

Survey to describe variability in early onset scoliosis cast practices

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Abstract

Purpose To investigate paediatric orthopaedists' cast practices for early onset scoliosis regarding patient selection, cast application, radiographic evaluation, treatment cessation and adjunctive bracing.

Methods A casting survey was distributed to all paediatric orthopaedists in Children's Spine and Growing Spine Study Groups (n = 92). Questions included physician and patient characteristics, technique, treatment, outcomes, radiographic measurements and comparison to other treatments. A total of 55 orthopaedists (60%) responded, and descriptive statistics were calculated on the subset who cast (n = 45).

Results A majority of respondents use cast treatment for idiopathic and syndromic scoliosis patients, but not for neuromuscular or congenital scoliosis patients. Major curve angle ranked most important in orthopaedists' decision to commence cast treatment, in comparison with rib-vertebra angle difference or clinical observations. The major curve angle threshold to initiate casting was a median of 30° (20° to 70°), and the minimum patient age was median ten months (3 to 24). First in-cast and out-of-cast radiographs are taken standing, supine, awake, under anesthesia and/or in traction. In all,

58% consistently cast over or under the arm, while 44% vary position by patient. Respondents were divided about the use of a brace after cast treatment: 22% do not prescribe a brace, 31% always do and 36% do in some patients.

Conclusions Future multicentre research studies must standardize radiographic practices and consider age and major curve angle at cast initiation and termination, scoliosis aetiology, shoulder position and treatment duration. Practices need to be aligned or compared in these areas in order to distinguish what makes for the best cast treatment possible.

Level of Evidence V, Expert opinion

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Introduction

Early onset scoliosis (EOS) encompasses a heterogeneous patient population, and there have historically been multiple strategies to treat it, including braces, casts, vertical expandable prosthetic titanium ribs, magnetically controlled growing rods, growth guidance, or spinal fusion.

Recent studies have captured the variability of EOS surgical treatment;¹⁻³ however, variability in serial cast treatment has not been documented. Healthcare variability is linked to poorer treatment outcomes.⁴

This survey was undertaken with the aim to understand orthopaedists' current cast practices, with the specific questions of: Which patients qualify for cast treatment? How is the cast applied? When are radiographs taken? When is cast treatment stopped? How is bracing used in conjunction with casts?

Most published cast studies have relatively small sample sizes. Multicentre studies are needed for robust conclusions, but this requires standardization of cast practices to make fair comparisons across patients. Characterization and quantification of current cast practices lay the foundation for future studies, so that the most effective cast practices may be discerned.

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Materials and methods

A survey was developed using Survey Monkey (Palo Alto, California) and sent to all orthopaedists who are current members of the Children's Spine and Growing Spine Study Groups. Consent was obtained via participation. The survey asked about physician and patient characteristics, cast technique, treatment, outcomes, radiographic practices and other treatments such as bracing and surgery. The survey was sent via email in July 2015, with a reminder email sent one week later.

There were 55 respondents out of 92 total members, giving a 60% response rate. Respondents were predominantly orthopaedists who cast for EOS ($n = 45$). Statistical analysis was limited to this subset. Results were assessed for normality and summarized by mean and SD or median and interquartile range using SPSS Software (version 22; IBM, Chicago, Illinois).

Results

Respondents

Most respondents (57%) have been in practice for over ten years. Patient volume for serial casts was a mean of 11 patients per year (1 to 35). Cast styles comprised Mehta/Cotrel/elongation-derotation-flexion (EDF) (76%), Risser (16%) and other (8%), which include bending and hanging casts.

Technique

In all, 22% of orthopaedists surveyed always cast over the shoulder, 36% always cast under the arm and 42% will do either, casting over the shoulder for upper thoracic apices (higher than T6 or T7) or casting under the arm for older children, flexible thoracic (below T9), thoracolumbar or lumbar curves.

Radiographic practices

Before initiation of casting, 100% obtain a radiograph of the coronal plane. In all, 67% obtain a lateral view as well. Flexibility is assessed by 23% of respondents, with traction (17%) or bending (6%) films being the preferred method.

For the first in-cast radiograph, 44% order a radiograph in the standing position while 56% opt for supine imaging. For supine imaging, 52% take it when patients are under anesthesia and 8% when awake; 52% take the radiograph out of traction and 8% in traction; and 40% did not further specify conditions.

First out-of-cast radiograph varied widely among respondents, with 28% obtaining it after a certain number of months, most commonly six months of treatment (1 to 12). In all, 21% go by in-cast major curve angles (10° to 25°). A total of 12% go by number of casts (1 to 5). Other

practices included a radiograph at each cast change, when major curve angle has plateaued after serial cast applications, or when cast treatment is deemed complete.

Cast initiation

Orthopaedists were asked which patients they treat with serial casts. Results varied by scoliosis aetiology: idiopathic (100%), syndromic (65%), neuromuscular (44%), multiple congenital anomalies (37%) and hemivertebra (36%).

Respondents were asked to rate (1) rib-vertebra angle difference (RVAD), (2) major curve angle and (3) clinical observations when deciding to initiate cast treatment. In all, 60% ranked major curve angle as 'very important', in contrast to 31% for clinical observations and 26% for RVAD. The most common major curve angle to commence cast treatment was 30° and to abandon it was 60° . However, these thresholds displayed substantial variability (Fig. 1). The most common age to cast patients was at 12 months, and to stop was at five years. Threshold ages similarly showed variability (Fig. 2).

Cast treatment

When asked the ideal length of cast treatment, 24% said six to nine months, 22% said one year, 27% said 14 months to two years and 13% said three years or more.

In all, 65% indicated they allow for summer brace holidays 'sometimes' or 'often', while 35% said 'rarely' or 'never'. Reasons given included: parent request (40%), child's well-being (33%), as well as heat, summer activities, swimming, vacation and core conditioning. Only 23% use waterproof casting, while 77% do not.

The most common response (55%) for at what major curve angle participants consider a cast patient cured was 10° ; however, 4% cite the threshold at 5° , 29% at 15° to 20° and 2% at 25° .

Cast graduation

Respondents were asked to estimate what percentage of their patients graduate to a brace and/or surgery. In all, 22% of respondents rarely or never prescribe a brace after cast treatment, 36% do in some patients and 31% always do. About half (51%) base their brace treatment on time, median 18 months (6 to 60), while 22% say it depends on curve controllability. As for the number of patients who graduate to surgery, responses were divided between few (24%), about half (41%) and most (16%).

Discussion

Technique

We found that most paediatric orthopaedists cast in the EDF style originally described by Cotrel and Morel⁵ and

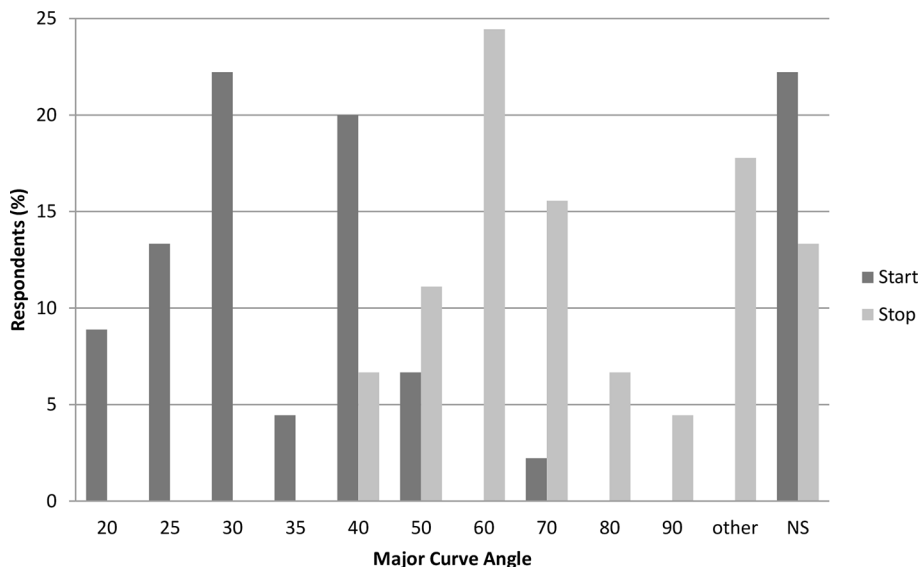


Fig. 1 Major curve angle thresholds to start and stop cast treatment by percentage of respondents. ‘Other’ included: at curve progression, or depending on age or precast Cobb angle (NS, not specified).

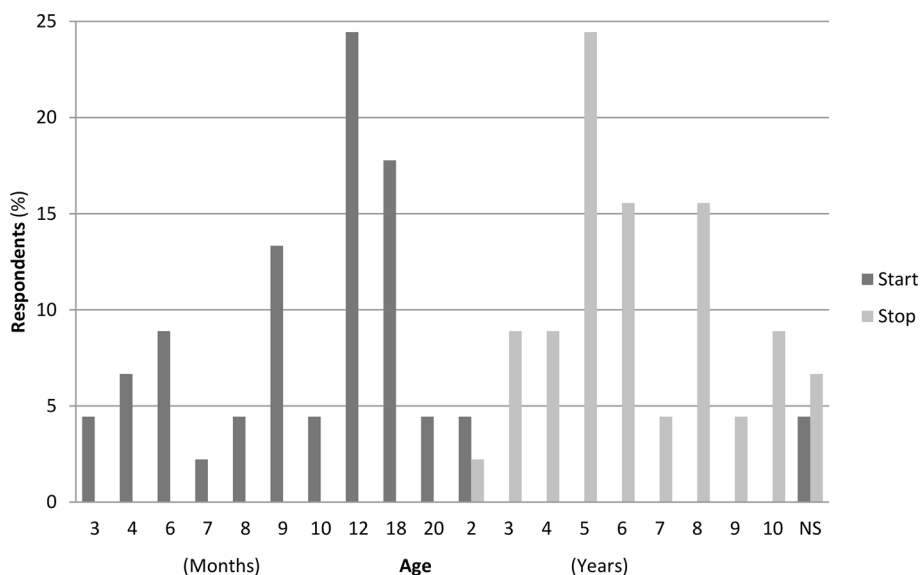


Fig. 2 Age thresholds to start and stop cast treatment by percentage of respondents (NS, not specified).

later endorsed by Mehta,⁶ which emphasizes derotating the spine and applying counter-rotation to the shoulders and pelvis. Risser casts use a three-point translational force including traction, lateral bending and posterolateral pressure over the convexity of the deformity.⁷ EDF-style casts have anterior and posterior windows, and Risser casts have anterior windows.

We found most (42%) orthopaedists go over or under the shoulder depending on the apex of the curve, as described by D’Astous and Sanders,⁸ while 58% do not vary shoulder placement. Historically, EDF casts go over

the shoulder, and Risser casts go under the shoulder. The effect of a cast’s shoulder position on curve correctability as well as patient burden currently remains unevaluated.

Radiographic practices

Two points are important in the comparison of treatment outcomes: the first in-cast radiograph and first out-of-cast radiograph.

The first in-cast radiograph indicates how much correction has been obtained. We found that 56% of orthopaedists take the first in-cast radiograph in the supine position,

while the rest take it with the patient standing and awake. The distinction is important because major curve angles are smaller in supine than standing radiographs,⁹ preventing accurate comparison between patients in different positions. However, it is important to consider the age and diagnosis of the patient population, which cause natural variations in ambulatory ability.

Secondly, the first out-of-cast radiograph shows the overall effect of treatment by indicating how the child maintains correction without the cast. The benefit of this information is counter-balanced by the harm of radiologic exposure. We found extreme variation as to when orthopaedists obtain this film. Future multicentre research studies will need standardization of radiographic practices, as variation in time points and conditions disallow comparison of outcomes.

Patient characteristics

Separating out aetiologies, a majority of orthopaedists cast idiopathic and syndromic patients, while a minority cast congenital and neuromuscular patients. Casting only infantile idiopathic and syndromic patients has been advocated.⁸ The literature shows syndromic patients have a better prognosis the younger they are cast.^{6,10} Hemivertebrectomy or *in situ* fusion is the common treatment for patients with a short angular congenital deformity. Recent reports of cast treatment for long congenital curves with multiple anomalous vertebrae found thoracic growth rate was slower than normal,¹¹ but that T1-T12 height increased significantly over treatment.¹² Neuromuscular patients often have respiratory and gastrointestinal co-morbidities,⁹ but their cast treatment outcomes have been described.^{6,7,10,13-15} In general, they are found to attain less major curve angle correction¹⁶ and greater correction loss after cast removal than idiopathic patients.^{13,14} Despite smaller radiographic benefits, cast treatment can stabilize curves and prevent progression, thus it is advocated as a delay tactic. Nonetheless, the survey results show significant discord in who qualifies for cast treatment.

Casting initiation

The decision to initiate serial cast applications was historically based on the determination of a progressive rather than resolving scoliosis, defined by RVAD > 20, progression of RVAD after three months, double curves or rib phase II relationship.¹⁷ Surprisingly, we found that major curve angle was the single most predominant factor currently guiding orthopaedists' decision-making, ranking more important than RVAD. Previous studies have given their cast indications using progressive major curve angles ranging from 10°¹³ to 20°^{10,18} to 25°⁷ to 30°¹⁹ to 35°.^{20,21} In using major curve angle for initiation, a low threshold questions whether smaller curves would resolve with

natural history, creating unnecessary treatment, while a high threshold runs the risk of failing to cure curves or prevent surgery. The preponderance of major curve angle may be because of its utility in deciding to cast older or non-idiopathic delay patients, while RVAD is used to distinguish progressive curves in infantile idiopathic patients who can be cured. Also, major curve angle is easier to measure and mark changes, while RVAD is subject to greater inter- and intraobserver variability.²²

We found the most common major curve angle threshold (47%) orthopaedists initiate casting at 30° to 40°, which is in line with studies that found in patients with completely resolving curves, cast treatment was begun at average major curve angles between 30° and 40°.^{6,10} However, a tenth of respondents had a threshold of 50° or greater.

We found 68% of orthopaedists commence cast treatment at an age of one year or less, while 27% always cast at greater than one year. Cast treatment for patients under one year is debated due to anaesthetic exposure;²³ yet, studies of completely resolving curves found these patients were casted at an average of one year old.^{10,18}

For older patients, 44% of respondents do not cast beyond age five years, while 49% do cast juvenile scoliosis. Recent reports of casting juvenile scoliosis describe a treatment protocol with only one or two casts and then transitioning to a brace, finding it could prevent surgery.^{24,25}

Cast treatment

We found that most orthopaedists expect a treatment length of about a year, but 24% cast less than a year, and 40% greater than one year, up to a maximum of three years. Length of treatment depends on orthopaedist's desire to cure or delay surgery. It has been reported that it takes at least one year or more for a curve to resolve,¹⁰ with Mehta⁶ finding an average resolution time of one year 11 months. For surgical delay, a one-year cast treatment protocol has been advocated,¹⁵ and longer treatment, up to three years, has been described.⁷ Treatment length for goals of cure and delay are distinct. For cure patients, the minimum treatment length possible with maximal long-term results is desired. For delay patients, the orthopaedist may want the child to grow as much as possible before surgery, and there is more focus on the patient and family's tolerance for casts.

We found that most orthopaedists allow for summer brace holidays, but some do not. The survey did not account for orthopaedists' geographic location, which could be an explanatory factor. Cast-brace cycles have been described, especially in the summertime when surgery for a patient was impending.¹⁰ The effect of summer brace holidays on curve correction currently remains unevaluated. Waterproof casting offers an alternative, allowing patients to swim and bathe. A study of waterproof casting for arm and leg casts using rayon or Goretex

found strong patient satisfaction.²⁶ While more expensive and difficult to apply, the benefits of waterproof casts may outweigh those challenges.

Ending cast treatment

The question of when to stop serial cast treatment, whether cure or delay, is pertinent. This study found for most orthopaedists the cure threshold is at 10°, while for delay patients, the threshold for surgery is at 60°. Interestingly, the threshold by which some orthopaedists commence casting (40° to 55°) is the same threshold that other orthopaedists abandon it (Fig. 1).

Cast graduation

We found that some orthopaedists regularly have their patients transition to a brace after cast treatment, while others do not. For those that do, there is little consensus on how long to brace. The effect of brace compliance after cast treatment on patients' outcome at skeletal maturity has not been clarified.⁶ Additionally, we found orthopaedists reported varied outcomes in casting's ability to prevent surgery. However, the ability to cure scoliosis depends heavily on patient aetiology, age and major curve angle at presentation.

Limitations

Reported results reflect only Children's Spine and Growing Spine Study Group members who cast for EOS, which is a sample not representative of all paediatric orthopaedists who treat EOS.

The survey did not explore all factors of casting such as anterior or posterior windows, or the underlayer. Underlayers previously described include stockinette,^{6,7} webril,¹⁴ felt on bony prominences and silver impregnated shirt,^{8,10} pads and splints,²⁷ or gore pantaloons.²⁸ The comparative ability of these methods to prevent skin ulceration or improve results remains unknown. For example, a recent study found the addition of adhesive pads increased major curve correction.²⁹

Among radiographic practices, MRI testing was not specifically asked about in the survey, although many orthopaedists wrote under free response that they order one before casting.

Lastly, an important distinction in cast treatment is the intent to cure or delay, requiring different tactics which the survey did not fully take into account. These have yet to be well-defined.

Conclusion

This study showed that major curve angle was more prevalent than RVAD in orthopaedists' decision-making. It also

found dramatic orthopaedist-specific differences in which patients qualify for cast treatment based on scoliosis aetiology, age and major curve angle. It demonstrates the need to standardize radiographic practices for future studies, particularly the timing and conditions of first in-cast and out-of-cast radiographs. It also elucidates a need to delineate cure *versus* delay protocols, especially for length of treatment and the use of bracing after serial casts.

Casts have risen in popularity in the past decade as a treatment modality for EOS. With current cast practices deviating from Mehta's original paper,¹⁷ studying the long-term outcomes of these treatments is necessary to ensure that we are not treating curves that would resolve spontaneously, as well as to clarify the goals of casting over several years. This study lays the groundwork to optimize treatment protocols for scoliosis patients by age and diagnosis. Through better research, the deleterious effects of scoliosis can be further mitigated. The far-flung variability reflected by this survey indicates a lack of evidence-based medicine. Future studies designed with the information uncovered from this survey will elicit data to support sound clinical practice.

Appendix

The survey used in this study can be found at the end of this article.

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COMPLIANCE WITH ETHICAL STANDARDS

FUNDING STATEMENT

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

OA LICENCE TEXT

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ETHICAL STATEMENT

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

ICMJE CONFLICT OF INTEREST STATEMENT

JS: Stock (Abbott, Abbvie, GE Healthcare), Financial/material support (GreenSun), Paid presenter (Nuvasive), Board or committee member (POSNA, SRS).

PS: Consultant (Biomet, DePuy, Medtronic, Nuvasive), Editorial board (JCO), Board or committee member (POSNA, SRS).

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Appendix

I. About You

1. Are you a member of (check all that apply): Children's Spine Study Group / Growing Spine Study Group
2. How long have you been in practice? Less than 5 years / 5 to 10 years / More than 10 years
3. Do you cast for early onset scoliosis? Yes / No

II. Casting Technique

4. How many PATIENTS do you cast per year?
5. SHOULDER POSITION. Casts go: Always OVER shoulder / Always UNDER arm / Sometimes OVER, sometimes UNDER [please specify]
6. Do you use waterproof casting? Yes / Sometimes / No
7. Style of casting (check all that apply): Mehta / Risser / Other [please specify]

III. Radiographs

8. Radiographic imaging BEFORE first cast application includes (check all that apply): PA / AP / Lateral / Traction / Bending films / Other [please specify]
9. First IN-CAST x-ray done (check all that apply): Supine / Upright / In traction / Out of traction / Asleep / Awake / Other [please specify]
10. When is the ideal time to obtain the first OUT-OF-CAST x-ray? Specify number below.
At in-cast Cobb angle ___ / After number of casts ___ / After number of months ___ / Other

IV. Cast Treatment

11. What factors do you weigh when deciding to initiate cast treatment? Somewhat important / Important / Very important

Rib-vertebra angle / RVAD
Cobb angle (specify minimum angle)
Clinical observations

12. Ideally, how many total MONTHS does cast treatment last?
13. When curve progresses, at what Cobb angle do you abandon cast treatment?

V. Summer Treatment

14. Do your patients exchange cast for brace in summer? Never / Rarely / Sometimes / Often
15. Why cast exchanged with brace over summer? (check all that apply):
Parent preference / Patient comfort / Patient expecting surgery / Other [please specify]

VI. Patient Characteristics

16. What is the EARLIEST age in MONTHS you cast or refer a patient to casting?
17. What is the LATEST age in YEARS you cast or refer a patient to casting?
18. What scoliosis ETIOLOGIES have you treated with casting?
Idiopathic / Congenital - short / hemivertebra / Congenital - multiple anomalous vertebrae / Neuromuscular / Syndromic
19. At what Cobb angle would you consider a casting patient cured?
< 5 degrees / < 10 degrees / < 15 degrees / < 20 degrees / < 25 degrees / Other [please specify]