# An International Consensus on Evaluation and Management of Idiopathic Genu Valgum: A Modified Delphi Survey

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**Background:** Idiopathic genu valgum beyond physiological limits may require treatment, which is based on age, growth remaining, and the magnitude of the deformity. There is no consensus on clinical, or radiologic evaluation, indications, and management of idiopathic genu valgum, which can range from observation to surgical treatment using various modalities. If available, such guidelines will help surgeons offer optimal treatment to their patients. The aim of our study was to establish an expert consensus on the evaluation and treatment of idiopathic genu valgum.

**Methods:** An international panel of 29 pediatric orthopaedic surgeons from 17 countries with clinical and research experience in the management of limb deformity participated in a modified Delphi survey. Surgeons were provided with patient and deformity characteristics and voted on 46 statements on history, clinical examination, radiographic evaluation, and treatment options for idiopathic genu valgum in round 1. Consensus was defined as when statements received $\geq 70\%$ votes. Statements that were important but received $< 70\%$ votes were reworded for clarity in round 2 (n = 13).

**Results:** Consensus was achieved for 28/46 statements and included obtaining a full-length standing radiograph of the lower extremities and measuring joint orientation angles. Participants did not agree to offer surgical treatment based only on the intermalleolar distance. They recommended surgical treatment if the mechanical axis falls in zone 2 or beyond on the lateral side and using guided growth by tension-band plating when the

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growth remaining is at least 2 years. The panel agreed on performing common peroneal nerve decompression for specific indications such as acute, opening wedge osteotomy of >20 degrees, but not for gradual correction. Consensus was not reached for indications and methods of bone age assessment, treatment when growth remaining is <1 year, indications for implant removal after guided growth in younger children, and the type of osteotomy for acute deformity correction.

**Conclusions:** We have generated consensus statements to guide the management of idiopathic genu valgum. Statements that lack consensus are areas for future multicenter research.

**Level of Evidence:** Level V.

**Key Words:** genu valgum, idiopathic genu valgum, treatment, guided growth, growth modulation, osteotomy, deformity correction

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Genu valgum is a common diagnosis in pediatric orthopaedic clinics and almost 80% are idiopathic. Idiopathic genu valgum (IGV) is considered pathologic when valgus angulation is >10 degrees in children older than 8 years.[1] Untreated genu valgum may lead to knee pain, patellofemoral joint instability, and contribute to the development of degenerative arthritis. Additional problems include gait abnormality and cosmetic concerns.[1–4] The decision to treat is based on the child's age, the magnitude and location of the deformity.

There is limited evidence to guide the surgeon for clinical evaluation, radiographic assessment, indication, timing, and type of surgery, and appropriate follow-up.[1,5–8] Mechanical axis (MA) deviation to zone 2 or beyond on the lateral side of the knee is a generally accepted indication for surgery,[5,6,9] although it is not based on any comparative studies. Several growth modulation techniques have evolved but there is limited data regarding the advantage of one over the other.[7,10,11] This makes it difficult for the treating surgeon to decide on the timing and method of guided growth surgery, choice of implant, frequency of follow-up to monitor the deformity correction, and the timing of implant removal.

In children closer to skeletal maturity, it is debated what treatment should be offered. Even in skeletally mature adolescents, although various types of osteotomies have been described, there is controversy regarding the type of correction (acute/gradual), the type of osteotomy, the method of fixation, and the indications for common peroneal nerve decompression (CPND).[5]

The modified Delphi method is an iterative process that gathers anonymous opinions from a panel of experts, helping to reach a consensus in a given area. It has been used to develop consensus-based guidelines for clinically important questions.[12] The aim of our study was to utilize the available literature and the expert opinions of an international panel to establish consensus-based guidelines regarding the evaluation, management, and follow-up of patients with IGV.

## METHODS

After obtaining approval from the Institutional Ethics Committee, the study was conducted between February 2024 and April 2024. A working group of 3 pediatric orthopaedic surgeons and 1 public health specialist was formed. The working group prepared a list of 40 pediatric orthopaedic surgeons representing all the continents based on clinical experience, leadership roles in national academic limb deformity or pediatric orthopaedic societies, and publications on limb deformity.

The working group studied the available literature and deliberated on the challenges surrounding the evaluation and treatment of IGV.[1,6–8,13] After several online meetings, the working group finalized 46 statements grouped under 4 headings: history, physical examination, radiographic investigations, and treatment with follow-up. There were 6, 10, 12, and 18 statements in the history, physical examination, radiologic investigations, and treatment with follow-up sections, respectively. The options for most of the statements were in the form of a 3-point Likert scale. Three statements had a "yes or no" option and 4 allowed free text.

Round 1 was initiated by sending a Google form to the 40 experts. Reminders were sent every 2 weeks and the survey was closed after 2 months. We gathered information on each panelist's number of years in practice and the proportion of their practice that involved deformity correction. "Consensus" was defined a priori as statements that received ≥70% votes and "unanimous" if there was 100% consensus.[14,15] The working group analyzed round 1 data (from 29/40 respondents) to separate the consensus statements. The statements that received <70% votes and those with large variability in responses but constituting important aspects of IGV management (eg, bone age assessment and indications for CPND) were reviewed. These statements were reworded for clarity, and their options were modified or restricted as deemed necessary. There were 4 free text questions in round 1. The responses to these questions were too varied to be categorized into groups. Based on these responses and the themes emerging from them, the working group created a new set of questions and provided objective options. At the end of this exercise, round 2 with a total of 13 statements was sent to the 29 respondents from round 1. There were 2 statements each in the physical examination and radiologic examination sections, and 9 in the treatment and follow-up sections. In addition, the panel was invited to provide comments and suggestions if they wished. Round 2 was open for 15 days. After analyzing round 2 responses, the working group was satisfied with the information obtained regarding the evaluation and management of idiopathic genu valgum. Also, the respondents were asked to share their views and comments regarding any additional information to be included in the survey, to which there were no suggestions. Hence, it was agreed that nothing of significance was to be gained by adding further rounds.

## RESULTS

The survey was sent to 40 surgeons and the responses for the first round were received from 29 surgeons (response rate 72.5%), of whom 27 responded in the second round (response rate 93.1%) (Fig. 1). The mean experience of the panel was 20 ± 8.5 years (range: 6 to 42 y) and the mean proportion of their practice that constituted deformity correction was 55% ± 27% (range: 10% to 90%).

### Round 1

In the first round, 20/46 statements reached consensus. In the history and clinical examination section, 8/16 obtained consensus, in the radiologic investigations section, 4/12, and the treatment section, 8/18 statements achieved consensus.

The panel unanimously agreed on asking about the progressive or static nature of the deformity and assessing pain in the affected knee. The group was also unanimous about obtaining a standing full-length radiograph of the bilateral lower extremities with the patella facing forward. Consensus was reached for offering surgical treatment if the MA passed through zone 2 or beyond on the lateral side (79.3%). Tension-band plating was the preferred treatment in children < 10 years (96.6%) and > 10 years of age (75.9%). Consensus was reached on recommending a follow-up every 3 to 4 months before implant removal (82.8%) and every 4 to 6 months after implant removal till skeletal maturity (82.8%). All the panelists agreed that CPND should not be performed in every case of IGV correction, and the decision should be based on the individual case.

Statements that did not reach consensus included clinical measurement of the tibiofemoral angle (44.8%), measuring intermalleolar distance (IMD) (58.6%), and performing the knee flexion test (44.8%). There was no consensus about obtaining supine (48.3% sometimes) or standing (20.7% always) orthogonal radiographs of the knees. In addition, consensus was not reached about obtaining lateral radiographs of the knee with 51.1% of the panel always obtaining lateral films.

Consensus was almost reached on the statement that bone age assessment should be done "sometimes" with 69% of the participants agreeing with the statement. There was no consensus regarding the indications for bone age assessment and the preferred methods of bone age assessment. Options for bone age assessment included Sanders method (58.6%), Gruelich-Pyle method (55.2%), Fels method (10.3%), and Sauvegrain method (31%).

There was no consensus about the position of the MA as an indication for implant removal after guided growth. Options and their respective agreements included: zone 1 on the medial side (48.3%), zone 1 on the lateral side (17.2%), and other (34.5%).

There was no consensus on the treatment strategy if < 1 year of growth remained and the options were waiting till skeletal maturity (31%), immediate guided growth

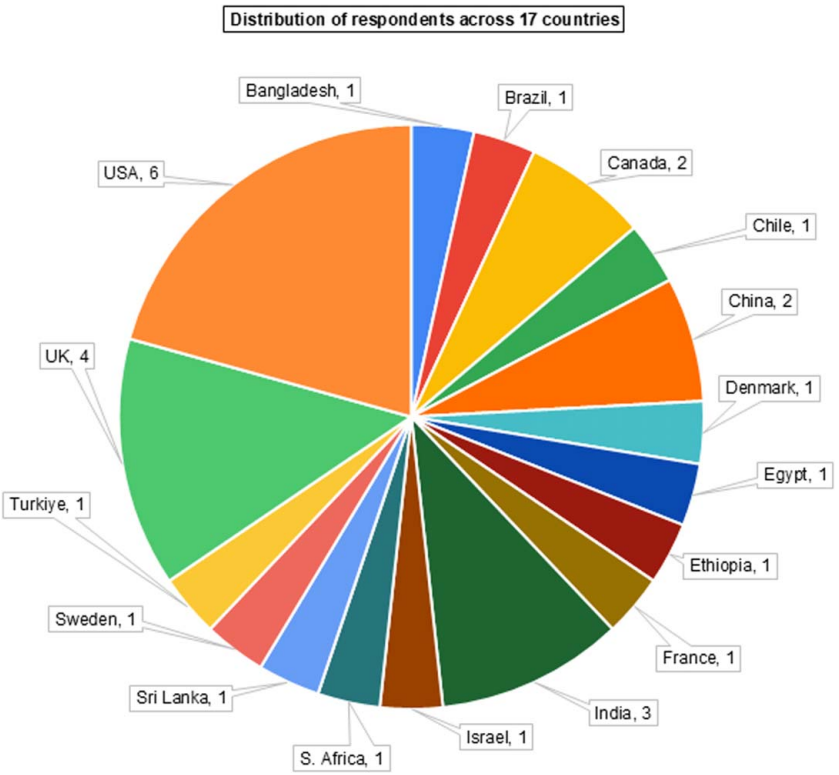


**FIGURE 1.** Distribution of respondents across 17 countries. full color online

(21.4%), immediate corrective osteotomy with internal fixation (17.2%), immediate osteotomy with external fixator correction (3.4%), and immediate permanent epiphysiodesis (24.1%).

There was no consensus on the treatment of the rebound deformity and the type of acute osteotomy, which included opening wedge (31%), closing wedge (48.3%), angulation translation osteotomy (20.7%), dome osteotomy (13.8%), and V osteotomy (0%).

Measurement of height (65.5%) and weight (58.6%) failed to achieve consensus, while 44.8% of panelists were unsure about modifying the technique of guided growth in obese children.

Table 1 shows consensus statements after rounds 1 and 2.

Table 2 shows statements not reaching consensus after rounds 1 and 2.

## Round 2

After limiting the options to ''yes'' or ''no,'' consensus was achieved for measuring height and weight in every child (70.4% for each). Consensus was also reached for obtaining a patellar skyline view if there is a history of patellar instability (70.4%) or clinical evidence of patellar maltracking (74.1%). There was consensus about implant removal after guided growth in older children when the MA returns to the center of the knee (70.4%).

Even after the second round, consensus could not be reached about indications for bone age assessment despite providing four specific options—when chronological age is closer to skeletal maturity (40.7%), when uncertain about the growth remaining based on the knee radiographs (48.1%), always (25.9%), and never (3.7%).

**TABLE 1.** Consensus Statements

| History | Clinical examination | Investigations | Treatment | % consensus |
|---|---|---|---|---|
| 1. Ask about the progressive/static nature of the deformity<br>2. Assess pain and its severity | — | 1. Obtain an erect leg full-length radiograph of bilateral lower extremities with the patella forward position | — | 100 |
| 1. Ask about the age of onset<br>2. Ask about the duration of the deformity<br>3. Ask about the history of patellar instability | — | — | 1. Surgery is recommended right away for severe deformity and age closer to skeletal maturity<br>2. Tension-band plating is the preferred method of guided growth for a child $<10$ years<br>3. Do not perform common peroneal nerve decompression while doing acute, closing wedge correction for $<20$ degree deformity<br>4. Do not perform common peroneal nerve decompression while doing gradual deformity correction for a deformity of any magnitude | 90-99.9 |
| 1. Ask about the age of menarche | — | 1. Measure the mechanical axis deviation on the EL radiograph<br>2. Measure joint orientation angles | 1. Plating is the preferred method of IGV corrective osteotomy fixation (plating and external-fixator-assisted plating)<br>2. Do not perform common peroneal nerve decompression while doing acute, opening wedge correction for $<20$ degree deformity<br>3. Perform common peroneal nerve decompression while doing acute, opening wedge correction for $>20$ degree deformity<br>4. The patient should be followed up every 3-4 months after guided growth surgery before implant removal<br>5. The patient should be followed up every 4-6 months after implant removal till skeletal maturity | 80-89.9 |
| | 1. Measure the height of every child with IGV<br>2. Measure the weight of every child with IGV<br>3. Assess the patellofemoral joint stability<br>4. Assess the knee stability | 1. Obtain a patellar skyline view of the affected knee —sometimes<br>2. Obtain a patellar skyline view if there is a history of patellar instability or/and patellar maltracking on clinical evaluation | 1. Two years of growth remaining is necessary to recommend guided growth (growth modulation surgery)<br>2. Offer surgical treatment if MA is in zone 2 and beyond on the lateral side<br>3. Tension-band plating is the preferred method of guided growth for a child $>10$ years<br>4. In general, the indication for implant removal after guided growth for older children is when the mechanical axis falls in the center of the knee | 70-79.9 |

EL indicates erect leg; IGV, idiopathic genu valgum; MA, mechanical axis.

**TABLE 2.** Statements Without Consensus

| Clinical examination | Investigations | Treatment | % consensus |
|---|---|---|---|
| | 1. It is important to assess bone age in every patient—sometimes<br>2. In your practice, who does the bone age assessment?<br>I do it | Your preferred method to do fixation after osteotomy is—plating | 60-69.9 |
| It is important to measure the intermalleolar distance | 1. I obtain supine radiographs of both knees AP view—sometimes<br>2. I obtain lateral radiographs of both knees —always<br>3. My preferred method to do bone age assessment—Sanders system | 1. The technique of guided growth should be modified in obese children—no<br>2. I would do common peroneal nerve decompression while doing acute, closing wedge correction for >20 degrees of deformity | 50-59.9 |
| 1. It is important to clinically measure the tibiofemoral angle<br>2. It is important to perform the knee flexion test for every genu valgum patient | 1. I obtain standing radiographs of both knees AP view—sometimes<br>2. I assess bone age—when uncertain about the growth remaining on the knee radiographs<br>3. I obtain a standing erect leg radiograph of both lower extremities during follow-up after guided growth surgery—every 3-4 months and no fixed schedule (will obtain it depending on the clinical limb alignment) | 1. If growth remaining (skeletal growth) is <1 year, my preferred treatment option is —wait till skeletal maturity and do not do any surgical treatment at present<br>2. My indication for implant removal after guided growth is— when the mechanical axis falls in zone 1 on the medial side (overcorrection)<br>3. In general, for younger children, my indication for implant removal after guided growth is when the mechanical axis—falls in zone 1 on the medial side (overcorrection)<br>4. How do you treat rebound deformity after implant removal?<br>5. While doing genu valgum correction by osteotomy, what is your preferred type of osteotomy?— Closing wedge osteotomy | <50 |



The panel reached a consensus on performing CPND when doing an acute opening wedge correction >20 degrees (88.9%). CPND should not be performed while doing gradual correction for deformity of any magnitude (96.3%), acute opening wedge correction <20 degrees (80.8%), or acute closing wedge correction <20 degrees (92.6%). However, the panel remained divided regarding CPND for an acute closing wedge correction >20 degrees (51.9% in favor).

## DISCUSSION

We present consensus statements for the evaluation and management of IGV developed through a modified Delphi technique with the participation of an international panel. There was consensus on 28/46 statements pertaining to the evaluation and treatment of IGV. It was our premise that having a consensus on clinical and radiographic assessment and treatment protocols would improve the overall level of care and outcomes of IGV treatment in children.

The management of IGV in children has evolved over the years. The clinical and radiographic examination of the child is essential to formulate the optimal treatment plan. Consensus was reached on several aspects of the history and physical examination that are consistent with current practice. The knee flexion test has been thought to differentiate between the femoral/tibial origin of the deformity.[16] This test has not been validated and does not add any information for therapeutic decision-making which could be the reason for no consensus that a knee flexion test should be performed. The panel recommended measuring joint orientation angles on a standing full-length radiograph to determine the origin of the deformity.

Radiographic evaluation is crucial in developing a precise treatment plan. Our panel unanimously agreed to obtain full-length standing radiographs when evaluating IGV. They did not recommend treatment decisions based on IMD. We believe this opinion is due to IMD being dependent on several factors such as body contours, and soft tissue thickness. Also, a study by Hardgrib et al[17] has shown that IMD measurement has no correlation with the Hip-Knee-Ankle angle on radiographs. We would argue against the conclusion of a recent systematic review which recommends doing guided growth for IMD >8 cm since it was based on insufficient data.[6] Interestingly, there was no consensus on obtaining a lateral radiograph of the knee in the evaluation of IGV. We believe this is due to the lack of information regarding sagittal plane deformities in a child with IGV.

A bone age assessment is performed when there is a concern about the physeal growth remaining. Our panel believed that bone age assessment is not necessary for every patient. Despite offering specific options, the panel could not agree on the indications and methods for bone age assessment. We believe this is because of practice variability around this area due to ethnic differences, boys and girls achieving skeletal maturity at different

ages, and surgeons' choice of the method of guided growth technique.

Treatment of IGV can range from observation to operative treatment using various modalities. Acute osteotomy with internal fixation can directly correct the deformity but is inappropriate for children with an open physis. Also, the size of the deformity may limit acute correction due to concerns about neurovascular injury. Larger deformities are typically treated with gradual correction using an external fixator, while guided growth is a useful option in skeletally immature patients, as its efficacy depends on the patient's growth potential and requires knowledge of the remaining skeletal growth.[5,10,18]

Artioli et al[6] recommend surgery when the growth remaining is $<1$ year. However, this information is based on 3 articles that do not describe the method to ascertain the growth remaining.[6] Our panel reached a consensus that the indications for surgery are 2 years of growth remaining and MA in zone 2 or beyond on the lateral side. We were hoping to arrive at a definitive answer about how to estimate the remaining growth through the statements about bone age assessment. However, this remains unanswered.

Guided growth is one of the most common surgeries for treating limb deformity. Despite several published studies on guided growth, there is limited information regarding the timing of surgery, implant removal, secondary deformities, and implant-related complications. Two important concerns after guided growth surgery are undercorrection and overcorrection.[10,11,18–23] After guided growth surgery, regular follow-up is important to prevent overcorrection of the deformity. The optimal timing and frequency of radiographs during follow-up are still being debated.

The options for guided growth are staples, tension-band plating, and percutaneous trans-epiphyseal screws (PETS). Although PETS has been used for epiphysiodesis, it is a relatively new technique for hemiepiphyseodesis and long-term data is not available. The rate of deformity correction has been thought to be faster with PETS, and its use in older children has been recommended. Although studies have compared the 3, the evidence is inconclusive.[10,11,19–23] The recommendation from our panel to use tension-band plating in children younger or older than 10 years of age addresses the ambiguity in this matter. Indications for implant removal in younger children, frequency of radiographs before implant removal, and treatment of rebound deformity remain gray areas.

In a skeletally mature adolescent, various osteotomy techniques can be used for deformity correction. The osteotomy may have several complications such as over or undercorrection, neurovascular injury, nonunion, and implant-related complications.[24–28] Given the very limited evidence regarding osteotomy type and fixation, it was thought that consensus would help guide surgeons. However, there was no consensus on the type of osteotomy and the method of fixation for the osteotomy with 69% of panelists preferring plate fixation. There is considerable debate regarding indications for CPND while correcting IGV. Our panel's recommendation of performing CPND for an acute opening wedge correction $>20$ degrees will help the surgeon overcome the dilemma of CPND in the absence of any other evidence. We acknowledge that tibial deformity correction will influence the decision of CPND. However, since the majority of IGVs are of femoral origin,[1] we did not consider tibial deformities when addressing the issue of CPND.

This study has several strengths. In the absence of higher levels of evidence, expert consensus proves valuable for clinicians. The panel was of sufficient size, global diversity, and expertize in managing IGV.[12]

There are some limitations of this study. There is no widely accepted method on which to base the diagnosis and treatment of IGV. However, as a first step, the authors felt that at this stage it is important to include a broad range of diagnostic and treatment modalities. We restricted our study to 2 rounds to maximize respondent compliance and minimize dropout. The conclusions based on the personal opinions of the respondents obtained through a Delphi survey constitute Level V evidence. We did not include a direct question asking the panelists how they determine the remaining growth since we thought that statements regarding bone age assessment would address this. However, it still remains unsolved. We acknowledge that the rate of deformity correction is a risk factor for recurrence.[20,29] We have not addressed this factor. In general osteotomy type is decided by factors such as whether there are associated deformities, the level of the apex of the deformity, whether the genu valgum is bilateral, and whether the patient has limb length discrepancy. However, considering IGV is usually bilateral and is not associated with any leg length discrepancy, we did not incorporate these factors.

We believe that pooled data from several centers would help to shed light on the debated conundrums. Good quality prospective studies are needed to establish credible evidence on this subject. The consensus statements from our study may serve as a guide for surgeons in the management of IGV.

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