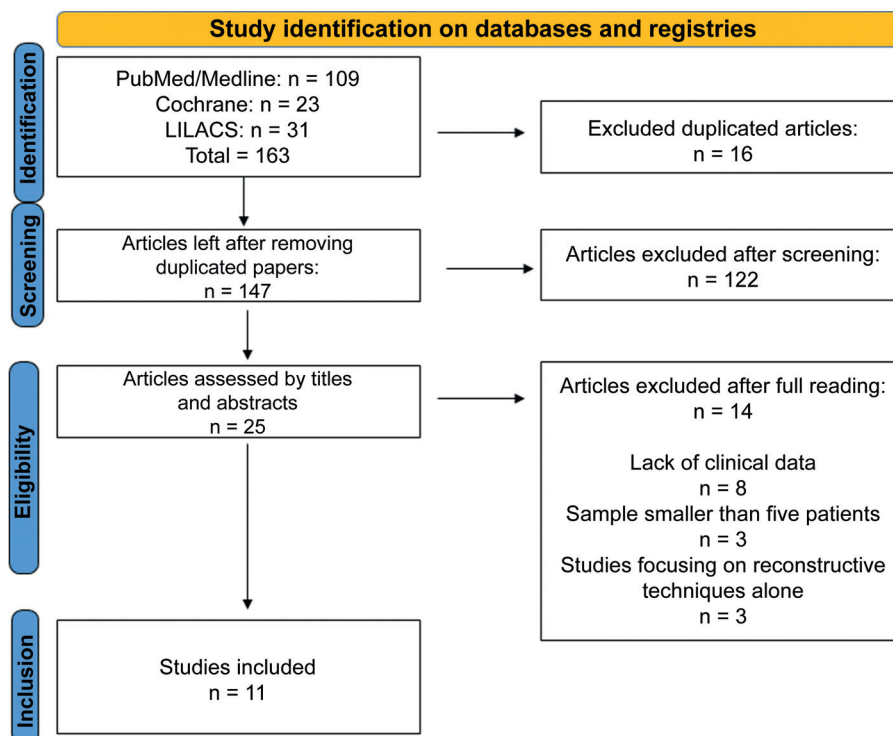
Two independent reviewers conducted the screening in two stages: first by reading titles and abstracts, and then by evaluating the full text of potentially eligible studies. The assessment of inter-rater agreement utilized Cohen's kappa coefficient ( $\kappa = 0.82$ ), which indicates a near-perfect level of concordance.

Assessment methods were objective (e.g., measurement of abdominal circumference, WHR, standardized imaging) or subjective (self-reported outcomes, surgeon evaluation, spontaneous satisfaction). Additionally, when applicable, standardized tools for psychosocial assessment in esthetic surgery, such as the BODY-Q, were identified and recorded.

Studies were grouped according to the surgical technique employed and primary clinical outcomes. A qualitative analysis was performed, with studies categorized as positive (+) if they demonstrated consistent waist reduction, low complication rates, and high esthetic satisfaction; neutral (0) if results were inconclusive, inconsistent, or limited by methodological shortcomings; and negative (-) if outcomes were unsatisfactory.

The design of each study guided the methodological quality assessment. Evaluation of observational studies followed the Newcastle-Ottawa Scale (NOS),<sup>8</sup> while case series analysis adhered to the adapted criteria proposed by Murad et al.<sup>9</sup>

The final synthesis was narrative due to the heterogeneity in study designs, populations, surgical interventions, and assessment tools, with no meta-analysis. Study screening and selection adhered to the PRISMA framework (►Fig. 1). ►Table 1 outlines the quality classification of included studies based on the NOS and Murad recommendations.



**Fig. 1** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart describing the study selection process.

**Table 1** Methodological assessment using the Newcastle-Ottawa Scale and Murad recommendations

Study	Design	Tool	N	Follow-up	Outcome measurement	Control group	Bias risk	NOS/Murad score*	Final classification
Cipriani et al. <sup>10</sup> , 2023	Case series	Murad	30	Insufficient (3 months)	Partially objective (circumference + satisfaction)	No	High	Aug 3	Low quality
Cipriani et al. <sup>11</sup> , 2024	Case series	Murad	100	NR	NR	No	NR	NR	Not classifiable
Donders and Saenz, <sup>12</sup> 2025	Case series	Murad	220	Adequate (6 months)	Circumference + imaging	No	Moderate	Aug 6	Moderate quality
Valdivieso et al. <sup>13</sup> , 2024	Prospective multicenter study	NOS (adapted)	131	Adequate	Objective (circumference) + subjective	No	Moderate	Sept 7	Moderate-to-high quality
Villa et al., <sup>14</sup> 2025	Retrospective cohort	NOS	27	Insufficient (< 6 months)	Objective	No	High	Sept 5	Low-to-moderate quality
Avilez et al., <sup>16</sup> 2025	Case series	Murad	120	Adequate	Objective	No	Moderate	Aug 6	Moderate quality
Perez et al., <sup>15</sup> 2023	Abstract	NR	NR	NR	NR	NR	NR	NR	Not classifiable
Kudzaev and Kraushkin, <sup>17</sup> 2021	Case series	Murad	93	Only 14 with objective follow-up	Objective for subgroup	No	High	Aug 4	Low quality
Hoyos et al., <sup>20</sup> 2023	Case series	Murad	15	Insufficient	Subjective + imaging	No	High	Aug 3	Low quality
Verdugo, <sup>18</sup> 2022	Retrospective series	NOS	104	NR	Subjective	No	High	NR (no numerical score for NOS)	Low quality
Chiu et al., <sup>19</sup> 2023	Case series	Murad	5	Insufficient	Objective WHR	No	High	Aug 4	Low quality

Abbreviations: NR, not reported; WHR, waist-to-hip ratio.

► **Tables 2–3** present the extracted data in an organized manner for descriptive analysis and qualitative synthesis, detailing study characteristics and categorizing key clinical outcomes.

As it represents a descriptive review with narrative synthesis and no preplanned meta-analysis, it does not meet the International Prospective Register of Systematic Reviews (PROSPERO)’s prioritization criteria; therefore, we did not register our study in this platform.

**Results**

The systematic search identified a total of 163 articles across the 3 electronic databases consulted: PubMed/MEDLINE (109), LILACS (31), and Cochrane Library (23). After removing 16 duplicates, 147 unique records remained for title and abstract screening. From these papers, we excluded 122 studies as they did not meet the eligibility criteria. We analyzed 25 full-text articles and excluded 14 for various reasons, including the absence of clinical data, a sample size smaller than 5 patients, or the exclusive use of reconstructive techniques. Ultimately, 11 studies met the inclusion criteria and comprised the final sample of this systematic review. ► **Table 2** presents a synthesis of the included studies, and ► **Fig. 1** shows the PRISMA flowchart.

Three studies evaluated the RibXcar technique (ultrasound-guided monocortical fracture repair), with sample sizes of 30, 100, and 220 patients. In the largest study (n = 220), the documented waist reduction ranged from 6 to 11 cm. These studies reported two minor burns and high esthetic satisfaction. However, satisfaction reports were qualitative, with no objective numerical scale.<sup>10</sup> An additional study assessed the intraoperative “clack” marker and demonstrated that only ultrasound confirmed monocortical fractures in 100% of cases, emphasizing the need for real-time imaging.<sup>11</sup>

Although the largest study (n = 220) reported a measurable reduction, the absence of a control group and potential confounding from concomitant procedures limit the isolated interpretation of the effect.<sup>12</sup> A similar approach, the UUAIST technique (n = 131), documented a reduction of up to 8 cm, with satisfaction exceeding 97% and 3 asymmetries recorded as postoperative events.<sup>13</sup>

Among structural techniques, RIBOSS resulted in reductions of up to 13 cm, the highest ones reported among the available studies. Although one case of minor dehiscence was reported with this technique, no functional follow-up was documented to assess the potential impact.<sup>14</sup> In a retrospective series, UUAIST and RIBOSS were frequently performed in combination with high-definition liposculpture (HDL) and other interventions, hindering the ability to isolate the effect of the rib procedures.<sup>15</sup>

Within the ultrasonic intervention group, the ultrasonic ostemodelling for body contouring (ORUS) technique (n = 120) reported a wide range of reductions between pre- and postoperative measurements, with two cases of atelectasis documented.<sup>16</sup> The greenstick fracture with brace technique (n = 93) documented reductions in a subgroup of

**Table 2** Clinical and technical characteristics and outcomes from the studies included in the review

Study	Objective	Method	Study design	Technique	Outcomes	Complications	Conclusion
Cipriani et al. <sup>10</sup> , 2023	Evaluate USG RibXcar	Case series, n = 30	Case series	USG RibXcar	Waist reduction; effect maintained for 3 months	2 mild skin burns; referred pain	Effective and feasible; imaging is essential for security
Cipriani et al. <sup>11</sup> , 2024	Validate the “clack” sound as an indicator of fracture	Case series, n = 100	Case series	RibXcar + ‘clack’ validation	“Clack” heard in 90% of patient; monocortical fracture confirmed by ultrasound in 100%	NR	It is recommended not to use the ‘clack’ sound to indicate the end of the surgery, and to conclude the procedure only after ultrasound verification
Donders and Saenz, <sup>12</sup> 2025	Analyze the effectiveness of RibXcar with HDL	Case series, n = 220	Case series	RibXcar + HDL	Reduction ranging from 6–11 cm in 6 months; high satisfaction	No severe complications; mild pain managed clinically	Consistent and safe technique, stable effect
Valdivieso et al. <sup>13</sup> , 2024	Describe the UUAIST technique with HDL	Multicentric series, n = 131	Case series	UUAIST (fracture + HDL)	Average reduction of ~ 8 cm; 97%	Prolonged pain; 3 asymmetries	Promising; requires monitoring and follow-up

(Continued)

Table 2 (Continued)

Study	Objective	Method	Study design	Technique	Outcomes	Complications	Conclusion
r Villa et al. <sup>14</sup> , 2025	Evaluate RIBOSS with titanium plates	Retrospective cohort, n = 27	Retrospective cohort	RIBOSS (osteotomy + plates)	satisfaction; low asymmetry Average reduction ~ 13 cm	1 mild dehiscence; mild postoperative pain	Anatomical, effective, but without controls
Avilez et al. <sup>16</sup> , 2025	Present the ORUS technique	Case series, n = 120	Case series	ORUS (piezotomy)	Waist circumference reduction from 89–110 cm to 65–69 cm	2 symptomatic atelectases	Minimally invasive, safe
Perez et al. <sup>15</sup> , 2023	UUAIST + RIBOSS esthetic results	Retrospective descriptive study (n not confirmed)	Retrospective descriptive study	UUAIST + RIBOSS	NR	No major complications; reports of prolonged pain and asymmetry associated with not wearing the brace	Safe and reproducible techniques, with the potential for greater waist definition and esthetic benefit
Kudzaev and Kraushkin, <sup>17</sup> 2021	Evaluate greenstick fracture with braces	Case series, n = 93	Case series	Greenstick fracture with braces	Average reduction of 8 cm in a single subgroup of 14 patients	No clinical complications reported	Simple, effective, requires brace
Hoyos et al. <sup>20</sup> , 2023	Evaluate WASP as an adjunct to liposuction	Case series, n ≈ 15	Case series	WASP	Improved esthetic contour; (approximate) WHR reduction	1 pneumothorax; 1 prolonged pleural effusion	Effective, minimally invasive alternative
Verdugo, <sup>18</sup> 2022	Assess 11 <sup>th</sup> –12 <sup>th</sup> rib resection	Retrospective series, n = 104	Retrospective series	11th–12th rib resection	Visible improvement, no objective measurements. 7.7% WHR reduction (from 0.78–0.72); high satisfaction	2 intraoperative pneumothoraces	Moderate esthetic outcome, moderate risk
Chiu et al. <sup>19</sup> , 2023	Quantify impact by WHR	Case series, n = 5	Case series	Resection of floating ribs		No complications: mild, transient pain.	Promising in transgender subjects, limited

Abbreviations: HDL, high-definition liposuction; n, sample size; NR, not reported; ORUS, ultrasonic ostemodelling for body contouring; RIBOSS, rib osteotomy with osteosynthesis stabilization; USG, ultrasound-guided; UUAIST, ultrasound- and ultrasonic-assisted indentation surgery of the torso; WASP, waistline esthetic slimming by puncture and parallel approach; WHR, waist-to-hip ratio.

**Table 3** Qualitative synthesis of the efficacy, safety, and feasibility of esthetic costal remodeling techniques.

Study	Technique	Classification	Safety	Satisfaction	Technical feasibility	Esthetic outcome	Recovery	Assessment method	Methodological quality	Technical/ results coherence	Time progression	Identified gaps
Cipriani et al. <sup>10</sup> , 2023	USG RibXcar	+	Mild burns + pain	High	High, requires ultrasound guidance	Significant reduction documented	Fast	Objective + subjective	Moderate (30 patients, no control group)	Yes	Short-term (3m)	No functional control; losses to follow-up not reported
Cipriani et al. <sup>11</sup> , 2024	RibXcar + 'clack' validation	+	No complications reported	NR	High	NR	NR	Intraoperative (ultrasound guidance for fracture and angulation)	Low; incomplete data	No (lack of numerical measurements)	NR	Complete absence of numerical outcomes; inability to interpret efficacy
Donders and Saenz, <sup>12</sup> 2025	RibXcar + HDL	+	No severe complications; mild pain	High	High	6 to 11 cm reduction	Good	Imaging + circumference	Moderate	Yes	Short-term (6m)	Combined procedure; isolated effect of the technique not measured
Valdivieso et al. <sup>13</sup> , 2024	UUAIST (fracture + HDL)	+	Prolonged pain; 3 asymmetries	97%	High	Average reduction of 8 cm	Good	Clinical measurements	High	Yes	Short-term	Requires monitoring; no functional assessment
Villa et al. <sup>14</sup> , 2025	RIBOSS (osteotomy + plates)	+	1 mild dehiscence; mild pain	High	High, plate use	Average reduction of 13 cm	Good	Objective (measurements)	Moderate	Yes	Short-term	No control group; high cost
Avilez et al. <sup>16</sup> , 2025	ORUS (piezotomy)	+	2 symptomatic atelectases	High	High	Reduction from 89–110 to 65–69 cm	Good	Clinical measurements	High	Yes	Short-term	No systematic functional assessment
Perez et al. <sup>15</sup> , 2023	UUAIST + RIBOSS	+	No major complications	High (described textually)	High (described as safe and reproducible)	Esthetic improvement	Fast (specially for RIBOSS)	Subjective	Low	Not verifiable	NR	Lack of objective data; no control group; absence no functional assessment
Kudzaev and Kraushkin, <sup>17</sup> 2021	Greenstick fracture with brace	+	No clinical complications	High	High, simple	Average reduction of 8 cm (single subgroup of 14 patients)	Good	Objective measurements	Moderate	Yes	Short-term	No control group; depends on adherence to the brace
Hoyos et al. <sup>20</sup> , 2023	WAASP	+	1 pneumothorax + 1 pleural effusion	High	High	Objective improvement of the side silhouette.	Fast	Subjective + imaging	Moderate	Yes	Short-term	No control; predominantly subjective evaluation

(Continued)

Table 3 (Continued)

Study	Technique	Classification	Safety	Satisfaction	Technical feasibility	Esthetic outcome	Recovery	Assessment method	Methodological quality	Technical/ results coherence	Time progression	Identified gaps
Verdugo, 2022 <sup>18</sup>	11 <sup>th</sup> -12 <sup>th</sup> rib resection	0	2 pneumothoraces	High (described, not measured)	High, anatomically complex	Visible (not objective) improvement	Moderate	Subjective	Low	Partial	Short-term	No objective measures; pulmonary risk
Chiu et al., 2023 <sup>19</sup>	Floating rib resection	+	No complications; mild, transient pain	High	High, direct technique	7.7% WHR reduction (from 0.78-0.7)	Good	Objective WHR	High	Yes	Short-term	n = 5; short follow-up

**Notes:** + indicates a reported positive result; 0 = neutral result. BODY-Q = Body-Related Quality of Life Questionnaire. "Feasibility" refers to clinical applicability and operational cost; "Technical/results coherence" corresponds to the alignment between the technique's objective, described execution, and the outcomes obtained. "Short-term" refers to  $\leq 6$  months of follow-up. HDL, High-definition liposuction; NR, not reported; ORUS, ultrasonic ostemodelling for body contouring; RIBOSS, rib osteotomy with osteosynthesis stabilization; USG, ultrasound-guided; UUAIST, ultrasound- and ultrasonic-assisted indentation surgery of the torso.

14 patients, with 1 case of non-union, but no reported functional impact.<sup>17</sup> ► **Table 4** presents a direct comparison of safety across techniques, highlighting the variable event incidence: RibXcar (two burns), ORUS (two atelectases), UUAIST (three asymmetries), RIBOSS (one dehiscence), waistline esthetic slimming by puncture and parallel approach (WASP) (one pneumothorax plus one pleural effusion), and greenstick fracture (one non-union).

Among other minimally invasive approaches, the WASP technique (n = 15) reduced lateralization of the costal margin, resulting in high patient satisfaction and no significant complications. Complete rib resection (n = 104) was associated with 2 intraoperative pneumothoraces. However, the lack of reports on objective waist circumference measurements limits the assessment of efficacy.<sup>18</sup>

Although 1 series (n = 5) documented a 7.7% reduction in WHR, the small sample size limits the interpretability of this finding.<sup>19</sup>

In summary, reported reductions across techniques ranged from 6 to 13 cm, with the highest reductions having been reported following RIBOSS. However, the absence of control groups, methodological heterogeneity, and lack of standardized functional evaluation limit the ability to draw definitive conclusions.

### Qualitative synthesis of included studies

The comparative synthesis highlights that RIBOSS achieved the greatest reductions (up to 13 cm), while minimally invasive techniques showed smaller reductions (6-8 cm). Respiratory events were most frequent with the WASP technique (one pneumothorax and one pleural effusion), whereas UUAIST presented the highest number of asymmetries (three cases). Most studies reported high patient satisfaction; however, few employed validated instruments (e.g., BODY-Q), and no study performed objective long-term functional assessments.

### Overall study classification

Among the 11 studies evaluated, 9 (81.8%) received a positive classification<sup>10-17,20</sup> by demonstrating favorable outcomes in terms of safety, technical feasibility, and patient satisfaction. Two studies (18.2%) were classified as neutral,<sup>18,19</sup> and no study received a negative classification, suggesting an initially favorable outlook for esthetic rib remodeling, albeit limited by methodological weaknesses.

### Patient safety and satisfaction

All positive studies reported high safety, with no severe complications,<sup>10,12,20</sup> only documenting minor events, such as one case of mild dehiscence,<sup>14</sup> two cases of mild atelectasis,<sup>16</sup> and one seroma.<sup>15</sup> A single case of non-union occurred in the brace-assisted technique, without reported functional impact.<sup>17</sup> Patient satisfaction was high in 100% of the studies with a positive classification.

Studies with a neutral classification reported two mild pneumothoraces<sup>18</sup> in association with complete rib resection. One study reported high satisfaction in terms of WHR reduction.<sup>19</sup>

**Table 4** Postoperative complications

Study	Technique	n (total)	Reported complications	n (cases)
Cipriani et al. <sup>10</sup> , 2023	USG RibXcar	30	2 mild skin burns + pain	2
Cipriani et al. <sup>11</sup> , 2024	RibXcar (clack)	100	NR	NR
Donders and Saenz, <sup>12</sup> 2025	RibXcar with no incision	220	No severe complications; pain not quantified	NR
Valdivieso et al. <sup>13</sup> , 2024	UUAIST	131	Prolonged pain + 3 contour asymmetries (number of pain cases not reported)	3
Villa et al. <sup>14</sup> , 2025	RIBOSS	27	1 dehiscence + 1 mild pain	2
Avilez et al. <sup>16</sup> , 2025	ORUS	120	2 symptomatic atelectases	2
Perez et al. <sup>15</sup> , 2023	UUAIST + RIBOSS	NR	NR	NR
Kudzaev and Kraiushkin, <sup>17</sup> 2021	Greenstick fracture with brace	93	No clinical complications reported	0
Hoyos et al. <sup>20</sup> , 2023	WASP	15	1 pneumothorax + 1 prolonged pleural effusion	2
Verdugo, <sup>18</sup> 2022	11th–12th rib resection	104	2 intraoperative pneumothoraces	2
Chiu et al. <sup>19</sup> , 2023	Floating rib resection	5	No complications; mild, transient pain	0

**Notes:** n (cases) = number of cases presenting with complications. “No severe complications” refers to the absence of pneumothorax, infection, bleeding, persistent chronic pain, or need for reoperation, according to the criteria of each study. HDL, High-definition liposuction; NR, not reported; ORUS, ultrasonic ostemodelling for body contouring; RIBOSS, rib osteotomy with osteosynthesis stabilization; USG, ultrasound-guided; UUAIST, ultrasound- and ultrasonic-assisted indentation surgery of the torso; WASP, waistline esthetic slimming by puncture and parallel approach.

### Technical feasibility and esthetic appearance

Most studies (n = 9) reported high technical feasibility, describing the methods as safe, reproducible, easy to perform, or minimally invasive.<sup>10–16,19,20</sup> A single study described the high anatomical complexity in resecting the 11th and 12th ribs.<sup>18</sup>

Regarding esthetic appearance, all positive studies reported objective reductions in waist circumference or clinically and esthetically significant measurements. Results from neutral studies were more variable or subjective.

### Recovery and assessment methods

For positive studies, recovery time was short and complication-free.<sup>10,13,17,20</sup> Two other studies<sup>14,16</sup> indicated the need for longer follow-up due to plate implantation or ultrasound use. After complete resection, improvement was visible after 40 days, with no reports of objective measurements.<sup>18</sup> Most studies (n = 6) used objective assessments (including circumference and standardized imaging).<sup>10–16</sup>

### Methodological quality and gaps

Methodological quality was high for seven studies,<sup>10–13,16,17</sup> moderate for three,<sup>14,15,20</sup> and partial for one study.<sup>1</sup>

The main identified gaps included the lack of a control group,<sup>10,15–17,20</sup> short follow-up times (in most studies), and the absence of standardized functional assessments.

— **Table 5** summarizes the main anthropometric outcomes of waist circumference and WHR from the 11 studies. When available, we included measures of dispersion (standard deviation and interquartile ranges) and reduction ranges;

studies not presenting numerical data were referred to as *not reported* (NR).

## Discussion

The current review shows that, although esthetic rib remodeling has gained popularity as a body-contouring alternative, the available scientific evidence remains scarce and methodologically weak. Most studies had observational designs, primarily as case series, which lacked control groups and included small sample sizes. These limitations hinder definitive conclusions about the long-term (i.e., over 12 months) efficacy and safety.<sup>1,2</sup> Interpretation of findings is further complicated by the heterogeneity of techniques—RibXcar, UUAIST, RIBOSS, ORUS, WASP, greenstick fracture, and floating rib resection—with variable short-term results and non-standardized outcomes.<sup>1,2,21</sup>

Observed effectiveness is mainly concentrated in the short term (fewer than 6 months). Documented reductions in abdominal circumference ranged from 6 to 13 cm, with the greatest decrease associated with the RIBOSS technique.<sup>21</sup> When assessed, WHR showed a mean reduction of 7.7%; however, this outcome was measured in only one study.<sup>1</sup> A major limitation is the lack of objective functional assessments, such as spirometry, chronic pain evaluation, and thoracic mobility, which represents a critical gap. This is particularly relevant given that other procedures involving rib manipulation have measurable respiratory effects, and remodeling techniques may involve osteotomy and resection.<sup>22–25</sup>

**Table 5** Anthropometric results (waist circumference)

Study	Technique	n	Anthropometric measurement	Preoperative value	Postoperative value (time)	Reduction	Reported dispersion
Cipriani et al. <sup>10</sup> , 2023	RibXcar (USG monocortical fracture with no incision)	30	Waist circumference (cm)	NR	NR	Waist reduction described only qualitatively, with no average values or numerical ranges	NR
Cipriani et al. <sup>11</sup> , 2024	RibXcar with 'clack' validation (tactile feedback)	~ 100	Waist circumference (cm)	NR	NR	Waist reduction and 'clack' maintenance, but with no complete numerical values	NR
Donders and Saenz, <sup>12</sup> 2025	RibXcar + HDL (no incision)	220	Waist circumference (cm)	Preoperative average = 77,92 cm	Postoperative average = 66,18 cm (6 months)	The authors reported a reduction ranging from 6–11 cm in waist circumference at 6 months of follow-up	Reduction range of 6 to 11 cm; no SD, IQR or CI are provided for waist measurement
Valdivieso et al. <sup>13</sup> , 2024	UUAIST (corticotomy with piezotome + HDL)	131	Waist circumference (cm)	Preoperative median = 72 cm (IQR, 6 cm)	Postoperative median = 65 cm (IQR, 5 cm) at 3 months	Median reduction = 8 cm (IQR, 4,5 cm); subgroup with rib remodeling only: median = 7 cm (IQR, 3 cm); subgroup with remodeling + liposuction/associated procedures: median = 9 cm (IQR, 4 cm)	IQR reported for pre- and posttreatment values and for the difference (4,5 cm overall; 3 cm in group 1; 4 cm in group 2)
Villa et al. <sup>14</sup> , 2025	RIBOSS (greenstick osteotomy + titanium plate)	27	Waist circumference (cm)	Preoperative average = 80,8 cm	68,8 cm in 1 month; 67,8 cm in 3 months	Average reduction = 12,1 cm in 1 month and 13,0 cm in 3 months; minimum reduction = 8 cm; reduction = maximum 18 cm.	Only average values and range (8 to 18 cm) are provided; the article does not report specific SD, IQR, or CI for waist circumference
Avilez et al. <sup>16</sup> , 2025	ORUS	120	Waist circumference (cm)	Pre-operative median value = 81,83 cm (10-90 percentiles: 70 to 96 cm)*	90-day median value = 65-67 cm	Documented reduction = 7–26 cm, with median values of 13 cm for ORUS and 15 cm for (ORUS + liposuction)	10–90 percentiles for preoperative values; SD and IQR values not reported
Perez et al. <sup>15</sup> , 2023	UUAIST + RIBOSS (preliminary series, conference summary)	Not confirmed	Waist circumference/WHR	NR	NR	Waist reduction of up to approximately 12 cm in some cases	NR
Kudzaev and Kraushkin, <sup>17</sup> 2021	Greenstick fracture of 11 <sup>th</sup> –12 <sup>th</sup> ribs + brace	93 (14 at ≥ 6 months follow-up)	Waist circumference (cm)	Aggregated values are not reported; the article focuses on differences	Absolute values not reported, only ranges	In 14 patients with ≥ 6-month follow-up: average reduction = ~8,0 cm in waist circumference, ranging from 4 to 15 cm	Mean and range (4–15 cm); DP, IQR, and CI for this variable are not reported
Hoyos et al. <sup>20</sup> , 2023	WASP (minimally invasive bone	~ 15	NR	NR	NR	The authors report a descriptive esthetic improvement in contour and a WHR	NR

**Table 5** (Continued)

Study	Technique	n	Anthropometric measurement	Preoperative value	Postoperative value (time)	Reduction	Reported dispersion
Verdugo, <sup>18</sup> 2022	remodeling as a complement to liposuction) 11 <sup>th</sup> -12 <sup>th</sup> rib resection + liposuction/abdominoplasty	104	Primarily WHR and visual esthetic assessment. Waist circumference (cm)	NR	NR	reduction; however, there is no table with average values or detailed numerical dispersion Retrospective series; the text describes "visible" improvement in waist circumference, but no average circumference or WHR values as tables	NR
Chiu et al. <sup>19</sup> , 2023	11 <sup>th</sup> -12 <sup>th</sup> floating rib resection	5	WHR	Preoperative mean WHR = 0.78 ± 0.04	Postoperative mean WHR = 0.72 ± 0.06 in 3 months	WHR average reduction = 7.7% WHR (individual variation from 4.8-10.9%)	SD reported for WHR (±0.04 and ±0.06) and percentage change (7.7 ± 2.4%); no aggregate circumference in cm

**Abbreviations:** HDL, high-definition liposuction; CI, confidence interval; IQR, interquartile range; NR, not reported; ORUS, ultrasonic ostemodelling for body contouring; RIBOSS, rib osteotomy with osteosynthesis stabilization; SD, standard deviation; USG, ultrasound-guided; UUAIST, ultrasound- and ultrasonic-assisted indentation surgery of the torso; WASP, waistline esthetic slimming by puncture and parallel approach; WHR, waist-to-hip ratio. Percentile values refer to the ranges described in the original articles.

**Table 6** Complications observed in the included studies

Technique	Reported complications
RibXcar (USG)	2 burns
RibXcar (clack)	Not informed
RibXcar with no incision	No severe complications reported
UUAIST	3 asymmetries, prolonged pain
RIBOSS	1 dehiscence, mild pain
ORUS	2 atelectases
Greenstick fracture with non-brace	No complications; 1 non-union with no clinical impact
WASP	1 pneumothorax, 1 pleural effusion
11 <sup>th</sup> -12 <sup>th</sup> rib resection	2 intraoperative pneumothoraces
Floating rib resection	No complications

**Abbreviations:** ORUS, ultrasonic ostemodelling for body contouring; RIBOSS, rib osteotomy with osteosynthesis stabilization; USG, ultrasound-guided; UUAIST, ultrasound- and ultrasonic-assisted indentation surgery of the torso; WASP, waistline esthetic slimming by puncture and parallel approach.

Although safety seems acceptable in the short term, this assumption relies on fragmented and heterogeneous data. Reported adverse events included the following: two burns with RibXcar; three asymmetries with UUAIST; one wound dehiscence with RIBOSS; two cases of atelectasis with ORUS; one pneumothorax and one pleural effusion with WASP; no complications in the greenstick fracture series; and 2 intraoperative pneumothoraces in the 11th to 12th rib resection technique.<sup>1,2,21</sup> In several publications, information on complications was insufficient or absent, preventing accurate estimation of incidence rates and meaningful risk-benefit comparisons. **Table 6** summarizes the adverse events reported for each technique as extracted from the included studies.

The absence of psychosocial assessment represents another important limitation. Although validated instruments, such as BODY-Q (measuring satisfaction, self-image, and quality-of-life impact), are available, none of the included studies applied structured psychometric scales to evaluate the actual psychological benefit in healthy patients undergoing esthetic rib remodeling.<sup>26</sup> Therefore, it is not possible to determine whether perceived esthetic outcomes correspond to emotional improvement or merely reflect responses to social expectations.

From a bioethical perspective, rib remodeling is an irreversible procedure occasionally performed in healthy subjects. The literature on ethics in esthetic surgery highlights potential vulnerabilities in patient autonomy, influenced by sociocultural factors, particularly in procedures aimed at modifying the body to conform to esthetic ideals.<sup>27-29</sup> Additionally, the absence of formal Brazilian or international guidelines on indications, techniques, or follow-up creates

ambiguity, placing the responsibility of clinical judgment and patient protection solely on the surgeon.<sup>27–29</sup>

From a Brazilian perspective, plastic surgery plays a prominent international role, including as a destination for medical tourism.<sup>30</sup> However, the lack of procedural regulation by the Brazilian Medicine Board (Conselho Federal de Medicina, CFM, in Portuguese) and Brazilian Society of Plastic Surgery (Sociedade Brasileira de Cirurgia Plástica, SBCP, in Portuguese) allows its performance outside accredited settings, which may increase the risk of complications and compromise the institutional reputation of the specialty.<sup>31</sup> The literature further suggests that Brazil has a strategic opportunity to lead the development of the first global ethical and technical guidelines for esthetic rib remodeling, standardizing indications, professional qualifications, and perioperative safety.<sup>30,31</sup>

In summary, rib remodeling shows immediate esthetic benefits; however, these advantages are backed by weak scientific evidence due to a lack of functional follow-up, psychosocial assessment, limited technical standardization, and a significant regulatory gap. Progress in this field depends on the development of prospective studies, objective functional assessment, the use of psychometric instruments, the establishment of multicenter registries, and the formulation of ethical and regulatory frameworks—ideally led by Brazilian plastic surgery.

## Conclusion

The available esthetic rib remodeling techniques demonstrate satisfactory short-term outcomes, with objective reductions in circumference and high patient satisfaction. Nevertheless, the absence of controlled studies, standardized functional assessment, and long-term follow-up precludes definitive conclusions regarding safety, durability, and optimal indications of these procedures.

### Supplementary Material 1

#### Data Availability

Data will be available upon request to the corresponding author.

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#### Conflict of Interests

The authors have no conflict of interests to declare.

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