

Figure 4. **A**, Relationship between change of the sagittal alignment (T5–T12) and the maximum aorta movement in the main thoracic curve of 17 patients. Positive change denotes more kyphotic change. Pearson correlative coefficient was 0.571 ($P = 0.017$); *i.e.*, more correction of the main curve meant greater aorta movement. **B**, Relationship between the postoperative apical vertebral translation and the maximum aorta movement. Pearson correlative coefficient was -0.550 ($P = 0.022$); *i.e.*, lower apical vertebral translation after surgery meant greater aorta movement. **C**, Relationship between the preoperative sagittal alignment (T5–T12) and the maximum aorta movement in the main thoracic curve of 17 patients. Positive change denotes more kyphotic change. Pearson correlative coefficient was -0.521 ($P = 0.032$); *i.e.*, more correction of the main curve meant larger aorta movement.

imposed risk on the aorta, but a large direction error (30°) by itself put the aorta at a high risk in any spine level regardless of the length of the pedicle screw.

There were only 5 warning pedicles in 96 examined lumbar spine and all were first lumbar spine. Therefore, further analysis was limited only in the thoracic spine. The distribution of the warning pedicles revealed 3 groups. The middle thoracic level (T7–T9) had a low ratio of warning pedicles before surgery, and the ratio increased statistically significantly after deformity correction. The upper thoracic level (T4–T6) as well as the lower thoracic level (T10–T12) had a moderate ratio of warning pedicles before surgery, and did not change considerably after deformity correction.

■ Discussion

The present study revealed that the aorta moved more than 10 mm in 17 of the examined 240 spines (5.8%), with a shift to the anterior and medial positions after posterior surgery. From our previous study,⁸ the aorta may be at risk at left concave pedicle at T4, T5, and T10–T12 before surgery, and there was a relative safety of the aorta for pedicle screw placement at the apical level. The present study showed that the dangerous pedicle ratio increased at the midthoracic level after surgery. At the apical level, the aorta often resides far lateral of the vertebral body which is far from the axis of the trunk. Surgeons assume from the preoperative imaging that the

Table 2. Warning Pedicles—Direction Error Within 10°

Screw Length	Level	Preoperative			Postoperative			Difference
		Warning (+)*	Warning (-)†	Ratio	Warning (+)*	Warning (-)†	Ratio	
25 mm	T4–T6	2	46	4.2%	0	48	0.0%	-4.2%
25 mm	T7–T9	0	66	0.0%	0	66	0.0%	0
25 mm	T10–T12	0	65	0.0%	0	65	0.0%	0
30 mm	T4–T6	5	43	10.4%	2	46	4.2%	-6.2%
30 mm	T7–T9	0	66	0.0%	1	65	1.5%	+1.5%
30 mm	T10–T12	0	65	0.0%	1	64	1.5%	+1.5%
35 mm	T4–T6	7	41	14.6%	5	43	10.4%	-4.2%
35 mm	T7–T9	0	66	0.0%	1	65	1.5%	+1.5%
35 mm	T10–T12	4	61	6.2%	6	59	9.2%	+3.0%
40 mm	T4–T6	7	41	14.6%	5	43	10.4%	-4.2%
40 mm	T7–T9	0	66	0.0%	1	65	1.5%	+1.5%
40 mm	T10–T12	8	57	12.3%	11	54	16.9%	+4.6%

*Number of the warning pedicles.
 †Number of the nonwarning pedicles.

Table 3. Warning Pedicles—Direction Error Within 20°

Screw Length	Level	Preoperative			Postoperative			Difference
		Warning (+)*	Warning (-)†	Ratio	Warning (+)*	Warning (-)†	Ratio	
25 mm	T4–T6	7	41	14.6%	5	43	10.4%	-4.2%
25 mm	T7–T9	1	65	1.5%	0	66	0.0%	-1.5%
25 mm	T10–T12	1	64	1.5%	1	64	1.5%	0
30 mm	T4–T6	11	37	22.9%	12	36	25.0%	+2.1%
30 mm	T7–T9	2	64	3.0%	1	65	1.5%	-1.5%
30 mm	T10–T12	1	64	1.5%	5	60	7.7%	+6.2%
35 mm	T4–T6	13	35	27.1%	16	32	33.3%	+6.2%
35 mm	T7–T9	4	62	6.1%	2	64	3.0%	-3.1%
35 mm	T10–T12	10	55	15.4%	14	51	21.5%	+6.1%
40 mm	T4–T6	13	35	27.1%	18	30	37.5%	+10.4%
40 mm	T7–T9	4	62	6.1%	2	64	3.0%	-3.1%
40 mm	T10–T12	19	46	29.2%	21	44	32.3%	+3.1%

*Number of the warning pedicles.

†Number of the nonwarning pedicles.

aorta stays out of the spine and become less careful of this organ during screw placement. In fact, after correction of the scoliosis in some cases, the vertebrae return to a more physiologic position, which is the center of the body: this movement of the spine results in the medialization of the aorta relative to the spine and the risk of the aorta by a pedicle screw increased by correction of the deformity at the middle thoracic spine. Accordingly, all left pedicles have substantial risk of indenting the aorta indentation if a pedicle screw breaches outside the pedicle.

Few authors have reported change of the aorta position after deformity surgery. The first analysis was reported by Bullmann *et al.*⁹ They analyzed the aorta movement in their experience of anterior surgery and found that the aorta migrates from a more posterolateral to a more anteromedial position in relation to the thoracic vertebrae. However, patients were scanned in supine position for preoperative CT and in a lateral decubitus position for postoperative magnetic resonance imaging. As the aorta location depends on the patient position at examination especially in the midthoracic

level as clearly shown by the study of Huitema *et al.*,¹⁰ the aorta movement in Bullman's report may come from a difference in the patient's position in the 2 examinations.

Recently, Wang *et al.*¹¹ analyzed the change of the position of the aorta after anterior or posterior instrumentation of type I Lenke curve and concluded that the aorta moved more in anterior surgery than in posterior surgery. They measured by 2 methods: one was from the aorta to the closest point of the cortex of the vertebral body and the other was from the posterior wall of the aorta to the anterior edge of the left rib head, neither of which was associated with the pedicle screw impingement. They measured 2 angles which were not suitable to describe the aorta position as for pedicle screw placement. Accordingly, parameters they adopted could not clarify the aorta movement relative to the spine, as do our results.

The present analysis indicated that the aorta position has a relationship with the curve characteristics of spinal deformity. The aorta movement highly correlated with the deformity characteristics: change of the sagittal alignment, preoperative AVT and sagittal alignment. Therefore, the

Table 4. Warning Pedicles—Direction Error Within 30°

Screw Length	Level	Preoperative			Postoperative			Difference
		Warning (+)*	Warning (-)†	Ratio	Warning (+)*	Warning (-)†	Ratio	
25 mm	T4–T6	15	33	31.3%	15	33	31.3%	0
25 mm	T7–T9	3	63	4.5%	15	51	22.7%	+18.2%‡
25 mm	T10–T12	6	59	9.2%	8	57	12.3%	+3.1%
30 mm	T4–T6	19	29	39.6%	23	25	47.9%	+8.3%
30 mm	T7–T9	9	57	13.6%	22	44	33.3%	+19.7%§
30 mm	T10–T12	14	51	21.5%	18	47	27.7%	+6.2%
35 mm	T4–T6	21	27	43.8%	27	21	56.3%	+12.5%
35 mm	T7–T9	11	55	16.7%	23	43	34.8%	+18.1%§
35 mm	T10–T12	24	41	36.9%	30	35	46.2%	+9.3%
40 mm	T4–T6	21	27	43.8%	29	19	60.4%	+16.6%
40 mm	T7–T9	11	55	16.7%	23	43	34.8%	+18.1%§
40 mm	T10–T12	33	32	50.8%	38	27	58.5%	+7.7%

*Number of the warning pedicles.

†Number of the nonwarning pedicles.

‡ $P < 0.01$ (Fisher exact test).§ $P < 0.05$.

degree of the aorta movement may be estimated from preoperative deformity and the degree of correction.

We did not measure and analyze the rotation of the spine as most CT did not include the pelvis because of the retrospective nature of this study. Accordingly, we could not estimate the effect of derotation.

In summary, the aorta moved anteromedially relative to the spine after the posterior correction and the risk of the aorta by a pedicle screw increased by correction of the deformity at the middle thoracic spine. Surgeons are recommended to anticipate the aorta movement in the surgical planning.

■ Key Points

- We evaluated the aorta positions before and after scoliosis surgery by multiplanar reconstruction of computed tomography.
- The aorta had a tendency to migrate to the anteromedial direction after corrective surgery of the scoliosis.
- The risk of the aorta by a pedicle screw increases by correction of the deformity at the middle thoracic spine.

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日本語版 Zurich claudication questionnaire
(ZCQ) の開発
— 言語的妥当性を担保した翻訳版の作成 —

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—— 言語的妥当性を担保した翻訳版の作成*

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はじめに

腰部脊柱管狭窄症 (lumbar canal stenosis : LCS) は主に腰椎の退行性変化に起因するもので、高齢社会に伴いその患者は急増している。長総の疫学調査では、LCS の症状を有している地域住民は 50 歳代から急増し、70 歳以上では約 30~40%にも及ぶとされている¹⁾。本症の主症状は、下肢の痛みやしびれに伴う神経性間欠跛行であり²⁾、歩行障害を生じるため生活の質 (QOL) に与える影響はきわめて大きい³⁾。LCS の疾患の重症度や治療の評価においては適切な評価尺度を使用し、QOL を含めた総合的な評価をすることが重要であるといえる。

Zurich claudication questionnaire (ZCQ) は、LCS の重症度・身体機能および満足度を多面的にとらえ、総合的に評価するために開発された、18 項目の質問から構成される自記式の英語版の質問票で、LCS に疾患特異的な評価尺度である。英語版の開発は Stucki らにより行われ、1996 年に計量心理学的な妥当性が確認された第 1 版が『Spine』に公表された⁴⁾。ZCQ はいくつかの名称をもち、Swiss spinal stenosis measure または Brigham spinal stenosis questionnaire という名称でも使用されている。

ZCQ は英語版のほかにすでにノルウェー語などで言語的妥当性が確認された翻訳版が作成されており⁵⁾、これまでに多数の論文中使用されている。また 2007 年

に North American Spine Society から刊行された LCS 臨床ガイドラインにおいて、ZCQ は LCS の治療アウトカム評価に適切な評価法の一つとして推奨されている⁶⁾。しかしわが国においては、言語的な妥当性が確認された翻訳版はないのが現状である。

わが国においても ZCQ を重症度評価・治療評価に導入すべく、英語の原作版を日本語に翻訳し、その言語的妥当性を検討したので報告する。

対象および方法

日本語版の開発は、言語的に妥当な翻訳版を作成する際に標準的に用いられる手順に従って行われた^{7,8)} (図 1)。言語的な妥当性を担保するために、原作版との内容的な整合性を保ちつつ、日本人患者にも違和感なく受け入れられる表現をめざすことが必要である。そのため、すべての段階において原作者である Dr. Stucki (Munich, Germany) に各質問の意図を確認しながら検討をすすめた。

1. 日本語版案の作成 (順翻訳と逆翻訳)

最初に、日本語を母国語とする 2 名の翻訳者が英語版質問票 (原作版) をそれぞれ日本語に翻訳した。それぞれの翻訳案を検討し、日本語翻訳第 1 案として一つの翻訳案にまとめた。その後 2 名の LCS の治療経験を有する臨床医との協議を経て、日本語翻訳第 2 案を作成した (順翻訳)。次に、英語を母国語とする翻訳者が日本語翻

Key words : lumbar canal stenosis, outcome measure, Zurich claudication questionnaire, Japanese version, linguistic validation

* Development of the Japanese version of the Zurich claudication questionnaire (ZCQ) ; translation and linguistic validation

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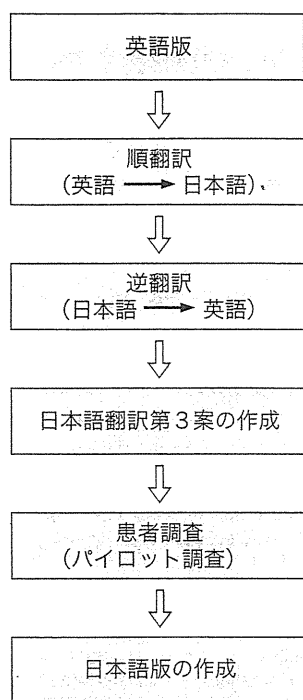


図 1. 日本語版作成の手順

訳第 2 案を英語に翻訳し (逆翻訳), その内容について原作者 (Dr. Stucki) に検討を依頼した. 原作者の指摘事項を含め再度検討を行い, 日本語翻訳第 3 案とした.

2. 患者調査

日本語翻訳第 3 案の文章表現や質問内容の妥当性を検討するため, 当科で 2008 年 3 月に個別面談方式による患者調査を実施した. 患者調査の実施に際しては, 当該施設における倫理委員会で承認を受けた後に実施し, 調査では患者の個人情報は一切収集しないなど, 患者のプライバシー保護には十分に配慮した.

個別面談は, 文書による同意を得た 5 名の LCS 患者に対し, Clinical Study Support 社 (名古屋) の心理学トレーニングを受けたインタビュー担当者によって実施した. インタビュー担当者は, 調査目的を調査参加者に十分説明した後, 自己記入で質問票に回答するように求めた. 回答終了後, ① 質問票の全体的な印象 (質問票は明瞭で理解しやすく回答しやすいか, 回答に要する時間や質問数は適当か, 説明文はわかりやすいか), ② 各質問文に関する印象 (質問文は簡単に理解できるか, どのような意味であると理解したか, 質問は内容的に回答しやすいか), および ③ 回答肢についての印象 (回答肢は明瞭で質問に対応しているか) について患者に意見を求めた. 原作者と患者調査の結果を協議し, 日本語翻訳

表 1. 英語版 ZCQ (原作版) と日本語版 ZCQ の対比表

名称	英語版: Zurich claudication questionnaire	日本語版: チューリヒ跛行質問票(ZCQ)
前書	In the last month, how would you describe :	最近 1カ月の状態について回答して下さい
質問文	The pain you have had on average including pain in your back, buttocks, as well as pain that goes down the legs?	痛みは平均してどの程度でしたか? (腰やおしりの痛み, またそこから脚 (あし) にまで及ぶ痛みを含みます)
回答肢	none mild moderate severe very severe	痛みはまったくなかった 弱い痛みであった 中程度の痛みであった 強い痛みであった 非常に強い痛みであった
質問文	How often have you had back, buttock, or leg pain?	どのくらいの頻度で腰, おしり, あるいは脚 (あし) の痛みがありましたか?
回答肢	less than once a week at least once a week every day, for at least a few minutes every day, for most of the day every minute of the day	1 週間に 1 回未満 1 週間に少なくとも 1 回 少なくとも 1 日 1 回 1 日の大半
質問文	The pain in your back or buttocks?	腰あるいはおしりの痛みはどうでしたか?
回答肢	none mild moderate severe very severe	痛みはまったくなかった 弱い痛みであった 中程度の痛みであった 強い痛みであった 非常に強い痛みであった
質問文	The pain in your legs or feet?	脚 (あし) や足部の痛みはどうでしたか?
回答肢	none mild moderate severe very severe	痛みはまったくなかった 弱い痛みであった 中程度の痛みであった 強い痛みであった 非常に強い痛みであった
質問文	Numbness or tingling in your legs or feet?	脚 (あし) や足部のしびれやうずきははどうでしたか?
回答肢	none mild moderate severe very severe	しびれやうずきはまったくなかった 弱いしびれやうずきであった 中程度のしびれやうずきであった 強いしびれやうずきであった 非常に強いしびれやうずきであった
質問文	Weakness in your legs or feet?	脚 (あし) や足部の衰え具合はどうでしたか?
回答肢	none mild moderate severe very severe	衰えはまったくなかった 軽い衰えであった 中程度の衰えであった 激しい衰えであった 非常に激しい衰えであった
質問文	Problems with your balance?	バランス (安定感) に問題はありましたか?
回答肢	No, I've had no problems with my balance Yes, sometimes I feel my balance is off, or that I am not sure-footed Yes, often I feel my balance is off, or I am not sure-footed	いいえ, バランスをとることにまったく問題はなかった はい, バランスを崩したり足元がしっかりしていなかったりすると, ときどき感じた はい, バランスを崩したり足元がしっかりしていなかったりすると, しばしば感じた

表 1 (つづき)

名 称	英語版：Zurich claudication questionnaire	日本語版：チューリヒ跛行質問票 (ZCQ)	名 称	英語版：Zurich claudication questionnaire	日本語版：チューリヒ跛行質問票 (ZCQ)
前 書	In the last month, on a typical day :	最近 1 か月における平均的な 1 日について考えて下さい	前 書	How satisfied are you with :	以下の事柄について、どの程度満足していますか？
質問文	How far have you been able to walk?	どのくらいの距離を歩くことができましたか？	質問文	The overall result of your back operation?	全体的に考えて、腰の手術結果に満足していますか？
回答肢	more than 2 miles more than 2 blocks, but less than 2 miles more than 50 feet, but less than 2 blocks less than 50 feet	3 km 以上 数百 m 以上、3 km 未満 15 m 以上、数百 m 未満 15 m 未満	回答肢	very satisfied somewhat satisfied somewhat dissatisfied very dissatisfied	非常に満足 やや満足 やや不満足 非常に不満足
質問文	Have you taken walks outdoors or in malls for pleasure?	戸外やショッピングセンター内を散歩したりしましたか？	質問文	Relief of pain following the operation?	手術後、痛みの軽減に満足していますか？
回答肢	yes, comfortably yes, but sometimes with pain yes, but always with pain no	はい、痛みが楽しく歩けた はい、しかしときどき痛みがあった はい、しかし痛みが常にあった いいえ、歩けなかった	回答肢	very satisfied somewhat satisfied somewhat dissatisfied very dissatisfied	非常に満足 やや満足 やや不満足 非常に不満足
質問文	Have you been shopping for groceries or other items?	食料品・日用品やその他の物などの買い物に出かけましたか？	質問文	Your ability to walk following the operation?	手術後、歩行能力に満足していますか？
回答肢	yes, comfortably yes, but sometimes with pain yes, but always with pain no	はい、痛みが楽しく出かけた はい、しかしときどき痛みがあった はい、しかし痛みが常にあった いいえ、出かけられなかった	回答肢	very satisfied somewhat satisfied somewhat dissatisfied very dissatisfied	非常に満足 やや満足 やや不満足 非常に不満足
質問文	Have you walked around the different rooms in your house or apartment?	家の中をほかの部屋に行ったりして歩きましたか？	質問文	Your ability to do housework, yard work, or job following the operation?	手術後、家事や庭仕事、仕事の出来具合に満足していますか？
回答肢	yes, comfortably yes, but sometimes with pain yes, but always with pain no	はい、痛みが楽しく歩けた はい、しかしときどき痛みがあった はい、しかし痛みが常にあった いいえ、歩けなかった	回答肢	very satisfied somewhat satisfied somewhat dissatisfied very dissatisfied	非常に満足 やや満足 やや不満足 非常に不満足
質問文	Have you walked from your bedroom to the bathroom?	寝室からトイレまで歩きましたか？	質問文	Your strength in the thighs, legs, and feet?	太ももや脚(あし)、足部の力強さに満足していますか？
回答肢	yes, comfortably yes, but sometimes with pain yes, but always with pain no	はい、痛みが楽しく歩けた はい、しかしときどき痛みがあった はい、しかし痛みが常にあった いいえ、歩けなかった	回答肢	very satisfied somewhat satisfied somewhat dissatisfied very dissatisfied	非常に満足 やや満足 やや不満足 非常に不満足
			質問文	Your balance, or steadiness on your feet?	バランス、または立ったときの安定感に満足していますか？
			回答肢	very satisfied somewhat satisfied somewhat dissatisfied very dissatisfied	非常に満足 やや満足 やや不満足 非常に不満足

第 3 案に表現および語句の修正を実施し、日本語翻訳最終版とした。

結 果

原作版と日本語版の比較を表 1 に示す。

1. 順翻訳および逆翻訳 (日本語翻訳第 3 案の作成)

順翻訳および逆翻訳を実施し、日本語翻訳第 3 案を作成するまでに検討した主な内容を下記に記した。

“In the last month, how would you describe :” は

「:」に続く質問項目が目的語になっており、英語特有の構文である。日本語としての理解しやすさを考慮し依頼形の表現にした。質問票全体をとおして回答肢間の間隔(程度)が不均一にならないように考慮した。

“The pain in your back or buttocks?” に「どうでしたか」という語句を加え、日本語として理解しやすくした。

“Numbness or tingling in your legs or feet?” の“tingle”の意味は“if a part of your body tingles, you

チューリヒ跛行質問票

最近 1ヶ月の状態について回答して下さい。

痛みは平均してどの程度でしたか？（腰やおしりの痛み、またそこから脚^{あし}にまで及ぶ痛みを含みます。）

痛みは全く 弱い痛み 中程度の痛み 強い痛み 非常に強い痛み
 なかった であった であった であった であった

どの位の頻度で腰、おしり、あるいは脚^{あし}の痛みがありましたか？

1 週間に 1 回未満
 1 週間に少なくとも 1 回
 少なくとも 1 日 1 回
 1 日の大半
 四六時中痛みがある

腰あるいは おしりの痛みはどうでしたか？

痛みは全く 弱い痛み 中程度の痛み 強い痛み 非常に強い痛み
 なかった であった であった であった であった

脚^{あし}や足部の痛みはどうでしたか？

痛みは全く 弱い痛み 中程度の痛み 強い痛み 非常に強い痛み
 なかった であった であった であった であった

脚^{あし}や足部のしびれや うずきは どうでしたか？

しびれやうずき 弱いしびれや 中程度のしびれや 強いしびれや 非常に強いしびれや
 は全くなかった うずきであった うずきであった うずきであった うずきであった

脚^{あし}や足部の衰え具合はどうでしたか？

衰えは全く 軽い衰え 中程度の衰え 激しい衰え 非常に激しい
 なかった であった であった であった 衰えであった

バランス(安定感)に問題はありましたか？

いいえ、バランスをとることに全く問題はなかった
 はい、バランスを崩したり足元がしっかりしていなかったりすると、ときどき感じた
 はい、バランスを崩したり足元がしっかりしていなかったりすると、しばしば感じた

図 2. チューリヒ跛行質問票

feel a slight stinging feeling, especially on your skin” (英英) や「人・体がぞくぞく、うずうずする」(英和) と記載されている。また、“stinging” の意味として「刺すような」(英英) と記載されており、slight stinging feeling の意味とも合致する「うずき」と翻訳した。

“Weakness in your legs or feet?” の“weakness” は当初「衰弱」と翻訳した。しかし、「衰弱」とは「衰え

弱ること」(『広辞苑』)であり、“weakness: state of being physically weak” (英英) であることをふまえると、「衰え」が適切であると考え採用した。

Physical function を問う質問群に対する回答肢 “no” には、“could not walk” の意味が含まれているため、「いいえ、歩けなかった」と翻訳した。

“mile” および “block” は「km (キロメートル)」お

<p>最近 1 ヶ月における平均的な 1 日について考えて下さい。</p> <p>どの位の距離を歩くことができましたか？</p> <p>3 キロメートル以上 <input type="checkbox"/></p> <p>数百メートル以上、3 キロ未満 <input type="checkbox"/></p> <p>15 メートル以上、数百メートル未満 <input type="checkbox"/></p> <p>15 メートル未満 <input type="checkbox"/></p> <p>戸外やショッピングセンター内を散歩したりしましたか？</p> <p>はい、痛みがなく楽に歩けた <input type="checkbox"/></p> <p>はい、しかし時々痛みがあった <input type="checkbox"/></p> <p>はい、しかし痛みが常にあった <input type="checkbox"/></p> <p>いいえ、歩けなかった <input type="checkbox"/></p> <p>食料品・日用品やその他の物などの買い物に出かけましたか？</p> <p>はい、痛みがなく楽に出かけられた <input type="checkbox"/></p> <p>はい、しかし時々痛みがあった <input type="checkbox"/></p> <p>はい、しかし痛みが常にあった <input type="checkbox"/></p> <p>いいえ、出かけられなかった <input type="checkbox"/></p> <p>家の中を他の部屋に行ったりして歩きましたか？</p> <p>はい、痛みがなく楽に歩けた <input type="checkbox"/></p> <p>はい、しかし時々痛みがあった <input type="checkbox"/></p> <p>はい、しかし痛みが常にあった <input type="checkbox"/></p> <p>いいえ、歩けなかった <input type="checkbox"/></p> <p>寝室からトイレまで歩きましたか？</p> <p>はい、痛みがなく楽に歩けた <input type="checkbox"/></p> <p>はい、しかし時々痛みがあった <input type="checkbox"/></p> <p>はい、しかし痛みが常にあった <input type="checkbox"/></p> <p>いいえ、歩けなかった <input type="checkbox"/></p>	<p>以下のことがらについて、どの程度満足していますか？</p> <p>全体的に考えて、腰の手術結果に満足していますか？</p> <p>非常に満足 <input type="checkbox"/></p> <p>やや満足 <input type="checkbox"/></p> <p>やや不満足 <input type="checkbox"/></p> <p>非常に不満足 <input type="checkbox"/></p> <p>手術後、痛みの軽減に満足していますか？</p> <p>非常に満足 <input type="checkbox"/></p> <p>やや満足 <input type="checkbox"/></p> <p>やや不満足 <input type="checkbox"/></p> <p>非常に不満足 <input type="checkbox"/></p> <p>手術後、歩行能力に満足していますか？</p> <p>非常に満足 <input type="checkbox"/></p> <p>やや満足 <input type="checkbox"/></p> <p>やや不満足 <input type="checkbox"/></p> <p>非常に不満足 <input type="checkbox"/></p> <p>手術後、家事や庭仕事、仕事の出来具合に満足していますか？</p> <p>非常に満足 <input type="checkbox"/></p> <p>やや満足 <input type="checkbox"/></p> <p>やや不満足 <input type="checkbox"/></p> <p>非常に不満足 <input type="checkbox"/></p> <p>太ももや脚^{あし}、足部の力強さに満足していますか？</p> <p>非常に満足 <input type="checkbox"/></p> <p>やや満足 <input type="checkbox"/></p> <p>やや不満足 <input type="checkbox"/></p> <p>非常に不満足 <input type="checkbox"/></p> <p>バランス、または立った時の安定感に満足していますか？</p> <p>非常に満足 <input type="checkbox"/></p> <p>やや満足 <input type="checkbox"/></p> <p>やや不満足 <input type="checkbox"/></p> <p>非常に不満足 <input type="checkbox"/></p>
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図 2 (つづき)

よび「m (メートル)」に換算して翻訳することとし、原作者の了承を得た。

原作版で“leg”, “feet”, “typical”, “strength” の各語句については翻訳案が複数あり、患者調査の結果をふまえて決定することとした。

2. 患者調査

LCS 患者 5 (男性 3, 女性 2) 例を対象に個別面談方

式による調査を実施した。参加者の平均年齢は、72.4 (66~79) 歳であった。平均回答時間は 13.4 (9~18) 分であった。調査の結果をふまえ、個々の質問項目について検討した結果を以下に記す。

ほとんどの参加者がこの質問票の質問内容および回答肢の意味について理解していた。2 名の参加者より「痛いのは背中とおしりではなく腰である」との意見があっ

記入時の注意事項

- ※ あまり考えすぎず、感じたとおりにお答え下さい
- ※ 質問票にある「^{あし}脚」と「足部」とは下図の部位を指します

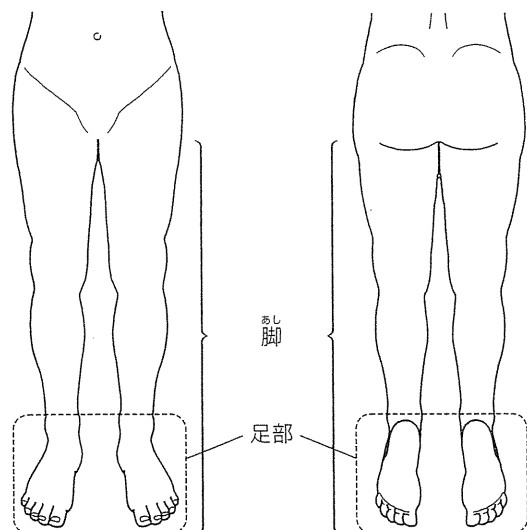


図 3. チューリヒ跛行質問票 (ZCQ)

た。「背中」と翻訳した英語“back”について、臨床医より「日本語の『腰痛』に該当する英語は“low back pain”であるが、西欧では“back pain”も同義として使用する場合もある」との意見があった。検討した結果、“back”を「腰」に修正した。

翻訳第3案作成時に“leg or feet”の訳として「足や足先」および臨床で通常使われている「脚や足部」ではどちらが理解しやすいか調査の結果をふまえて決定することにした。調査の結果、「足」と「脚」では言葉が示す部位の理解が参加者間で異なっていた。また、3名の参加者より「『足部』はどこを示すかわからない」との意見があった。検討した結果、「記入時の注意事項(図3参照)」を別に作成し、“leg”および“feet”が示す部位を図示した。なお、質問票の“leg or feet”の訳として「^{あし}脚や足部」に決定した。3名の参加者より「『うずき』はわかりづらく、回答しづらい」との意見があった。検討の結果、「しびれ」が理解できれば質問に回答可能であるため、変更は行わず注釈もつけないこととした。

翻訳第3案作成時に、「典型的な1日」と「平均的な1日」のどちらが理解しやすいか調査の結果をふまえて決定することにした。調査の結果、3名より「『平均的な1日』のほうがわかりやすい」との意見があったた

め、「平均的な1日」に決定した。回答肢「はい、痛みがなく楽に買い物ができる」について、回答に対応する質問の意図として「買い物できた」より「出かけられた」に重点がおかれているため、「はい、痛みがなく楽に出かけられた」に修正し、最終的な翻訳として採用した。すべての参加者より「『歩き回る』は広い家の場合に使用する表現であり自分の家には不適切である」との意見があった。検討の結果、日本の住居環境に適した言葉とするため、「歩き回る」を「歩き」に修正した。また、「家の中でほかの部屋に行ったりして歩きましたか?」より「家の中をほかの部屋に行ったりして歩きましたか?」のほうが日本語として自然な表現であると判断し、修正した。3名の一般成人男女を対象に修正案についての調査を実施したところ、質問の意図を正しく理解していたため、上記の修正案を最終的な翻訳として採用した。

“bathroom”には「浴室」だけでなく、「トイレ」も備わっている場合が多い(英和)。日本では浴室とトイレは別々の部屋にある場合が多いため、どちらかに限定する必要があると考えた。最近1ヵ月の1日(physical function)についての質問群は、質問がすすむに従い、日常生活の活動範囲が狭くなるように構成されている。この質問は日常生活の活動範囲がもっとも狭い場合に該当する。日常生活では、一般的に浴室(入浴)よりトイレ(排泄)の必要性が高いことを考慮すると、“bathroom”を「トイレ」とするほうが適切であると判断した。また、臨床医からも同様の意見があったため、検討の結果「浴室」を「トイレ」に修正した。3名の一般成人男女を対象に修正案についての調査を実施したところ、質問の意図を正しく理解していたため、上記の修正案を最終的な翻訳として採用した。

翻訳第3案作成時に、「強さ」と「力強さ」のどちらが理解しやすいか調査の結果をふまえて決定することにした。調査の結果、4名から「『太ももや足、足先の強さに満足していますか?』のほうがわかりやすい」との意見があった。しかし臨床医からは、「筋力の強さを明示するためには、『強さ』より『力強さ』のほうが適している」との意見があった。検討の結果、臨床医の経験から得られた意見に従い、「力強さ」に決定した。調査の結果からも質問の意図自体は力強さでも正しく理解されていたため、上記の最終案で特に問題はないものと考えた。

3. 日本語版の作成

患者調査の結果をふまえ、上記の修正を加え、その内容について原作者の同意を得た。一連の手順に従って原語版を翻訳し、言語的妥当性の担保された「日本語版 ZCQ」を確定した(図 2, 3)。

考 察

ZCQ は LCS に疾患特異的な評価尺度であり、英語版以外に複数の言語で言語的妥当性が確認された翻訳版が作成されている。現時点においても重症度判定や治療効果判定として幅広く使われているが、2007 年の北米脊椎学会のガイドラインに推奨されたことにより、今後さらに世界的に広く使用されるようになると予想される。本研究では、ZCQ を日本でも使用できるように ZCQ の日本語版を作成した。

他言語の質問票についての翻訳版の作成にあたっては、文化的な背景および言語の相違を慎重に考慮する必要がある。今回の研究では、質問票の翻訳版の言語的妥当性を担保するために使用される標準的手法を用いて日本語版を作成した。翻訳者・臨床医および原作者が検討を複数回実施し、患者調査により患者の意見をとり入れたうえでさらに検討を行うことで、言語的な精度を高めてゆくことができた。これらの過程を経て、原作版と同じ概念を有し、言語的に妥当性のある翻訳がなされた日本語版 ZCQ が完成した。今後必要に応じて日本語の文章表現について検討を実施し、質問票としての精度をさらに高めてゆくことが重要である。

また、今後は信頼性や妥当性などの計量心理学的な検討を実施する必要があると考えており、筆者らは約 100

名の LCS 患者を対象に計量心理学的検討をすすめている。

ま と め

質問票の翻訳版の言語的妥当性を担保するために使用される標準的手法を用いて、言語的妥当性の担保された「日本語版 ZCQ」を作成した。

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脊椎内視鏡下手術 基本手技から技術認定まで DVD付 南江堂

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脊椎内視鏡下手術技術認定医に求められる知識と技術を網羅した実践的テキスト。実際の手術のステップごとに、術中写真とシェーマをふんだんに用いてわかりやすく解説。より安全・確実に行うためのテクニックと、リスクを回避するための注意点をステップごとに示す。現場で役立つ困ったときの対処法や、応用的なテクニックも囲み記事で紹介。理解を助けるための DVD 付き。

Predictors of residual symptoms in lower extremities after decompression surgery on lumbar spinal stenosis

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Abstract Leg pain/numbness and gait disturbance, two major symptoms in the lower extremities of lumbar spinal stenosis (LSS), are generally expected to be alleviated by decompression surgery. However, the paucity of information available to patients before surgery about specific predictors has resulted in some of them being dissatisfied with the surgical outcome when the major symptoms remain after the procedure. This prospective, observational study sought to identify the predictors of the outcome of a decompression surgery: modified fenestration with restorative spinoplasty. Of 109 consecutive LSS patients who underwent the decompression surgery, 89 (56 males and 33 females) completed the 2 year follow-up. Both leg pain/numbness and gait disturbance determined by the Japanese Orthopedic

Association scoring system were significantly improved at 2 years after surgery compared to those preoperative, regardless of potential predictors including gender, preoperative presence of resting numbness in the leg, drop foot, cauda equina syndrome, degenerative spinal deformity or myelographic filling defect, or the number of decompressed levels. However, 27 (30.3%) and 13 (14.6%) patients showed residual leg pain/numbness and gait disturbance, respectively. Among the variables examined, the preoperative resting numbness was associated with residual leg pain/numbness and gait disturbance, and the preoperative drop foot was associated with residual gait disturbance, which was confirmed by logistic regression analysis after adjustment for age and gender. This is the first study to identify specific predictors for these two remaining major symptoms of LSS after decompression surgery, and consideration could be given to including this in the informed consent.

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Keywords Lumbar spinal stenosis · Decompression surgery · Outcome · Predictor

Introduction

Lumbar spinal stenosis (LSS) is a degenerative disorder causing neurological symptoms in the lower extremities such as leg pain/numbness and gait disturbance, both of which dramatically deteriorate the patients' quality of life [3, 4, 17]. With elderly populations growing worldwide, degenerative LSS has become the most frequent indication for spine surgery [12]. The most common surgery is decompression of the lumbar spine, which is performed mainly to reduce the above symptoms in the lower extremities. In fact, a prospective study revealed that the surgery generally resulted in a more preferable greater outcome than non-surgical treatments in the LSS

patients [20]. However, about 20–40% of patients have been reported to be dissatisfied with the result due to residual symptoms [1, 8, 9]. To avoid the discrepancy between a patient's expectations and actual surgical outcome, a surgeon should preoperatively inform the patient in detail of the possible post-surgery outcome of the major symptoms such as leg pain/numbness and gait disturbance.

There have been several reports on the factors that could predict the outcome of LSS surgeries [7–9, 15, 19]; however, some of the surgeries included arthrodesis in addition to decompression. Furthermore, the outcomes were evaluated using several validated measures, so that they covered a broad range including low back pain, psychological status, patients' satisfaction, quality of life, etc. other than symptoms in the lower extremities. Hence, the predictors identified are rather ambiguous such as the presence of other comorbidities, patient's assessment of his/her health, subclinical vascular factors and illness behavior. Since little has been known about the specific predictors of outcomes in the lower extremities after decompression surgery, this study sought to identify the factors associated with two major symptoms in the lower extremities of LSS patients: leg pain/numbness and gait disturbance, after a minimally invasive decompression surgery.

Materials and methods

Patients

Consecutive patients, who were blinded to the study, were entered into this prospective observational study from January 2000 through December 2002. Symptoms of leg pain/numbness and/or gait disturbance in LSS patients, which did not respond to conservative therapies for more than 3 months, were considered to be indications for the decompression surgery [10]. The LSS was confirmed by plain radiographs, magnetic resonance imaging and myelography followed by contrast-enhanced computed tomography scan. The patients with severe spinal deformity (spondylolisthesis with Meyerding grades \geq II or lumbar scoliosis with Cobb angle $>$ 20 degrees), spondylolysis, post-traumatic stenosis or re-stenosis after prior decompression surgery were excluded, because they were indicated for an additional arthrodesis surgery. A total of 109 patients who met the criteria underwent our original decompression surgery called modified fenestration with restorative spinoplasty [11]. They were allowed to sit up and walk on the 1st or 2nd postoperative day with a soft lumbar support. Examinations were performed preoperatively and at 2 years after surgery. The study was conducted with the approval of the institutional review board (IRB) and all participants (blinded) provided written informed consent.

Data elements

The severity of leg pain/numbness or gait disturbance was evaluated as four grades according to the Japanese Orthopedic Association (JOA) scoring system [5]: 0 (none), 1 (occasionally mild), 2 (always present or sometimes severe) and 3 (always severe) for leg pain/numbness; and 0 (none), 1 (able to walk $>$ 500 m with pain/numbness/weakness), 2 (unable to walk 500 m due to pain/numbness/weakness) and 3 (unable to walk 100 m due to pain/numbness/weakness) for gait disturbance. The presence of a residual symptom was defined as a JOA score of 0 or 1 at 2 years after surgery, regardless of the preoperative score. In addition, a score of 2 after 2 years and of 2 or 3 preoperatively were also regarded as the presence of a residual symptom. Potential predictors of outcome included age, gender, preoperative presence of resting numbness in the leg, drop foot [manual muscle test (MMT) score below 3 out of 5 in the tibialis anterior and/or peroneal muscle], cauda equina syndrome (urinary retention, perineal anesthesia or symptoms in bilateral lower extremities), degenerative spinal deformity (spondylolisthesis with more than 5% anterior slippage by the Taillard method [16] and/or lumbar scoliosis with more than 10 degrees of Cobb angle) on plain radiographs, a complete filling defect on myelography in the standing position and the number of decompressed levels. Radiographic findings were independently evaluated by three spine surgeons and were determined with the agreement of at least two of them.

Analyses

Statistical analyses were performed using the SPSS 16.0J for Windows. A *P* value of $<$ 0.05 was considered to be statistically significant and all reported *P* values were two sided. Paired *t* test was used to examine the difference between the preoperative and postoperative JOA scores. Association of age, gender, preoperative presence of the above findings or the number of decompressed levels with residual leg pain/numbness or gait disturbance was evaluated by chi-square test in the stratified subgroups. Logistic regression analysis was performed to estimate odds ratio (OR) and the associated 95% confidence interval (CI) after adjustment for age and gender.

Results

Comparison of preoperative and postoperative scores

Of the 109 patients enrolled, 101 (93%) could be followed postoperatively for 2 years. The reasons for the eight dropouts were two deaths from lung cancer and heart

failure, three moved to distant areas and three lost contact. Twelve other patients who showed symptoms in the lower extremities due to cerebral infarction, myelopathy or dementia during the postoperative follow-up period were excluded. Symptoms in the lower extremities of the remaining 89 patients (56 males and 33 females; mean ± SD, 66.3 ± 11.2 years) were surveyed 2 years after surgery. There was no complication in the surgical procedure except for slight dural tears in four patients, which were repaired without additional treatment. During the follow-up period, a superficial infection, a pseudomembranous enteritis, a disc herniation at the operated level and a compression vertebral fracture occurred, all of which were cured with conservative therapies. None of the patients underwent spinal re-operation because of progression of stenosis or instability.

The background data of the 89 patients are shown in Table 1. Comparison of preoperative and postoperative JOA scores on symptoms in the lower extremities of all the patients revealed that both leg pain/numbness (1.0–2.0) and gait disturbance (0.7–2.4) were significantly improved by surgery (Table 1). The stratified comparisons by gender, preoperative presence of the above findings and the number of decompressed levels showed that the JOA scores of both symptoms were significantly improved by the surgery in all subgroups. However, the subgroup with preoperative drop foot showed somewhat less improvement in both leg pain/numbness ($P = 0.009$) and gait disturbance ($P = 0.007$) than other subgroups ($P < 0.0001$).

Predictors of the residual symptoms in lower extremities

According to the definition of residual symptoms as above, 27 (30.3%) and 13 (14.6%) patients showed residual leg pain/numbness and gait disturbance, respectively (Table 2). To identify the predictors of residual symptoms in the lower extremities, we compared the number (percentage) of patients with and without residual symptoms in the stratified subgroup according to the variables. Among the variables, preoperative resting numbness was positively associated with both residual leg pain/numbness ($P = 0.03$) and residual gait disturbance ($P = 0.02$). Furthermore, preoperative drop foot was more strongly associated with residual gait disturbance ($P = 0.0002$), although not with residual leg pain/numbness. Age, gender, preoperative presence of cauda equina syndrome, degenerative spinal deformity, myelographic complete filling defect or the number of decompressed levels was not associated with either of the residual symptoms in the lower extremities.

To further identify the principal predictors, we further performed logistic regression analysis after adjustment for age and gender to estimate OR and 95% CI. We confirmed the significant association of resting numbness with residual leg pain/numbness and gait disturbance, as well as the significant association of drop foot with residual gait disturbance (Table 3).

Table 1 Comparison of preoperative and postoperative JOA scores on symptoms in lower extremities

	<i>n</i>	Leg pain/numbness				Gait disturbance				
		Preop. (SD)	Postop. (SD)	Change (SD)	<i>P</i> value	Preop. (SD)	Postop. (SD)	Change (SD)	<i>P</i> value	
All	89	1.0 (0.5)	2.0 (0.8)	1.0 (0.8)	<0.0001	0.7 (0.8)	2.4 (0.8)	1.8 (1.0)	<0.0001	
Gender	Male	56	1.0 (0.6)	2.1 (0.8)	1.1 (0.8)	<0.0001	0.7 (0.8)	2.4 (0.8)	1.7 (0.9)	<0.0001
	Female	33	0.9 (0.4)	1.8 (0.8)	0.9 (0.8)	<0.0001	0.6 (0.8)	2.4 (0.8)	1.8 (1.0)	<0.0001
Resting numbness	(+)	40	0.9 (0.5)	1.4 (0.7)	0.6 (0.7)	<0.0001	0.6 (0.7)	2.2 (0.9)	1.6 (1.0)	<0.0001
	(-)	49	1.1 (0.6)	2.5 (0.5)	1.4 (0.6)	<0.0001	0.8 (0.8)	2.7 (0.6)	1.9 (0.9)	<0.0001
Drop foot	(+)	9	0.9 (0.8)	1.9 (0.6)	1.0 (0.9)	0.009	0.6 (0.9)	1.9 (1.2)	1.3 (1.1)	0.007
	(-)	80	0.9 (0.5)	2.0 (0.8)	1.0 (0.8)	<0.0001	0.7 (0.8)	2.5 (0.7)	1.8 (0.9)	<0.0001
Cauda equina syndrome	(+)	66	0.9 (0.5)	1.9 (2.2)	1.0 (0.8)	<0.0001	0.6 (0.7)	2.4 (0.8)	1.8 (0.9)	<0.0001
	(-)	23	1.0 (0.7)	2.2 (0.9)	1.0 (0.8)	<0.0001	0.9 (0.9)	2.4 (0.7)	1.5 (1.0)	<0.0001
Degenerative spinal deformity	(+)	47	1.0 (0.6)	2.0 (0.8)	1.0 (0.8)	<0.0001	0.7 (0.8)	2.4 (0.7)	1.7 (0.9)	<0.0001
	(-)	42	0.9 (0.4)	2.0 (0.9)	1.1 (0.9)	<0.0001	0.6 (0.7)	2.5 (1.0)	1.9 (1.0)	<0.0001
Complete filling defect	(+)	56	0.9 (0.6)	1.9 (0.8)	1.0 (0.8)	<0.0001	0.7 (0.8)	2.4 (0.8)	1.7 (1.0)	<0.0001
	(-)	33	1.0 (0.5)	2.2 (0.9)	1.2 (0.7)	<0.0001	0.7 (0.8)	2.5 (0.8)	1.8 (0.9)	<0.0001
Number of decompressed levels	1	50	1.0 (0.5)	2.1 (0.7)	1.1 (0.7)	<0.0001	0.9 (0.8)	2.6 (0.6)	1.7 (0.8)	<0.0001
	≥2	39	0.9 (0.6)	1.9 (0.8)	0.9 (0.9)	<0.0001	0.4 (0.7)	2.2 (0.9)	1.8 (1.2)	<0.0001

P value was determined by the paired *t* test

Table 2 Number (percentage) of patients with and without residual symptoms in the lower extremities

		Leg pain/numbness			Gait disturbance		
		(+)	(-)	<i>P</i> value	(+)	(-)	<i>P</i> value
		<i>n</i> = 27	<i>n</i> = 62		<i>n</i> = 13	<i>n</i> = 76	
Mean age (years)		72.0	68.1	0.10	64.6	69.1	0.10
Gender	Male	17 (30.4)	39 (69.6)	0.26	10 (17.9)	46 (82.1)	0.26
	Female	10 (30.3)	23 (69.7)		3 (9.0)	30 (91.0)	
Resting numbness	(+)	26 (65.0)	14 (35.0)	0.03*	9 (22.5)	31 (77.5)	0.02*
	(-)	1 (2.0)	48 (98.0)		4 (8.2)	45 (91.8)	
Drop foot	(+)	4 (44.4)	5 (55.6)	0.33	5 (55.6)	4 (44.4)	0.0002*
	(-)	23 (28.8)	57 (61.2)		8 (10.0)	72 (90.0)	
Cauda equina syndrome	(+)	23 (34.8)	43 (65.2)	0.11	9 (13.6)	57 (86.4)	0.66
	(-)	4 (17.4)	19 (82.6)		4 (17.4)	19 (82.6)	
Degenerative spinal deformity	(+)	17 (36.2)	30 (63.8)	0.60	7 (14.9)	40 (55.1)	0.60
	(-)	10 (23.8)	32 (76.2)		6 (14.3)	36 (55.7)	
Complete filling defect	(+)	21 (37.5)	35 (62.5)	0.06	8 (14.3)	48 (85.7)	0.91
	(-)	6 (18.2)	27 (81.8)		5 (15.2)	28 (84.8)	
Number of decompressed levels	1	11 (22.0)	39 (78.0)	0.05	4 (8.0)	46 (92.0)	0.05
	≥2	16 (41.0)	23 (59.0)		9 (23.1)	30 (76.9)	

P value was determined by the chi-square test

Table 3 Logistic regression analyses for odds ratio (OR) and 95% confidence interval (CI) of the variables for residual symptoms in the lower extremities

	Leg pain/numbness		Gait disturbance	
	OR	(95% CI)	OR	(95% CI)
Resting numbness	85.6*	(15.9–1603.1)	4.5*	(1.2–23.2)
Drop foot	2.1	(0.5–9.0)	11.6*	(2.5–59.1)
Cauda equina syndrome	2.6	(0.09–4.1)	1.3	(0.006–2.5)
Degenerative spinal deformity	0.7	(0.1–4.9)	0.6	(0.1–2.2)
Complete filling defect	2.2	(0.9–2.4)	1.4	(0.004–2.3)
Number of decompressed levels	2.5	(1.0–2.7)	4.2	(0.06–9.8)

Data were calculated by logistic regression analysis after adjustment for age and gender, **P* < 0.01

Discussion

This prospective observational study for the first time identified the specific predictors for the remaining major symptoms of LSS after decompression surgery: leg pain/numbness and gait disturbance. Preoperative resting numbness was found to be a predictor of both residual leg pain/numbness and gait disturbance, and preoperative drop foot was a predictor of residual gait disturbance. It would seem to be natural that preoperative resting numbness eventually leads to postoperative leg pain/numbness. In fact, 65.0% (26 of 40 patients) of patients with preoperative resting numbness still showed residual leg pain/numbness

2 years after the operation (Table 2). Numbness caused by LSS has been reported to be more difficult to alleviate by surgery than other neurological symptoms such as muscle weakness or pain [2, 6]. Also, it is not surprising that preoperative drop foot eventually leads to postoperative gait disturbance. More than half (55.6%; 5 of 9 patients) the patients with preoperative drop foot showed residual gait disturbance (Table 2). A previous study on the surgical outcome of LSS patients with drop foot revealed that especially those with a preoperative MMT score of 0 or 1 for ankle dorsiflexion exhibited poor alleviation of this disorder [1]. In the present study as well, there were three patients with an MMT score of 0 or 1, and all of them showed residual gait disturbance due to the unchanged drop foot (data not shown). Furthermore, comparison of preoperative and postoperative JOA scores revealed that the subgroup with preoperative drop foot showed less improvement of symptoms in the lower extremities than other subgroups (Table 1). Taken together, resting numbness and drop foot may be derived from less reversible neurological disorders, so that they are difficult to restore by decompression. The preoperative durations of these symptoms may influence the surgical outcomes, which we should examine as a next task. More interesting is that preoperative resting numbness, a sensory disorder, was identified as a predictor of residual gait disturbance, which is a motor disorder. Although the underlying mechanism remains unclear, we speculate a possible involvement of irreversible peripheral neural damage that is related to both resting numbness and gait disturbance.

In addition to resting numbness and drop foot, the number of decompressed levels also showed a trend toward positive association with residual leg pain/numbness and residual gait disturbance, although not statistically significant (Table 2, $P = 0.05$ in both symptoms; Table 3, OR = 2.5 and 4.2, respectively). Although the present comparison was performed between a single level of decompression and two or more levels of decompression, a comparison between one or two levels ($n = 80$) and three or more levels ($n = 9$) showed a significant association of the number of decompressed levels with residual leg pain/numbness ($P = 0.01$, OR = 7.5, 95% CI = 1.6–50.0), but not with residual gait disturbance ($P = 0.50$, OR = 1.3, 95% CI = 0.1–6.3) (data not shown in the tables). Indeed, there is greater possibility of multiple levels of decompression to cause surgical invasion, which may eventually result in the residual symptoms. Alternatively, independently of the surgery itself, residual symptoms may be derived from irreversible symptoms of the preoperative disorders, since the multi-level canal stenosis, which is an indication of multi-level decompression, may cause more damages to the nerve root, cauda equina and the blood circulation [13, 14, 18]. Hence, unlike preoperative symptoms such as resting numbness and drop foot, the number of decompressed levels may not be suitable for the predictor. In fact, previous reports on the relationship between the number of decompressed levels and the surgical outcome have been controversial, depending on the outcome measures including standardized instruments and self-reported satisfaction by patients [7, 9].

As the decompression surgery, the present study utilized our original technique called modified fenestration with restorative spinoplasty. Since this technique was developed to achieve good visibility of the spinal canal and safe decompression even in patients with narrow and steep facet joints, the ability to decompress the spinal canal and nerve roots is sufficient, similar to conventional laminectomy/foraminotomy techniques [11]. Hence, we believe that the present results obtained using this unique technique are applicable generally to typical decompression surgeries.

Although approximately 30 and 15% of patients were shown to have residual symptoms after the decompression surgery, respectively (Table 2), the present residual symptoms were defined according to our original criteria based on the JOA score and were not completely or directly linked with the dissatisfaction of the patients. Indeed, there are other factors such as back pain and psychological status to be considered for the recommendation of the surgery. Furthermore, since the JOA scores of leg pain/numbness and gait disturbance were significantly improved after the surgery, regardless of the presence or absence of these predictors (Table 1), decompression surgery is definitely

worth performing to decrease the severity of these symptoms. Hence, the present study suggests that it is desirable for this surgery to be performed before the onset of resting numbness or drop foot at least to prevent residual symptoms in the lower extremities. Even in the presence of these preoperative predictors, however, we encourage this surgery with sufficient informed consent, including the findings obtained from this study, to avoid misunderstanding or over-expectation of the patient with regard to the surgical outcome.

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New parameters to represent the position of the aorta relative to the spine for pedicle screw placement

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Abstract Parameters of the position of the aorta in previous reports were determined for anterior surgery. This study evaluated the relative position of the aorta to the spine by new parameters, which could enhance the safety of pedicle screw placement. Three parameters were defined in a new Cartesian coordinate system. We selected an entry point of a left pedicle screw as the origin. The transverse plane was determined to include both the bases of the superior facet and to be parallel to the upper endplate of the vertebral body. A line connecting the entry points of both sides was defined as the *X*-axis. The angle formed by the *Y*-axis and a line connecting the origin and the center of the aorta was defined as the left pedicle–aorta angle. The length of a line connecting the origin and the aorta edge was defined as the left pedicle–aorta distance. Distance from the edge of the aorta to the *X*-axis was defined as the pedicular line–aorta distance. These parameters were measured preoperatively in 293 vertebral bodies of 24 patients with a right thoracic curve. We simulated the placement of the pedicle screw with variable length and with some direction error. We defined a warning pedicle as that when the aorta enters the expected area of the screw.

Sensitivity analysis was performed to find the warning pedicle ratio in 12 scenarios. The left pedicle–aorta angle averaged 29.7° at the thoracic spine and –16.3° at the lumbar spine; the left pedicle–aorta distance averaged 23.7 and 55.2 mm; the pedicular line–aorta distance averaged 18.3 and 51.0 mm, respectively. The ratio of warning pedicles was consistently high at T4–5 and T10–12. When a left pedicle screw perforates an anterior/lateral wall of the vertebral body, the aorta may be at risk. These new parameters enable surgeons to intuitively understand the position of the aorta in surgical planning or in placement of a pedicle screw.

Keywords Scoliosis · Pedicle screw · Aorta · Computed tomography

Introduction

Several authors have reported serious injuries of the aorta due to inappropriate placement of screws or plates in anterior surgery [8, 9]. Sucato et al. [10] reported that 12% (13/106) of vertebral screws in right thoracic scoliosis created some contour defect in the aorta on the contralateral side of the vertebral body, although patients had no sequela. They subsequently analyzed the position of the aorta in patients with scoliosis compared to those with non-scoliotic spine and found that the aorta often resides on the lateral side of the vertebral body and concluded that a potential risk of the aorta by a vertebral screw increases in the scoliotic spine. Maruyama et al. [7] studied the spatial relations between the spine and the aorta in adolescent idiopathic scoliosis and concluded that the aorta can be located in the direction of the screw passage in 33 of 40 vertebrae (83%) between T6 and T9. These studies,

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however, paid less attention to the relationship between the aorta and a pedicle screw. Accordingly, parameters describing the position of the aorta in these reports were not intuitive and surgeons have had difficulty utilizing these values in posterior surgery. The purpose of the present study was to evaluate the relative position of the aorta to the spine by new parameters, which can enhance the safety of pedicle screw placement.

Materials and methods

Thirty-seven patients with scoliosis underwent posterior instrumentation and fusion at the University Hospital from 2005 to 2007. Patients with congenital scoliosis were excluded. A total of 24 patients with a right thoracic curve were included in this study. Scoliosis was idiopathic in 17 patients, Chiari-syrinx in 2, Marfan syndrome in 2, multiple epiphyseal dysplasia in 1, Noonan syndrome in 1, and tuberous sclerosis in 1. Age at surgery was 10–29 (mean 17.1) years; 19 patients were women and 5 were men. Lenke's classification of scoliosis [4] was type 1 in eight patients, type 2 in five, type 3 in two, type 4 in four, type 5 in one, and type 6 in four. Preoperative Cobb angle averaged 66.4° (50°–103°). The apex vertebra ranged from T5 to T10 (median T10). All patients were treated by posterior correction and fusion by pedicle screw instrumentation. One patient with a curve of 103° had undergone anterior release before posterior spinal fusion. Computed tomography was taken before surgery and pedicle screws were placed with guidance of the CT-based navigation system. Postoperative Cobb angle averaged 20.3° (11°–39°).

A computer tomography was taken from the upper thoracic to the lower lumbar spine with a width of 1.25 mm for navigation. All DICOM data were transferred to a personal computer and analyzed by DICOM software (ExaView LITE: ©Ziosoft, Tokyo, Japan). We defined three parameters in a new Cartesian coordinate system and those parameters from T4 to L4 were measured in 293 vertebral bodies of 24 patients. We selected the middle of the base of the left superior facet as the origin of this coordinate system (Fig. 1), because the most probable threat to the aorta by a pedicle screw is on the left side at the thoracic spine. The transverse plane was determined to include both the bases of the superior facet and to be parallel to the upper endplate of the vertebral body. A line connecting the middle points of both bases of the superior facets is defined as the pedicular line (PL) (X -axis). The Y -axis perpendicular to the X -axis is drawn ventrally from the origin. The angle formed by the Y -axis and a line connecting the origin and the center of the aorta is defined as the left pedicle–aorta angle length of a line connecting the origin and the edge of the aorta as the left pedicle–aorta

distance, and distance from the edge of the aorta to the X -axis as the pedicular line–aorta distance. Moreover, we break down the left pedicle–aorta distance into the X - and Y -unit. The X -unit is the rectangular component of the left pedicle–aorta distance to the X -axis and the Y -unit is that to the Y -axis.

We simulated placement of the pedicle screw with a direction different from the ideal trajectory. Sensitivity analysis was performed by changing the direction error and the length of the screw independently. The direction error started from 10° up to 30° with 10° increments (three scenarios). The length of the screw started from 25 to 40 mm with increments of 5 mm (four scenarios). We set up a total of 12 scenarios (three by four). We defined a warning pedicle as that when the aorta enters the expected area of the screw. The ratio of warning pedicles was calculated from T4 to L4 in the 12 scenarios (Fig. 2). From the repeatability test from our previous study, interclass correlation coefficients were 0.922–0.957 in the intraobserver measurement and 0.896–0.929 (0.864–0.961) in the interobserver measurement [12].

To determine the relationship of the location of the aorta and the characteristics of scoliosis, the Cobb angle of the main thoracic curve, apical vertebral translations of the main thoracic curve, and the angle at T5–T12 in the sagittal plane were measured, and correlations between these

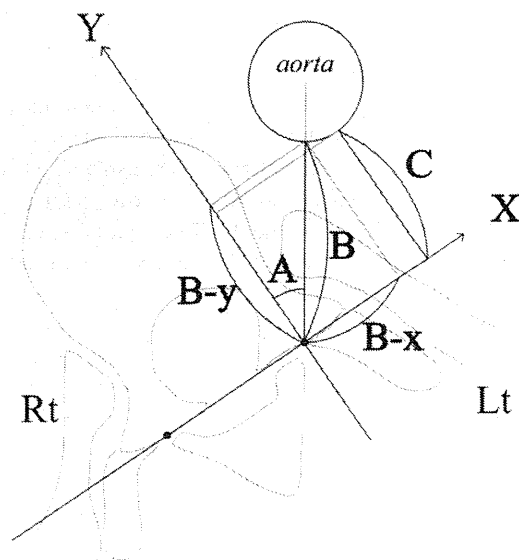


Fig. 1 Measurement of new parameters. The origin is set at the middle of the base of the left superior facet. A line joining the middle points of both bases of the superior facets is defined as the X -axis (the pedicular line). The Y -axis, perpendicular to the X -axis, is drawn ventrally from the origin. A The left pedicle–aorta angle. B The left pedicle–aorta distance. $B-x$ the X -unit of the left pedicle–aorta distance. $B-y$ the Y -unit of the left pedicle–aorta distance. C the pedicular line–aorta distance

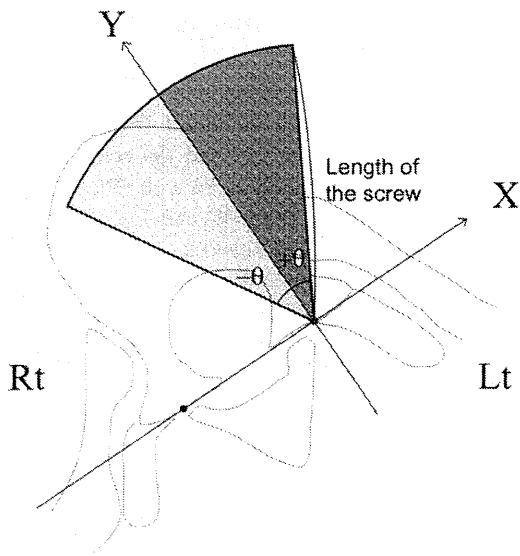


Fig. 2 The expected area of the pedicle screw. We simulated the pedicle screw placement with some direction error ($\pm\theta$) and the variable length (length of the screw) with sensitivity analysis. We defined a warning pedicle as that when the aorta enters this zone

parameters and the X-and Y-unit of the left pedicle–aorta line at the apex were calculated.

Results

The relative position of the aorta to the spine changed dramatically at the thoracic spine (Table 1; Fig. 3). The left pedicle–aorta angle spanned from -46° to 78° (average 29.7°) at the thoracic spine and from -38° to 13° (average -16.3°) at the lumbar spine; the left pedicle–

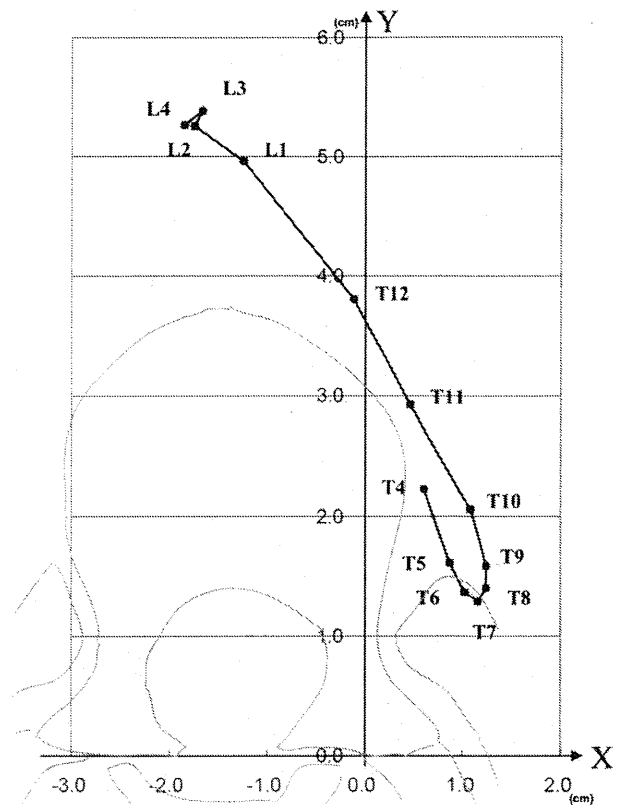


Fig. 3 The average course of the aorta relative to the spine. The origin is set at the middle of the base of the left superior facet. A line joining the middle points of both bases of the superior facets is defined as X-axis. The aorta begins to be seen from T4. It descends laterally and posteriorly and turns back at T7. At T12, the aorta is in front of the left pedicle and moves to the right side at the lumbar level. Attention should be paid to the spine drawn in the figure, because the size of the spine changed considerably at the level of the spine

Table 1 Distribution of the left pedicle–aorta angle, the left pedicle–aorta distance, and the pedicular line–aorta distance

	Left pedicle–aorta angle ($^\circ$)	Left pedicle–aorta distance (mm)	The pedicular line–aorta distance (mm)
T4	20.1 ± 22.7	24.5 ± 6.2	20.9 ± 9.7
T5	32.1 ± 20.3	19.4 ± 4.4	14.1 ± 8.5
T6	39.5 ± 17.3	17.8 ± 3.5	10.9 ± 7.2
T7	43.8 ± 13.6	17.6 ± 3.6	10.1 ± 6.3
T8	42.8 ± 11.9	19.0 ± 4.2	11.4 ± 6.5
T9	40.0 ± 12.8	20.6 ± 4.9	13.6 ± 7.2
T10	30.2 ± 15.1	24.0 ± 6.4	19.2 ± 8.6
T11	13.0 ± 19.9	31.5 ± 8.1	29.1 ± 11.0
T12	0.3 ± 15.6	39.3 ± 8.3	36.9 ± 8.4
L1	-12.9 ± 13.3	52.4 ± 7.1	48.3 ± 7.0
L2	-17.7 ± 10.3	56.2 ± 6.2	51.2 ± 5.2
L3	-16.9 ± 6.8	56.7 ± 5.4	52.9 ± 4.2
L4	-19.4 ± 5.0	56.0 ± 5.0	52.4 ± 7.4