の既往はない．T1/2 での骨化占拠率は 61％と高かった．また骨化巣に途絶を認め，同高位で頸椎前後屈時に可動性を有し，脊髄へのストレス増大の要因となっていた可能性がある．巨大な骨化巣による静的な脊髄圧排に加えこれらの動的因子が加わり，胸髄症の発症・増悪を招いたと考えられた．

本症例では G-CSF 投与による神経保護療法と胸頸椎後方除圧固定術により，臨床症状の著明な改善を認め，術式の選択を含めたわれわれの治療法[8] が有効であったことが示された．

結　語

頸椎 OPLL に対する椎弓形成術後に骨化が増大し手術を要した胸椎 OPLL の 1 例を経験した．上位胸椎で骨化が急速に増大した原因としては，糖尿病や肥満といったリスクファクターに加え，頸椎椎弓形成術によって頸椎前後屈可動域が減少したことで代償性に上位胸椎のメカニカルストレスが増大したためと考えられた．対策として，頸椎術前後の前後屈 X 線側面像を用いた脊椎アライメント変化の観察と定期的な CT 画像検査を行い，胸腰椎を含めた注意深い術後経過のフォローアップが不可欠であると考えられた．

（本論文の投稿に際し，患者に論文中に使用したデータや写真などすべての情報の掲載について説明し，同意を得ている．）

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〔症例〕

献腎移植後30年経過時に頸髄症に対して後方除圧固定術が施行された1例

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要　旨

症例は62歳男性。32歳時に献腎移植を受けた。53歳時に，頸椎症性脊髄症に対して自家腓骨を用いた前方除圧固定術（C2-C6），56歳時に第4腰椎変性辷り症に対して後側方固定術（L4-L5）が施行され，神経学的には順調に経過していた。61歳時頃から，移植腎の機能低下が顕著となった。62歳時，初回頸椎手術で偽関節となっていたC2-C3高位の不安定性が増し，脊髄圧迫が生じたため，四肢麻痺が急速に進行した。インストゥルメンテーションを併用した頸椎後方除圧固定術（C2-C7）が施行された。術中は腹臥位の体位で，移植腎が圧迫を受けないように注意を払い，超音波検査で腎血流を確認して手術を施行した。さらに，循環血液量の管理を慎重に行うことで，周術期の移植腎の機能低下を防止した。術後，偽関節部の骨癒合は得られ，麻痺も改善した。

Key words: 献腎移植，脊椎手術，移植腎機能

I．緒　言

本邦における腎移植件数は，2001年までは年間500～700件で推移してきたが，2002年以降増加傾向にある。2006年には1,000件を超え，以後，毎年約100件ずつ増加している[1]。しかし，腎移植後の脊椎手術に関するまとまった報告は少ない[2-4]。今回我々は，献腎移植後21年から30年の10年間に計3回の脊椎手術を受けた1例を経験したので報告する。

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Ⅱ．症　例

患者: 62歳男性

主訴: 立位不能および座位困難，両手巧緻運動障害

既往歴: 25歳時，慢性糸球体腎炎の診断を受け，腎不全にて31歳時から1年間，血液透析を受けた。32歳時に献腎移植を受け，以後，メチルプレドニゾロン8mg/日とアザチオプリン50mg/日の内服を続けている。25歳時から高血圧，49歳時から糖尿病にて内服治療を受けている。

第1回脊椎手術: 51歳頃から誘因なく両手の痺れ，両上肢近位筋の脱力，筋萎縮が出現した。画像所見では，頸椎の後弯変形およびC2-C3からC5-C6高位にかけての前方からの脊髄圧迫を認めた。筋萎縮を伴う頸椎症性脊髄症と診断され，術前の日本整形外科学会頸部脊髄症治療判定基準（日整会点数: 17点満点［上肢運動4点－肩肘機能障害2点，下肢運動4点，上肢感覚2点，体幹感覚2点，下肢感覚2点，膀胱機能3点］）は10/17（3-2, 4, 0.5, 1, 0.5, 3）点であった。53歳時（移植後21年目）に自家腓骨を用いた頸椎前方除圧固定術（C2-C6）が計画された。術前の血液・尿検査で，貧血および低アルブミン血症を認め，血清クレアチニン値は1.21mg/dL，クリアチニンクリアランスは38.8ml/minと，腎機能が軽度低下していた（表1）。手術は仰臥位で予定どおりに施行された。術中術後は，腎血流量が低下しないように，特に補液管理に注意を払い，周術期を通して移植腎の機能は安定していた。術後，両上肢筋力は回復し，日整会点数は12/17（3-1, 4, 1, 1, 1, 3）点に改善した。術後3ヵ月間ハローベストを装着したにもかかわらず，C2-C3高位が偽関節となった。偽関節の伴う頸髄症の再悪化が生じなかったため，外来で経過観察となった。

第2回脊椎手術: 55歳頃から腰背部痛，両下肢痛，歩行障害が出現し，増悪した。56歳時（移植後24年目），第4腰椎変性辷り症の診断にて，L4およびL5椎弓根スクリューを用いた腰椎後側方固定術（L4-L5）が計画された。術前の血液・尿検査では，血清クレアチニン値が1.35mg/dL，クリアチニンクリアランスが29.3ml/minと，前回の頸椎手術時に比して腎機能障害がやや進行していたが，手術は可能と判断した（表1）。手術は腹臥位で行われたが，移植腎が圧迫を受けないように，術中体位に注意を払った。さらに，術直前に腹臥位をとった段階で超音波検査にて移植腎の血流を測定し，腎血流が保たれていることを確認して手術を開始した。手術は予定どおりに行われ，周術期を通して腎機能障害の進行は認めなかった。術後，両下肢痛は軽快した。術後1年の画像所見で，両側L4-L5横突起間の骨癒合は完成していた。

現病歴: 腰椎手術後，神経学的には順調に経過していたが，59歳頃から歩行が不安定となり，徐々に増悪した。61歳（移植後29年目）頃から，血清クレアチニン値が1.60mg/dL前後と，移植腎の機能低下が顕著となった。今回の入院の2ヵ月前（62歳: 移植後30年目）から四肢の脱力が急激に進行し，歩行不能となったため，精査加療目的で当科入院となった。

入院時神経学的所見: 両上下肢の筋力低下を認

表1　腎移植後経過年数と血液・尿検査データ

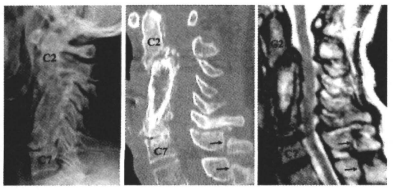
	第1回手術前	第2回手術前	第3回手術前	（正常値）
年齢（歳）	53	56	62	
腎移植後経過（年目）	21	24	30	
ヘモグロビン（g/dL）	13.0	13.0	7.0	（14.0～17.0）
アルブミン（g/dL）	3.5	3.4	2.7	（3.9～5.1）
血清クレアチニン（mg/dL）	1.21	1.35	1.70	（0.61～1.04）
クリアチニンクリアランス（ml/min）	38.8	29.3	14.0	（70～130）

め，特に両側の三角筋および上腕二頭筋の筋力は徒手筋力検査（MMT: 最大5）で，それぞれMMT＝1/5，2/5と著しく低下していた。立位が不可能であり，座位も困難であった。感覚障害としては，cervical line以下で1～3/10の痛覚鈍麻を認めた。糖尿病の影響で深部腱反射は上下肢ともに減弱していた。膀胱直腸障害は著しく，自排尿は困難であった。日整会点数は－0.5/17（0-2, 0, 0.5, 0.5, 0.5, 0）点であった。

入院時血液検査: 前回の腰椎手術時と比し，血中ヘモグロビン値が7.0g/dL，血清アルブミン値が2.7g/dLと貧血および低アルブミン血症が著しかった（表1）。血清クレアチニン値は1.70mg/dL，クリアチニンクリアランスは14.0ml/minであり，移植腎の機能は著しく低下していた（表1）。尿蛋白定性＋2と蛋白尿が顕著であり，胸水貯留を認めた。

入院時画像所見: 頸椎単純X線側面像で，移植骨はC2-C3高位で偽関節の状態であった（図1a）。前後屈機能撮影でC2-C3は不安定性を呈しており，前屈時に移植骨の後方への転位が著しかった。CT矢状断再構築像にてC2-C3高位での偽関節は明瞭であり（図1b），T2強調MRI矢状断像にて同部位での脊髄圧迫を認めた（図1c）。また，C7およびT1棘突起に疲労骨折の所見を認めた（図1b，c矢印）。

手術所見: 脊髄の除圧と頸椎安定性の獲得を目的として，頸椎後方除圧固定術（C2-C7）が計画されたが，問題点として，手術に伴う腎臓への負

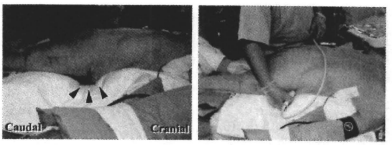


a　b　c

図1　入院時頸椎画像所見

（a）単純X線側面像，（b）CT正中矢状断再構築像，（c）T2強調MRI正中矢状断像

C2-C3高位は偽関節の状態。C2-C3高位で移植骨が後方に転位し，脊髄を圧迫。C7およびT1棘突起に疲労骨折の所見（矢印）。



a　b

図2　手術時体位

（a）移植腎に圧迫がかからないように右側には短い枕を使用。右下腹部に移植腎が存在（矢印）。（b）超音波検査にて移植腎の血流を測定。

担増により，移植腎機能の喪失，透析再導入のリスクが少なからず存在した。最終的には，インフォームド・コンセントの結果，本人の希望により手術が選択された。手術に際しては，腹臥位をとる段階で，腹圧減圧用の長枕が右下腹部に存在する移植腎を圧迫しないように注意を払った。右側に短い枕を使用することで，移植腎に圧迫がかからないことを確認した（図2a）。さらに，超音波検査にて移植腎の血流を測定し，血流が低下していないことを確認した（図2b）。

透視下にC2-C3高位の頸椎アライメントが整復位にあることを確認し，手術を開始した。後正中切開にて展開すると，C7およびT1の棘突起は偽関節の状態であった。C2ドーム状椎弓部分切除術，C3-C6観音開き式椎弓形成術にて後方除圧を行った。両側C2およびC7椎弓根スクリュー，C3-C5外側塊スクリューをアンカーとして後方固定を行った。Nesplon cableを用いてC7椎弓にsublaminar wiringを追加した。手術時間は6時間20分，術中の出血量は877gであった。術後，C2-C3高位の頸椎アライメントは改善し，MRIにて脊髄除圧が確認された。

術後経過: 術後に尿路感染を5回，IVHカテーテル感染を1回発症したが，抗生剤の投与（メロペネム1g/日を3日間，メロペネム1g/日を3日間，セフォペネム1g/日を1日間，メロペネム0.5g/日を3日間，リネゾリド1.2g/日を4日間）で軽快した。貧血，低アルブミン血症に対して，手術前後に頻回の輸血（赤血球濃厚液を術前に4単位，術中に4単位および術後に8単位）を行い，アルブミン製剤の投与を行った。しかしながら，ヘモグロビン値，アルブミン値を正常値ま

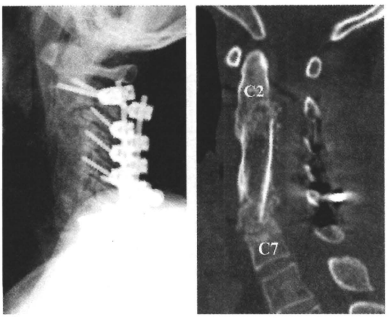


図3　術後1年時頸椎画像所見

(a) 単純X線側面像，(b) CT正中矢状断再構築像
頸椎アラインメントは良好。偽関節であったC2-C3高位に骨癒合の所見を認める。

で補正することはできず，術後も貧血，低アルブミン血症（術後55日目の血中ヘモグロビン値が8.6g/dL，血清アルブミン値が2.4g/dL）が持続した。術後2ヵ月間は血清クレアチニン値が1.7mg/dL前後と，移植腎のさらなる機能低下を防ぐことができた。しかし，その後もタンパク尿が持続した（術後5ヵ月目の尿蛋白定性＋2）。慢性拒絶腎症によると考えられる腎機能の悪化がしだいに進行し（術後6ヵ月目の血清クレアチニン値が4.3 g/dL），術後6ヵ月の時点で透析再導入となった。

術後1年の経過観察時の頸椎単純X線側面像では，頸椎アラインメントは良好に保たれており，スクリューの緩みも認めない（図3 a）。CT矢状断再構築像では，偽関節であったC2-C3高位に骨癒合が確認された（図3 b）。神経学的には四肢の筋力低下の改善を認め，両側の三角筋および上腕二頭筋の筋力は，それぞれMMT＝2/5，3/5となった。座位が可能となり，両手巧緻運動障害の改善を認めた。cervical line以下の痛覚鈍麻の程度が6/10となり，感覚障害の改善も認めた。

Ⅲ．考　察

腎移植後の脊椎手術については，1982年Dunnらが始めて報告を行い[5]，以後，安藤ら[2]，米田ら[3]，Yoonら[4]が報告を行っている。これらの報告では，移植から手術までの期間は，それぞれ平均11年，5年，6年であった。今回の症例のように，腎移植後30年という長期経過後に手術が施行された例の報告はこれまでになく，また，本例では頸椎手術2回，腰椎手術1回の合計3回の脊椎手術が施行されたが，このような複数回の脊椎手術例の報告もない。

Yoonらは，15年間に行われた腎移植例1974例を調査したところ，32例（1.6％）が移植後に脊椎手術を受けたと報告している[4]。この報告では，32例中21例が高血圧を，12例が糖尿病を，10例が冠動脈疾患を合併していた。また，頸椎前方手術が行われた1例では，移植骨の脱転とimplant failureが生じたために後方固定再手術が追加された。また，長期のステロイド内服に伴う骨粗鬆症が問題になると述べている[4]。安藤らは，腎移植後の7例の脊椎手術について検討し，問題点として，免疫抑制剤の使用による易感染性，貧血を指摘している[2]。また，腎不全悪化予防，感染予防，再透析導入回避を念頭において手術を行うべきとしている[2]。米田らは，腎移植後の6例の脊椎手術のうち，1例で術後感染が生じたと報告している[3]。

自験例においても，免疫抑制剤の長期使用が易感染性もたらしたと考えられ，周術期に複数回の尿路感染，IVH感染を発症した。また，初回の頸椎前方手術時の骨移植骨部位が偽関節となっており，C7・T1棘突起に疲労骨折を生じていた。ステロイドの長期投与により，骨粗鬆症が発症して易骨折性となり，さらに，骨折後の骨癒合過程が障害されることが報告されている[6]。本症例も長期間のステロイド使用の結果，骨癒合不全をきたし，易骨折性の状態にあったと考えられる。第2回目の腰椎手術および第3回目の頸椎手術では，椎弓根スクリューなどの脊椎インストゥルメンテーションを併用することで，骨癒合を得ることができた。本経験から，腎移植患者に対して脊椎固定術を行う際は，インストゥルメンテーション

の併用が骨癒合獲得のために有用と考えられる。

本症例の脊椎手術に際しては，腎不全の悪化防止に特に注意を払った。術中出血による急激な血圧低下，貧血によって移植腎の機能障害が進行する可能性があると報告されていることから[2]，我々は手術前後に頻回の輸血，アルブミン製剤の投与を行い，周術期の循環血液量の維持に努めた。また，第2回目の腰椎手術，第3回目の頸椎手術は腹臥位での手術であったため，体位によって移植腎が圧迫を受ける恐れがあった。我々は，超音波検査で移植腎の血流を測定することにより，体位によって移植腎の血流低下が生じていないという確証を得てから，手術を施行した。これまでに腎移植患者の腹臥位手術の報告はあるが[2-5]，超音波検査により移植腎の血流を確認した報告は，我々が渉猟しえた限り，本例が初である。本例では，第3回目の頸椎手術の直前には，移植腎の機能が著しく低下していた。しかし我々は，上述の対策を行うことにより，周術期に関しては，移植腎のさらなる機能低下を防止することができたと考えている。

小角らは，1978年から2008年までの30年間に大阪府で行われた献腎移植例447例を解析し，生着率は10年経過時で54.3%，15年で42.4%，20年で36.9%であったとしている[7]。また，移植腎機能喪失の原因の63.2%が慢性拒絶反応であったとしている[7]。本例のような移植後30年経過例の生着率については明記されていないが，これは献腎移植の初期の症例が対象になるために症例数が少なく，統計解析が充分に行えていないためと考えられる。移植後10年以降，生着率が経時的に急速に低下しているという小角らのデータから推測すると，30年経過時の生着率は相当に低くなっていると考えられる。本例では，第3回目の頸椎手術後6ヵ月の時点で，透析再導入となったが，手術の1年前頃から移植腎の機能低下が顕著となっており，手術直前には胸水貯留を合併するほどのネフローゼ症候群の状態に陥っていた。さらには，周術期には腎機能のさらなる低下は生じていなかった。本例の移植腎の機能喪失の原因に関しては，腎生検，病理検査は行っていないものの，上述の臨床経過から判断して，手術に伴う腎機能の低下の要素は少なく，いわゆる慢性拒絶腎症の進行によるものが主要因であったと推察する。

SUMMARY

A 62-year-old man was admitted to our institute with the complaint of severe paralysis of his bilateral upper and lower extremities. When he was 32 years old, he underwent a renal transplant from a deceased donor. At the age of 53 years, he underwent anterior decompression surgery and fusion with an autologous fibula strut at C2-C6 levels for the treatment of cervical spondylotic myelopathy. At the age of 56 years, posterolateral fusion at L4-L5 levels was performed to treat degenerative spondylolisthesis at L4. After the first and the second spine surgeries, he was neurologically improved. At the age of 62 years, instability at the C2-C3 level, where pseudoarthrosis had developed after the first spine surgery, increased, causing compression myelopathy. Posterior decompression with instrumented fusion was performed at C2-C7 levels. Intraoperatively, we were careful that prone positioning did not cause compression of the transplanted kidney. We confirmed the blood flow of the transplanted kidney using ultrasonography. We carefully controlled his circulating blood volume, such that the function of the transplanted kidney was maintained during the perioperative period. After surgery, bone union was obtained at the pseudoarthrosis site, and his paralysis was improved.

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THREE-YEARS RESUSTS OF CERVICAL DISC PROSTHESES IN THE SWISSSPINE REGISTY

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Background context: The Swiss federal office of public health required a mandatory nationwide HTA-registry for cervical total disc arthroplasty (TDA), amongst other technologies, to decide about reimbursement of these interventions.
Purpose: The goal of the SWISSspine registry is to generate evidence about the safety and efficiency of these medtech innovations.
Study design: Prospective multicenter observational case-series.
Patient sample: From 3.2005 until 3.2010 1,044 interventions with implantation of 1,201 discs from five different suppliers were performed.
Outcome measures: neck and arm pain levels, medication, segmental mobility, quality of life, work status, complication and revision rates.
Methods: Surgeon administered outcome instruments were primary intervention, implant and follow-up forms; patient self-reported measures were EQ-5D, COSS, and a comorbidity questionnaire. Data is recorded perioperative, at 3 months and 1 year postoperative, and annually thereafter.
Results: There was significant and clinically relevant reduction of neck (preop/postop 58.6/22.4 points) and arm pain (preop/postop 64.5/20.4) on VAS and a consequently decreased analgesics consumption. Similarly, quality of life improved from preop 0.43 to postop 0.84 points on EQ-5D scale. There were 6 intraoperative complications and 14 revisions during the same hospitalization for 887 monosegmental TDAs and 2 intraoperative complications and 8 revisions for 157 two-level surgeries. A pharmacologically treated depression was identified as important risk factor for achieving a clinically relevant pain alleviation >20 points on VAS. Two-level surgery resulted in similar outcomes compared with the monosegmental interventions.
Conclusions: Cervical TDA appeared as safe and efficacious in short-term pain alleviation, consequent reduction of pain killer consumption and in improvement of quality of life. A clinically relevant pain reduction of more than 20 points was most probable if patients had preoperative pain levels higher than or equal to 40 points on VAS. A pharmacologically treated depression and two-level surgery were identified as risk factors for less pronounced pain alleviation or quality of life improvement.

6
ANOMALOUS VERTEBRAL ARTERY AT THE EXTRAOSSEOUS AND INTRAOSSEOUS REGIONS OF THE CRANIOVERTEBRAL JUNCTION DETECTED BY 3-D CT ANGIOGRAPHY: ANALYSIS ON THE 100 CONSECUTIVE OPERATIVE CASES

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Objectives: To avoid intraoperative vertebral artery (VA) injury during instrumentation surgery at the craniovertebral junction (CVJ), we have preoperatively analyzed VA anomalies using 3-dimensional CT angiography (3DCTA).
Methods: We analyzed 100 consecutive patients who underwent instrumentation surgery since July 1998. Fifty-nine patients had atlanto-axial subluxation, and cervical fixation including C2 was required in 41 patients. Among the 100 patients, 28 had congenital skeletal anomaly (CSA) at the CVJ (CSA-positive cases) and the other 72 had no CSA. Anomalous VAs at the extraosseous and intraosseous regions were evaluated by 3DCTA.
Results: During operation, no neurovascular injury occurred. (1) Anomaly of extraosseous VA: Abnormal courses of the VA at the extraosseous region were detected in 11 cases (11.0%) out of the 100 cases: 2 had fenestration and 11 had persistent first intersegmental artery. In both anomalies, the VA entered the spinal canal at the caudal side of the C1 posterior. Intraoperatively, we determined the course of the abnormal branch of the VA using Doppler ultrasonography, and carefully exposed the operative site. Interestingly, all 11 cases with had CSA at the CVJ. When we focused on the 28 CSA-positive cases, 39.2% of them had such extraosseous VA anomalies. (2) Anomaly of intraosseous VA: In 29 cases (29.0% of 100 cases), the VA groove was located too medially, posteriorly, and cranially at the C2 isthmus (high-riding VA). Fourteen cases out of the 29 cases had CSA at the CVJ, indicating 50.0% of the 28 CSA-positive cases had high-riding VA.
Conclusions: The present findings suggest that the frequency of abnormal VA at the extraosseous and intraosseous regions is increased when patients have CSA at the CVJ. With preoperative 3DCTA, we can precisely identify the anomalous VA, and reduce the risk of intraoperative injury to the VA, in advance.

7
NEUROPROTECTIVE THERAPY USING GRANULOCYTE COLONY-STIMULATING FACTOR (G-CSF) FOR ACUTE SPINAL CORD INJURY: PHASE I, IIA CLINICAL TRIAL

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Background: Granulocyte colony-stimulating factor (G-CSF) is a 19.6-kDa glycoprotein that is commonly used to treat neutropenia. Several recent reports have indicated that G-CSF can be used as a potential drug for neuronal injury including stroke. So we thought G-CSF administration has neuroprotective effects for acute SCI, and examined in the compression-induced spinal cord in rodents. As a result, we have reported the mechanism of G-CSF for acute SCI; G-CSF mobilized bone marrow-derived cells into injured spinal cord, and suppressed the neuronal apoptosis directly (Brain Res 1149:223, 2007, J Neuropathol Exp Neurol 66:724, 2007). Because of these studies, we have started a Phase I and IIa clinical trial to assess the safety and feasibility of neuroprotective therapy using G-CSF for patients with acute SCI. In this study, we investigated the progresses of first 6 cases in acute SCI using G-CSF.
Materials and methods: Six patients with acute SCI were received intravenous G-CSF injection [5 g/(kg day)] for 5 days. After injection, we had neurological evaluations with American Spinal Cord Injury Association (ASIA) score, and confirmed side effects for medication with physical findings and laboratory data. In all six

patients, some neurological improvement was obtained after medication.
Results: In all six patients, some neurological improvement was obtained after medication in ASIA score. And in two of six patients, AIS was improved one step (B to C, and C to D). Mean white blood cell (WBC) counts were 10.6 ± 2.8 (103/l) previous the administration, on the other hand, 31.0 ± 5.3 (103/l) on 1 days after administration and that was significantly higher than previous counts ($p < 0.01$). From 1 to 5 days after the medication, during the administration, WBC counts kept higher than previous counts ($p < 0.01$), and 1 days after the end of medication, WBC counts returned to the previous rate. No severe adverse effects were seen in all patients after G-CSF injection.
Discussion: In acute myocardial infarction and cerebral infarction, clinical trials of G-CSF administration have been started and some studies showed the effect of improvements of function. We first started the neuroprotective therapy using G-CSF for acute spinal cord injury. The aim of this study is to confirm the safety and feasibility of G-CSF administration. After the confirmation, we will have the Phase IIb clinical trial that assesses the effect of G-CSF for acute SCI, and want to prove the effect of it.

SURGICAL SUCCESS AND FAILURE IN THE LUMBAR SPINE

8
IMPROVED QUALITY OF LIFE, PAIN, AND FUNCTION AFTER SPINAL FUSION IN CHRONIC LOW BACK PAIN ARE NOT DEPENDENT ON OPERATIVE TECHNIQUE

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Background: Despite being a widely accepted treatment for chronic low back pain (LBP) the published long-term-results of spinal fusion surgery with regard to different techniques are far from equivocal.
Patients and methods: A total number of 822 patients (461 female) with chronic LBP were followed prospectively within the Swedish National Spine Registry program after spinal fusion surgery. Functional parameters as SF-36 subscores and Oswestry Disability Index (ODI) were obtained preoperatively and after 2 years. Furthermore VAS for leg and back pain was determined. Quality of life was evaluated by EQ-5D.
Results: Sixty-four patients were operated with uninstrumented fusion (UIF), 380 patients with instrumented posterolateral fusion (PLF), and 378 patients with posterior or transforaminal lumbar interbody fusion (PLIF). Average leg pain improved in VAS from 45 to 27, back pain improved in VAS from 63 to 34. SF-36 MCS (Mental Component Score) improved from 33.7 to 39.0, SF36 Physical Component Score (PCS) from 36.2 to 45.4. ODI improved from 45.6 to 28.1. EQ5D improved from 0.33 to 0.61. A slightly greater improvement of ODI was seen in the PLIF-group of about 3 points compared to the PLF-group. No clinically relevant differences were seen between the outcome of the subgroups.
Conclusion: The presented results are in line with the results known from previously performed multicenter trials, that fusion surgery does improve function, pain and quality of life of patients with chronic LBP. Interestingly in the investigated patient cohort operative fusion technique does not seem to have a significant impact on patient outcome.

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A LONG TERM CLINICAL EXPERIENCE WITH THREE DIFFERENT NUCLEUS REPLACEMENT DEVICES: LESSONS LEARNED AFTER 9 YEARS FOLLOW UP

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Introduction: The nucleus replacement devices have been developed for treating moderate forms of degenerative disc disease, trying to fill the gap between discectomy and fusion. The surgical goals are pain relief, maintenance of the disc height and flexibility at the index and adjacent levels.
Purpose: The purpose of the present abstract is to show our experience after 9 years using three different nucleus replacement prostheses.
Study design/setting: Prospective, non randomized, single center clinical study.
Patient sample: 125 patients with moderate forms of degenerative disc disease were enrolled in this study.
Outcome measures: Radiographic (AP, lateral and dynamic) and clinical outcomes were collected preoperatively, 1 week and 1, 3, 6, 9, and annually through 9 years postoperatively. The VAS and ODI questionnaires were used to assess pain and functional outcomes.
Material and methods: 80 patients had PDN disc prosthesis, 26 patients with PNR (Trans1) and 19 patients using the NUBAC (Pioneer) device. The surgical techniques for each device were performed following the prosthesis indications.
Results: After 9 years follow up, the global retrieval incidence was 48.8% (61/125). From these patients, 15 (57.7% of the specific device) had PNR failures, 8 (42.1% of the specific device) experienced NUBAC retrievals and 38 (47.5% of the specific device) had PDN flaws. The failures included significant loosening of the disc height at the operated level, displacement, silicon inside de canal and migration. All patients underwent fusion as a retrieval surgery.
Conclusion: The retrieval rate in our series is very high. It shows that the end-plate reaction in a long period of time happens, resulting in important subsidence and mechanic back pain. The device expulsion was another cause of pain and second surgery, as shown in the literature.

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A FULL ECONOMIC EVALUATION OF DISC PROSTHESIS VS. LUMBAR FUSION IN PATIENTS WITH CHRONIC LOW BACK PAIN: A RANDOMIZED CONTROLLED TRIAL WITH 2-YEAR FOLLOW UP

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Background: Patients with chronic low back pain may in selected cases be treated with surgery. The gold standard today is lumbar

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C5 PALSY FOLLOWING ANTERIOR DECOMPRESSION AND SPINAL FUSION FOR CERVICAL DEGENERATIVE DISEASES

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Backgrounds: Postoperative C5 palsy is a common complication after cervical spine decompression surgery. However, the incidence, prognosis, and etiology of C5 palsy after anterior decompression with spinal fusion (ASF) have not yet been fully established.
Purpose: The purpose of the present study was to analyze the clinical and radiological characteristics of patients who developed C5 palsy after ASF for cervical degenerative diseases, and to discuss the mechanism of development of this disorder.
Study design: Clinical case series.
Patient sample: Between 1996 and 2004, a total of 199 consecutive patients who underwent ASF were analyzed to clarify the incidence of postoperative C5 palsy.
Outcome measures and methods: We defined C5 palsy as when patients showed a deterioration in muscle power of the deltoid or biceps by at least 1 grade in the manual muscle test (MMT) without aggravation of lower extremity function. The Japanese Orthopaedic Association (JOA) score was used to evaluate the severity of myelopathy. We evaluated the onset and prognosis of C5 palsy. The presence of high signal changes (HSCs) in the spinal cord was analyzed using T2-weighted magnetic resonance images.
Results: C5 palsy occurred in 17 patients (8.5%), and in 15 of them, the palsy developed after ASF of 3 or more levels. Among 10 patients who had a manual muscle test (MMT) grade 2 at the onset, 5 patients showed incomplete or no recovery. Sixteen of the 17 C5 palsy patients presented neck and shoulder pain prior to the onset of muscle weakness. All of the 17 patients showed a recovery from their myelopathy. Their extent of recovery ranged from 27.6% to 100% (average 71.2%). In the 10 patients with a MMT grade 2 at the onset, 9 patients showed HSCs at the C3–C4 and C4–C5 levels.
Discussion: The present findings demonstrate that, in most patients with severe C5 palsy after ASF, pre-existing asymptomatic damage of the anterior horn cells at C3–C4 and C4–C5 levels may participate in the development of motor weakness in combination with the nerve root lesions that occur subsequent to ASF.
Conclusion: When patients with spinal cord lesions at C3–C4 and C4–C5 levels undergo multilevel ASF, we should be alert to the possible occurrence of postoperative C5 palsy.

SPECIAL POSTER PRESENTATIONS, EUROSPINE 2010

ADULT THORACOLUMBAR SPINE NON-DEGENERATIVE: SERIOUS SPINE DISORDERS, ASSESSMENT AND SURGICAL TREATMENTS

SP1
METASTASES TO THE SPINE EVALUATION OF POSTERIOR VERSUS ANTERO-POSTERIOR TREATMENT WITH REGARD TO FRANKEL-SCORE

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Purpose: The spine is the most common site of bone metastases. Approximately 20,000 patients per year require treatment of symptoms related to spinal cord compression. Restoring stability and securing of neurological structures is the goal of surgery in these cases. Although exact statistics are not available, it is estimated that spinal metastases will eventually develop in approximately 40% of all patients who have cancer. Thus, further data has to be acquired and analyzed to provide a basis for deciding the course of treatment. The purpose of the present study was to evaluate which operation technique (posterior vs. antero-posterior) most reliably restored neurological integrity.
Methods: Between February 1998 and April 2009 101 patients (62 male, 39 female) with a mean age at operation of 63 years (median 63, range 27–87 years) were treated for metastases to the spine. The most frequent site of metastasis was the thoracic spine (60 cases), followed by the lumbar (23) and cervical spine (16). Given that indications for surgery are based on dislocation and neurological symptoms, we want to compare changes in Frankel-Score and individual survival rates to demonstrate differences after posterior vs. anterior-posterior stabilization.
Results: Forty-three patients were still alive as of February 2010 with a maximum follow-up of 7.8 years. All other patients died after a

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NEUROPROTECTIVE THERAPY USING GRANULOCYTE-COLONY STIMULATING FACTOR FOR PATIENTS WITH RAPIDLY AGGRAVATING COMPRESSION MYELOPATHY: PHASE I AND IIA CLINICAL TRIAL

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Background: Rapidly aggravating compressive myelopathy results in severe neurological deficit, and its functional recovery is quite poor due to limited axonal regeneration. To date, there has been no effective therapy except for early surgical treatment. In previous reports, we have shown that granulocyte-colony stimulating factor (G-CSF), one of hematopoietic growth factors, has neuroprotective effects on experimental spinal cord injury (SCI) [Brain Res 1149: 223–231, 2007, J Neuropathol Exp Neurol 66: 724–731, 2007]. Based on the results, we have started a phase I and IIa clinical trial that evaluates the safety of neuroprotective therapy using G-CSF for patients with rapidly aggravating compression myelopathy.
Purpose: In the present study, we evaluate the results of the first stage cases of the G-CSF clinical trial.
Study design: Clinical case series
Patient sample: The trial was performed in five patients, in whom the Japanese Orthopaedic Association (JOA) score for cervical myelopathy decreased 2 points or more during a recent 1-month period.
Outcome measures: We evaluated the presence of diverse events that related to the G-CSF therapy. We also evaluated motor and sensory functions of the patients.
Methods: After obtaining informed consent from the patients, G-CSF (5 μg/kg/day) was intravenously administrated for five consecutive days. We evaluated the patients' American Spinal Injury Association (ASIA) score, ASIA impairment scale, and JOA score. In addition, we performed blood and urinary test of the patients.
Results: All five patients enrolled in this study exhibited myelopathy caused by ossification of posterior longitudinal ligament of the spine. In all of the five patients, neurological improvement of both motor and sensory functions was obtained, though the degree of the improvement differed depending on the patient. On the day following the start of G-CSF therapy, white blood cell (WBC) count increased more than 15,200. It was maintained from 15,200 to 43,200 during the administration, and returned to preadministration levels by the third day after the final administration. No adverse event occurred during or after the administration.
Discussion and conclusion: In the present clinical trial, no serious side effect occurred, indicating that this low-dose G-CSF administration is principally safe. In addition, a certain neurological recovery was obtained in all the patients even after the low-dose administration, suggesting that G-CSF is an attractive candidate for therapeutic drug for damaged spinal cord. Further clinical trials with high-dose administration of G-CSF (10 g/kg/day) will be required to establish the G-CSF therapy for patients with rapidly aggravating compression myelopathy.

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EFFECT OF MULTILEVEL LUMBAR DISC ARTHROPLASTY ON SPINE KINEMATICS AND FACET JOINT LOADS IN FLEXION AND EXTENSION: A FINITE ELEMENT ANALYSIS

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Total disc arthroplasty (TDA) has been successfully used for monosegmental treatment in the last few years. However, multi-level TDA led to controversial clinical results. We hypothesize that: (1) the more artificial discs are implanted, the stronger the increases in spinal mobility and facet joint forces in flexion and extension; (2) deviations from the optimal implant position lead to strong instabilities.

A three-dimensional finite element model of the intact L1–L5 human lumbar spine was created. Additionally, models of the L1–L5 region implanted with multiple Charité discs ranging from two to four-levels were created. The models took into account possible misalignments in the antero-posterior direction of the artificial discs. All these models were exposed to an axial compression preload of 500 N and pure moments of 7.5 Nm in flexion and extension.

For central implant positions and the loading case extension, a motion increase of 51% for two implants up to 91% for four implants and a facet force increase of 24% for two implants up to 38% for four implants compared to the intact spine were calculated. In flexion, a motion decrease of 5% for two implants up to 8% for four implants was predicted. Posteriorly placed implants led to a better representation of the intact spine motion. However, lift-off phenomena between the core and the implant endplates were observed in some extension simulations in which the artificial discs were anteriorly or posteriorly implanted.

The more artificial discs are implanted, the stronger the motion increase in flexion and extension was predicted with respect to the intact condition. Deviations from the optimal implant position lead to unfavorable kinematics, to high facet joint forces and even to lift-off phenomena. Therefore, multilevel TDA should, if at all, only be performed in appropriate patients with good muscular conditions and by surgeons that can ensure optimal implant positions.

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A NEW IN VITRO BIOMECHANICAL TEST SYSTEM TO EVALUATE ADJACENT LEVEL EFFECTS OF THE LUMBAR SPINE

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The in vitro testing of new surgical reconstruction or stabilization methods provides essential findings for clinical use on biomechanics

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Paper #56

Neuroprotective Therapy using Granulocyte Colony-Stimulating Factor (G-CSF) for Acute Spinal Cord Injury: A Phase I and IIa Clinical Trial

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Introduction: Granulocyte colony-stimulating factor (G-CSF) is a 19.6 kDa glycoprotein and an important cytokine that is commonly used to treat neutropenia. Several reports have indicated that G-CSF also has non-hematopoietic functions and could potentially be used as a drug for neuronal injury, including stroke and neurodegenerative disease. Thus, we hypothesized that administration of G-CSF might have neuroprotective effects for acute spinal cord injury (SCI), and examined its effect using compression-induced spinal cord injury models in rodents. We previously reported that G-CSF mobilized bone marrow-derived cells into the injured spinal cord, and directly suppressed neuronal apoptosis (Brain Res 1149:223, 2007, J Neuropathol Exp Neurol 66:724, 2007). Based on those results, we have started a phase I and IIa clinical trial to assess the safety and feasibility of neuroprotective therapy using G-CSF for patients with acute SCI. The aim of the present study was to confirm the safety and feasibility of G-CSF administration for acute SCI.

Methods: The trial was performed in a total of 17 SCI patients within 48 hours of onset. Informed consent was obtained from all patients. In the first step, G-CSF (5 μg/kg/day) was intravenously administered for five consecutive days to five patients (5 μg group). In the second step, G-CSF (10 μg/kg/day) was similarly administered to 12 patients (10 μg group). We evaluated the presence of adverse events related to the G-CSF therapy. We also evaluated motor and sensory functions of the patients using American Spinal Cord Injury Association (ASIA) score and ASIA impairment scale (AIS).

Results: In all 17 patients, neurological improvement was obtained after G-CSF administration. AIS increased one step in 8 of 17 patients. A significant increase of ASIA motor score was detected one day after the injection ($p<0.01$), and both light touch and pin prick scores improved three days after the injection ($p<0.05$). Mean white blood cell (WBC) counts rose to 28.6 ± 3.2 ($\times 10^3/\mu L$) in the 5 μg group and 25.9 ± 6.1 in x 10 μg group one day following the start of G-CSF therapy. During the administration, WBC counts remained at higher levels than those observed before administration ($p<0.01$). Three days after the final administration, WBC counts returned to the pre-administration levels. No adverse effects were seen after G-CSF injection.

Conclusion: We have initiated a clinical trial of neuroprotective therapy using G-CSF for acute SCI. The results indicate that low to moderate doses of G-CSF are essentially safe and a degree of neurological recovery was obtained in all patients. We suggest that G-CSF could be a therapeutic drug for injured spinal cord.

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Paper #63

C5 Palsy Following Anterior Decompression and Spinal Fusion for Cervical Myelopathy

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Introduction: Postoperative C5 palsy is a common complication after cervical spine decompression surgery. Previous reports have indicated that C5 palsy occurs not only after posterior cervical decompression surgery, such as laminoplasty, but also after anterior surgery. However, the incidence, prognosis, and etiology of C5 palsy after anterior decompression with spinal fusion (ASF) have not yet been fully established.

Purpose: The purpose of the present study was to investigate the clinical and radiological characteristics of patients who developed C5 palsy after ASF for cervical degenerative diseases, and discuss the mechanism of development of this disorder.

Methods: Between 1996 and 2004, a total of 199 consecutive patients who underwent ASF was analyzed to elucidate the incidence of postoperative C5 palsy. We defined C5 palsy as when patients showed a deterioration in muscle power of the deltoid or biceps brachii by at least 1 grade in the manual muscle test (MMT) without aggravation of lower extremity function. The Japanese Orthopaedic Association (JOA) score was used to evaluate the severity of myelopathy. We evaluated the onset and prognosis of C5 palsy. The presence of high signal changes (HSCs) in the spinal cord was analyzed using T2-weighted magnetic resonance images.

Results: C5 palsy occurred in 17 patients (8.5%), and in 15 of them, the palsy developed after ASF of 3 or more levels. In cervical spondylotic myelopathy cases, 9 of 113 patients (7.9%) developed C5 palsy. Similarly 6 of 62 (9.7%) ossification of posterior longitudinal ligament patients and 2 of 16 (12.5%) cervical spondylotic amyotrophy patients developed C5 palsy. No patients with cervical spondylotic radiculopathy and disc herniation developed C5 palsy. All of the 17 C5 palsy patients showed a recovery from their myelopathy. Their recovery rate of JOA score ranged from 27.6% to 100% (average: 71.2%). Sixteen of the 17 C5 palsy patients had radiating neck and shoulder pain prior to the onset of muscle weakness. Pain was recognized 1-7 days (average 3.6 days) after surgery. Muscle weakness developed 2-23 days (average 7.2 days) after surgery. Twelve patients completely recovered from their C5 palsy.

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Paper #63 (cont.)

However, the recovery was incomplete in 3 patients, and 2 patients with OPLL showed no recovery. All 7 patients who had an MMT grade ≧3 at the onset of their C5 palsy showed full recovery. Among the 10 patients who had a manual muscle test (MMT) grade≦2 at the onset, 5 patients showed incomplete or no recovery, and 9 patients showed HSCs at the C3 – C4 and C4 – C5 levels on T2 weighted MR images.

Discussion: The present findings demonstrate that, in most patients with severe C5 palsy after ASF, pre-existing asymptomatic damage of the anterior horn cells at C3 – C4 and C4 – C5 levels may participate in the development of motor weakness in combination with the nerve root lesions that occur subsequent to ASF.

Conclusion: When patients with spinal cord lesions at C3 – C4 and C4 – C5 levels undergo multilevel ASF, we should be alert to the possible occurrence of postoperative C5 palsy.

Neuroprotective Therapy using Granulocyte-Colony Stimulating Factor for Rapidly Aggravating Compression Myelopathy: A Phase I and IIa Clinical Trial

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Introduction: We have undertaken a Phase I and IIa clinical trial that evaluates the safety of neuroprotective therapy using granulocyte-colony stimulating factor (G-CSF) for patients with rapidly aggravating compression myelopathy.

Methods: At the first stage of this trial, we confirmed the safety of administering G-CSF at 5 μg/kg/day. In the present study, the second stage of this trial, we investigated the administration of G-CSF at 10 μg/kg/day. The trial was performed in twelve patients in whom the Japanese Orthopaedic Association score for cervical myelopathy decreased two points or more during a recent one month period. After obtaining informed consent from the patients, G-CSF (10 μg/kg/day) was intravenously administered for five consecutive days. We evaluated the presence of adverse events related to G-CSF therapy. We also evaluated motor and sensory functions of the patients.

Conclusion: In all twelve patients, neurological improvement of both motor and sensory functions was obtained, though the degree of the improvement differed among the patients. The mean American Spinal Injury Association score before G-CSF administration was 91 points for motor function, 92 for soft touch and 88 for pin prick. One month after completing administration, the mean score improved to 98 points for motor function, 99 for soft touch and 100 for pin prick. On the day following the start of G-CSF therapy, the mean white blood cell count increased to more than $22.7 \times 10^3/\mu L$. It stabilized between 22.7 and $47.3 \times 10^3/\mu L$ during administration, and returned to preadministration levels by the third day after the final administration. No adverse event occurred during or after the administration.

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- **Quantitative Assessment of Cervical Myelopathy by a Hand Function Test**

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Introduction: Clumsy hand is one of the common symptoms in cervical myelopathy. The purposes of this study are to examine postoperative recovery of upper extremity function after laminoplasty by determining clumsiness using a simple test for evaluating hand functions (STEF) and to show which patients attain high STEF scores after surgery.

Methods: A total of 104 patients who underwent laminoplasty were examined in this study. The hand function test (STEF) was performed according to Kaneko and Muraki's previously published method (Figure 1). The STEF score is the sum of 10 subtest scores. Before surgery, all patients were tested and received a STEF score (before), JOA scoring systems especially for upper extremity motor function (JOA (u/m)), grip and release (10-second test), deltoid muscle weakness (estimated manual muscle test), and grasping power. The STEF was administered 1 week (STEF (1w)), 3 months (STEF (3m)) and 6 months after surgery (STEF (f/u)) repeatedly. Patient history of traumatic tetra paresis (trauma) and diabetes mellitus (DM) was confirmed. Differences between STEF (before), STEF (1w), STEF (3m) and STEF (f/u) were tested with the Friedman repeated measures analysis of variance on ranks. Multiple linear regression was performed to explore the determinants of post-operative recovery. Plausible predictors (age, trauma, DM, JOA (u/m), 10-second test, grasping power, and STEF (before)) were included in the original model. Best subset regression was performed and the final regression model was selected according to Akaike's Information Criterion.

Results: STEF (f/u) improved significantly after surgery (Figure 2). All the odds ratios (ORs) are presented with 95% confidence intervals (CIs). The final linear regression model included age ($P = 0.03$), STEF (before) ($P < 0.01$), trauma ($P = 0.02$), DM ($P = 0.04$), 10-second test ($P < 0.01$), and JOA (u/m) ($P = 0.04$) as significant variables influencing STEF (f/u). Compared with patients with no history of trauma, the OR for those who had a history of trauma was 0.01 (95% CI, 0.84×10^{-4}–0.43). Also, compared with patients with no history of DM, the OR for those who had that history was 0.04 (95% CI, 0.18×10^{-2}–0.89).

Conclusion: STEF scores in most myelopathy patients improved after surgery. However, some patients' scores did not improve. This finding indicates that irreversible damage of the spinal cord before decompression surgery might affect the recovery process. STEF is a useful tool for monitoring upper extremity function in cervical myelopathy. A history of trauma and DM in myelopathy patients may greatly influence their recovery after surgery. This study provides an improved understanding of the recovery from myelopathy after decompression surgery.

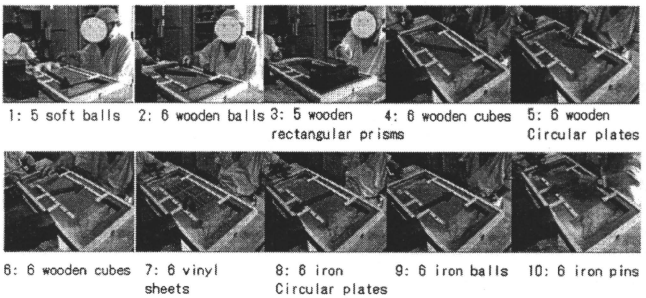

Figure 1. Simple Test for Evaluating Hand Function (STEF). The battery consists of 10 subtests, and 10 points (1 to 10) are awarded for each subtest. The left and right hands were evaluated separately.

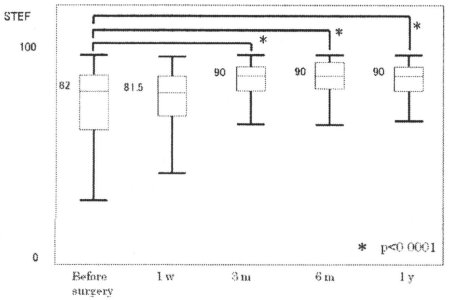

Figure 2. Time course of STEF score after surgery

Anomalous Vertebral Artery at the Extraosseous and Intraosseous Regions of the Craniovertebral Junction Detected by 3-D CT Angiography: Analysis on the 100 Consecutive Operative Cases

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Objectives: To avoid intraoperative vertebral artery (VA) injury during instrumentation surgery at the craniovertebral junction (CVJ), we have preoperatively analyzed VA anomalies using 3-dimensional CT angiography (3DCTA).

Methods: We analyzed 100 consecutive patients who underwent instrumentation surgery since July 1998 through January 2009. Fifty-nine patients had atlanto-axial subluxation, and cervical fixation including C2 was required in 41 patients. Among the 100 patients, 28 had congenital skeletal anomaly (CSA) at the CVJ (CSA-positive cases) and the other 72 had no CSA (CSA-negative cases). Anomalous VAs at the extraosseous and intraosseous regions were evaluated by 3DCTA. Fisher exact probability test was applied for statistical analysis between CSA-positive and CSA-negative cases.

Results: During surgery, no neurovascular injury occurred. **(1) Anomalous VA at extraosseous region**: Abnormal courses of the VA at the extraosseous region were detected in 11 cases (11.0%) out of the 100 cases: 2 had fenestration and 9 had persistent first intersegmental artery. In both anomalies, the VA entered the spinal canal at the caudal side of the C1 posterior. Intraoperatively, we determined the course of the abnormal branch of the VA using Doppler ultrasonography, and carefully exposed the operative site. Interestingly, all 11 cases with had CSA at the CVJ. When we focused on the 28 CSA-positive cases, 39.2% of them had such extraosseous VA anomalies ($p<0.01$). **(2) High-riding VA:** In 29 cases (29.0%), VA groove was located too medially, posteriorly, and cranially at the C2 isthmus. Fourteen cases out of the 29 cases had CSA at the CVJ, indicating 50.0% of the 28 CSA-positive cases had high-riding VA ($p<0.01$). **(3) Side-to-side asymmetry:** In 26 cases (26.0%), lumen diameter of VA on one side was more than twice than that of the other side. Eight cases out of the 26 cases had CSA at the CVJ, indicating 28.6% of the 28 CSA-positive cases had high-riding VA ($p=0.79$). **(4) Cases in whom screw placement was scheduled:** Before surgery, the placement of C1-2 transarticular screw in 39 cases (78 sides). After the 3DCTA analysis, however, we decided not to insert the screw in 14 cases (18 sides); 23.1% of the planned screws were not inserted. Similarly, the placement of C2 pedicle screw was scheduled in 58 cases (116 sides). At surgery, however, the screw was not inserted in 19 cases (27 sides); 23.3% of the planned screws were not inserted.

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Conclusions: The present findings suggest that the frequency of abnormal VA at the extraosseous and intraosseous regions, i.e., persistent first intersegmental artery, fenestration and high-riding VA, is increased when patients have CSA at the CVJ. With preoperative 3DCTA, we can precisely identify the anomalous VA, and reduce the risk of intraoperative injury to the VA, in advance.