

## ABSTRACTS OF PAPERS

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## SAMENVATTINGEN VAN DE UITEENZETTINGEN

voorgesteld aan het Jaarlijks Symposium van de KBVR, op 19 november 2011

## RESUMES DES COMMUNICATIONS

présentées lors du Symposium Annuel de la SRBR, le 19 novembre 2011

### Percutaneous pedicle screw implantation: en route to fully robotic intraoperative 2D/3D fluoroscopy

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#### Introduction

When dealing with chronic low back pain refractory to medical treatments (LBPR), spine stabilization can be a very effective option. This surgical strategy requires most of the time implantation of pedicle screws (1, 5) which can be performed through either a large open posterior approach, or tubular approaches (minimal open) or even percutaneously (minimally invasive percutaneous) (2, 3, 6). A precise placement of these screws is paramount in particular to avoid any additional nerve root lesion. Working percutaneously reduces the aggression on the patient's muscular system but increases the difficulty of being intrapedicular. Percutaneous surgery requires improved intraoperative imaging quality control. Our use of *percutaneously placed pedicle screws (PPS)*, led us to test different intraoperative imaging systems reaching a climax of efficiency with the robotic multi-axis 2D/3D fluoroscopy Artis Zeego of Siemens. We report our experience using this system for PPS placement in the treatment of LBPR.

#### Population and method

Our first 24 patients showed a mean age of 59 years. One hundred and six PPS were implanted using the Viper 2 fixation system (DePuy Spine, Johnson & Johnson, Arlington, USA) associated when necessary with a TLIF (transforaminal lumbar interbody fusion) procedure (84%) or a posterior lumbar fusion procedure.

For complex scoliotic cases, we introduced the data of a preopera-



Fig. 1

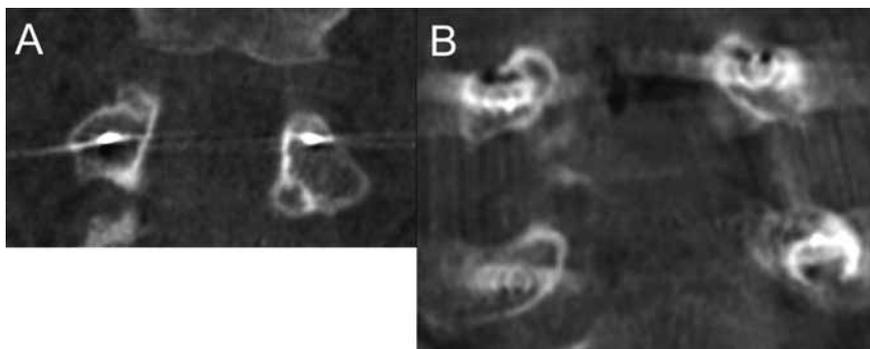


Fig. 2

tive CT into our Dextroscope system (Volumes Interactions, Bracco, Singapore) (4). This system gives surgeons a preoperative virtual 3D view of the treated lumbar spine and helps the surgeon to better plan the surgical procedure.

The intraoperative imaging system is an Artis Zeego characterized by the combination of robotic multi-axis C-arm fluoroscopy and a translucent robotic table (Fig. 1). The different memorized positions can

be repeated as often as necessary, and the quality of the 3D sequences is near to a CT.

The surgical process, using the Viper system (DePuy Spine, Johnson & Johnson, Arlington, USA) is characterized by nine consecutive steps described elsewhere (Raftopoulos et al, Adv Tech Stand Neurosurg, in press).

To check the PPS accuracy using the Zeego, each patient had a control CT postoperatively. To quantify the

severity of the PPS pedicle breach, we used a scale of four grades (7): Grade 0, no pedicle breach; grade I, a breach less than two mm; grade II, a breach between two and four mm and, grade III, a breach of more than four mm.

## Results

One hundred and six consecutive PPS were implanted. Pedicle breaches were checked at the two main stages of the surgical procedure (Fig. 2). The rate of guide-wire pedicle breaches was very low (5.7%). All the misplaced wires were corrected. The rate of PPS pedicle breach disclosed by the i3DF was 11.4%. Only five PPS, were relocated. The postoperative CTs disclosed a percentage of PPS pedicle breaches of 4.7%, with all the breaching PPS of grade I except for one grade II and two grade III (lateral breaches, asymptomatic). This series was characterised by the absence of surgical nerve root injuries, surgical revision and other complications.

## Conclusion

Placing PPS under control of i3DF images allows to significantly reducing the rate of PPS pedicle breach (4.7% instead of 14.2%) with a most stable osteosynthesis possible and a minimal risk of complication.

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### MR imaging of the spinal bone marrow : age patterns and normal variants

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### Imaging of the degenerative lumbar spine : a pattern-based approach

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### Spinal dysraphisms

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**Learning objectives:** To identify the neuroradiological appearance of spinal dysraphisms, to correlate such features with a corresponding embryologic derangement, and to be able to use a clinical-neuroradiological classification scheme in the everyday clinical practice.

**Embryology and classification:** Spinal cord development occurs through three consecutive periods: (i) *gastrulation* (2<sup>nd</sup> gestational week): the embryonic disk is converted from a bilaminar into a trilaminar arrangement, with formation of the intervening mesoderm; the notochord is laid down along the midline, identifying the craniocaudal embryonic axis; (ii) *primary neurulation* (18<sup>th</sup>-27<sup>th</sup> day): under the induction of the notochord, the midline ectoderm specializes into neural ectoderm. The initially flat neural plate progressively bends and folds until it fuses in the midline to form the neural tube. The primary neural tube produces the uppermost 9/10 of spinal cord; (iii) *secondary neurulation* (28<sup>th</sup>-48<sup>th</sup> day): a secondary neural tube is laid down caudad to the termination of the primary neural tube. Retrogressive differentiation of the secondary neural tube results in the tip of the conus medullaris and filum terminale.

Defects in one of these three embryological steps produce *spinal dysraphisms*, characterized by anomalous differentiation and fusion of dorsal midline structures. Spinal dysraphisms may be categorized clinically in two subsets: open and closed spinal dysraphisms.

**Open spinal dysraphisms:** In open spinal dysraphisms (OSD) the placode (non-neurulated neural tissue) is exposed to the environment through a cutaneous defect along the child's back. OSD include myelomeningocele, myelocele, hemimyelomeningocele and hemimyelocele, and are always associated with a Chiari II malformation. Myelomeningocele is by far the most common of these forms; the placode protrudes through a posterior defect and is elevated above the skin surface due to concurrent dilatation of the subarachnoid spaces.

**Closed spinal dysraphisms:** Closed spinal dysraphisms (CSD) are covered by intact skin, although cutaneous stigmata usually belie their presence. Two subsets may be identified based on whether a subcutaneous mass is present. *CSD with tumefaction* comprise lipomas with dural defect (lipomyelocele and lipomyelomeningocele), meningocele, and myelocystocele. Lipomas with dural defect are more common; they are differentiated with one another based on the position of the placode-lipoma interface, that lies within the spinal canal in lipomyelocele, and outside the spinal canal (ie, into a meningocele) in lipomyelomeningocele. *CSD without tumefaction* comprise complex dysraphic states (ranging from complete dorsal enteric fistula to neurenteric cysts, diastematomyelia, dermal sinuses, caudal agenesis, and spinal segmental dysgenesis), bony spina bifida, tight filum terminale, filar and intradural lipomas, and persisting terminal ventricle. The most complicated forms (*complex dysraphic states*), including diastematomyelia, caudal regression, and segmental spinal dysgenesis) are related to faulty gastrulation. Diastematomyelia (literally, split cord) is caused by failure of midline notochordal integration, resulting into two heminochords that induce two separate hemineural plates. Caudal agenesis and segmental spinal dysgenesis are related to defective notochordal formation, characterized by absence or hypoplasia of a segment of the notochord, in turn resulting into absence or hypoplasia of a corresponding segment of the spinal cord.

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### Imaging evaluation of the child with back pain

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Back pain is quite uncommon in children under 10 years of age but is frequently reported in pre-adolescents and adolescents. The vast majority of back pains is benign or has no definitive cause. It can however reveal relevant congenital or acquired pathologies, such as infectious and neoplastic processes (1-4).

### Epidemiology

Although back pain is an uncommon complaint in young children, the cumulative prevalence of non-specific musculoskeletal back pain appears high in pre-adolescents and adolescents (5-10). At the age of 18 this prevalence approaches 50 % in girls and 20% in boys (8, 10).

Contributing factors include sedentary, practice of high level sports with repeated subclinical traumas, female gender, family history of back pain, anxiety, psychosocial distress and maybe individual susceptibility.

Most cases of back pain are mild and non-disabling. Except in a traumatic context, they constitute rarely the motive of visit to the emergency department or to the specialized rheumatic or orthopaedic consultations. If not taken into account, they can evolve to chronicity with fluctuating symptoms (6-8, 11).

Careful medical history and physical examination are mandatory to differentiate a benign back pain from symptoms related to a serious underlying condition (4, 12).

### Medical history

Medical history looks for « red flags » suggesting the presence of specific patho-physiologic mechanism such as young age of the child, evidence of neurologic dysfunction, past medical history of infection,

malignancy, acute or repetitive trauma and some pain characteristics.

Those that should alert the physician are severe, progressive or constant pain, even during the night, pain that interferes with activity, pain with dysesthesia or pain that radiates suggesting nerve root compression.

In young children, clinical presentation can be poor such as refusal to walk and irritability (13).

### Physical examination

Physical examination should track signs of systemic disease or other underlying condition such as fever, unexplained weight loss, neurologic abnormality (eg, abnormal reflexes, bladder or bowel dysfunction, paraplegia, cauda equina syndrome), limitation of motion, tenderness and postural shift of the trunk (scoliosis, kyphosis, torticollis...). Severe back pain should not indeed be attributed to scoliosis without excluding other causes, especially when the scoliosis is of recent onset, of rapid progress, with left thoracic curve and/or an abnormal neurological examination

...

### Complementary evaluation

Only if medical history and physical examination reveal « red flags » for a specific cause or a serious underlying condition, additional diagnostic procedures are indicated. Laboratory evaluation looks for inflammatory or infectious process (eg complete blood count, erythrocyte sedimentation rate, blood culture) and radiologic evaluation is performed, directed by the suspected disease (14).

### Imaging

To date, there have been few prospective studies on diagnostic modalities in pediatric back pain.

Plain radiographs of the spine with antero-posterior and lateral views are usually the initial imaging study in prolonged localized pain to search for congenital or acquired bony anomalies but their sensitivity and specificity are often low. Oblique views may be required for the detection of spondylolysis.

Bone scan (scintigraphy) is useful in cases of normal plain radiographs. It has a localiser value if there is an hypercaptation, to orientate multiplanar imaging as computed tomography (CT) and Magnetic resonance imaging (MRI) (5).

MRI is the modality of choice in emergency if medullar compression or cauda equina syndrome are suspected. Moreover, MRI becomes more frequently the second imaging modality after plain X-ray films to document non-bony or even bony processes in children.

MRI provides a good visualization of the vertebral column (vertebral body and posterior elements) and disc but also the dural sac, the spinal cord, the cauda equina and the paraspinal soft tissues.

Imaging of the entire spine may be indicated in young children in whom localization of the abnormal process is often quite difficult.

A first simplified MRI approach may include sagittal T1-weighted and T2-weighted with and without fat sat images (STIR) with preliminary knowledge of age-related red marrow replacement by yellow marrow.

Total-body MRI may be useful to identify and precise the extension of diseases with multifocal characters such as histiocytosis, hemopathies, recurrent multifocal osteomyelitis.

Computed tomography (CT) scan focalized on the lesion can best characterize the bone involvement (osteolysis, osteosclerosis, mixed form ...) and states precisely its extension into the body of vertebrae or into its posterior arch. CT can moreover guide percutaneous vertebral biopsy for histological samples.

### Etiologies

There is a wide spectrum of diseases causing back pain in children. It depends upon the referral care clinician and on the studied population. Most back pain seem to be related to benign or nonspecific musculoskeletal diseases whereas the remainder can be attributed to specific causes divided among musculoskeletal, infectious, tumoral and miscellaneous causes (1-4, 12, 14).

#### Musculoskeletal

- Aspecific microtraumatic musculoskeletal disease
- Spondylolysis and spondylolisthesis
- Degenerative disc diseases such as Schmorl's nodes, Scheuermann kyphosis
- Disc herniation
- Disc calcification
- Idiopathic juvenile osteoporosis
- Vaso-occlusive crisis in sickle cell disease
- Ankylosing spondylitis
- Arthritis of inflammatory bowel diseases...

### Infectious

- Discitis and spondylodiscitis
- Acute osteomyelitis
- Pott's disease
- Chronic osteomyelitis, chronic recurrent multifocal osteomyelitis
- Epidural abscess
- Nonspinal infections (septic sacroiliitis, pyomyositis (psoas), retropharyngeal abscess, pyelonephritis, pelvic inflammatory disease, pancreatitis...)

### Tumoral

#### Vertebral

##### Benign:

- Eosinophilic granuloma, chordoma, hemangioma...(mostly in the vertebral body),
- Osteoid osteoma, osteoblastoma, aneurysmal bone cyst...(mostly in the spinous process)

##### Malignant:

- Metastasis
- Leukemia, lymphoma
- Ewing sarcoma, osteosarcoma...

#### Intramedullary:

- Astrocytoma
- Ependymoma
- Oligodendroglioma...

#### Extradural:

- Chloroma
- Neuroblastoma with intraspinal invasion

#### Intradural

- Subarachnoidal metastases
- Dermoid cyst, neuroenteric cyst
- Lipoma,
- Neurofibroma in neurofibromatosis type 1...

#### Miscellaneous

- Spinal and medullar malformations (diastematomyelia, Chiari 1, tethered cord ...)
- Epidural hematoma
- Nephrolithiasis, ureteropelvic junction obstruction
- Chronic pain syndromes

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### Diagnostic work up in the setting of back pain and sciatica

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Low-back pain and sciatica represent a major problem in public health and have a significant social and economic impact (1). Up to 80% of the population have such an experience at least once in a lifetime (2).

In case of an acute onset of low-back pain without neurological signs and without "red flags" background, there is no need for imaging as 90% of those cases resolve spontaneously within one month.

After six weeks of medical treatment, the imaging will be necessary only in the case of poor outcome or worsening of the symptoms.

The imaging is also indicated if either manipulation therapy or local drug infiltration are considered (3).

Emergency Imaging is indicated in the setting of malignancy, possible infection, neurologic deficit, corticosteroid therapy and osteoporotic fractures ('red flags').

### Choice of imaging modalities

#### Plain films

The plain films are generally performed in the work up of trauma especially in cervical spine. However, even major dislocation can be missed and generally only minor injury are referred for plain films.

The plain films are still used in the evaluation of static abnormalities, especially in young patients (< 20 years) and in older patients (> 55 years) namely because of the high frequency of osteoporotic fractures (Fig. 1).

Also keep in mind, the plain films can be falsely reassuring and are

#### Plain Films: Indications

- Recent trauma
- Young patients (< 20 y)
  - Static abnormalities, spondylolysis-listhesis, inflammatory and rheumatismal diseases (spondylarthritis, late diagnosis)
- Older patients (> 55 y)
  - Osteoporotic fractures

Fig. 1. — Plain films : indications

CT-MR Indications	
<ul style="list-style-type: none"> <li>• <i>CT</i></li> <li>- trauma</li> <li>- (disk anomalies)</li> <li>- osteoarthritis</li> <li>- (vertebral fractures)</li> <li>- canal stenosis</li> </ul>	<ul style="list-style-type: none"> <li>• <i>MRI</i></li> <li>- spinal cord lesions</li> <li>- tumors / epidural involvement</li> <li>- Spondylodiskitis</li> <li>- operated disk hernia / expelled fragment</li> <li>- canal stenosis</li> </ul>

Fig. 2. – CT and MR indications

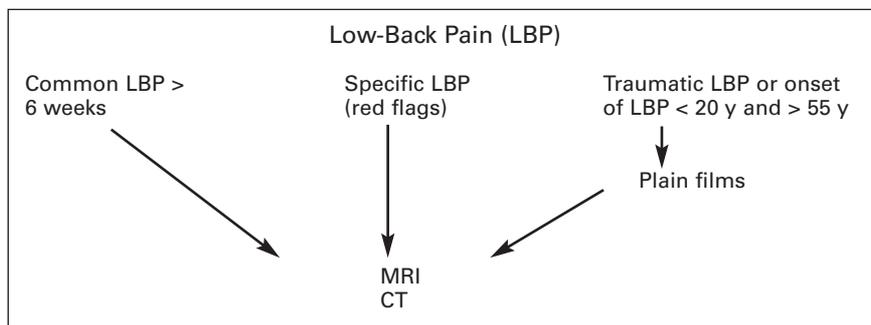


Fig. 3. – Choice of imaging procedure according to suspected pathology

generally not indicated in the age range between 20 and 55 years.

**CT scanner**

Spiral CT with multiplanar reconstructions is the first step modality in the setting of spinal trauma and should be always performed in high energy injury even without neurologic deficit. CT is also superior to MR in the evaluation of bony impingement especially in case of degenerative osteoarthritis and foraminal stenosis. CT scanner, particularly due to its high spatial resolution, allows a fine and precise study of such diseases.

**MRI**

When soft tissues pathology or disco-vertebral impingement are suspected, MRI is from far superior to CT. In case of lumbar disk extrusion, CT remains reliable in the most cases. However, when arthrosis, spinal canal stenosis or lack of epidural fat reduce the soft tissues interface, MRI should be advocated. The suspicion of disk recurrence, intradural pathology, infection or neoplasm require an MRI study before and after iv Gd injection (Fig. 2).

**Conclusions**

In case of low-back pain and sciatica the need for imaging is largely dependent on the clinical information.

In case of an acute onset of low-back pain without neurological signs and without "red flags" background, generally there is no need for imaging. After six weeks of medical treatment, the imaging will be necessary only in the case of poor outcome. The emergency imaging is indicated in the setting of malignancy, possible infection, neurologic deficit, corticosteroid therapy and osteoporotic fractures. The choice of imaging is dependent on the suspected pathology (Fig. 3).

Keep in mind that conventional radiology has limited value even in case of traumatic lesions.

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**Imaging trauma to the spinal cord**  
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**Correlations between clinical findings and imaging: What's significant and what's not?**  
T. Stadnik<sup>1</sup>

The role of the radiologist should not be limited to description of abnormal findings only. The final report should also conclude which findings may be related to the clinical complaints if any and suggest additional imaging protocol if necessary.

This imply the knowledge of imaging guidelines for a given clinical situation, of normal variants which may simulate disease and of abnormal imaging findings which are usually without clear association with the clinical symptoms.

In the setting of spine trauma without neurological signs the conventional xr is still frequently performed but may be falsely reassuring and the false negative findings are frequent. A multidetector CT should be preferred in case of diagnostic doubt.

In case of spine trauma with neurological signs the scanner should be performed as soon as possible followed by MR especially in case of discordance between CT and clinical findings.

The normal variants or congenital anomaly may occasionally simulate disease.

The partial butterfly deformity may by mistake for compression fracture.

The vascular channel is normally easy to differentiate from fracture because of corticalisation and typical anatomic location.

On CT, the conjoined nerve root anomaly may be mistaken for foraminal mass or disc herniation (Fig. 1).

The absent cervical pedicle syndrome (Fig. 2) is frequently misdiagnosed as post-traumatic interapophyseal luxation what may result in inappropriate therapy including aggressive traction or surgery.

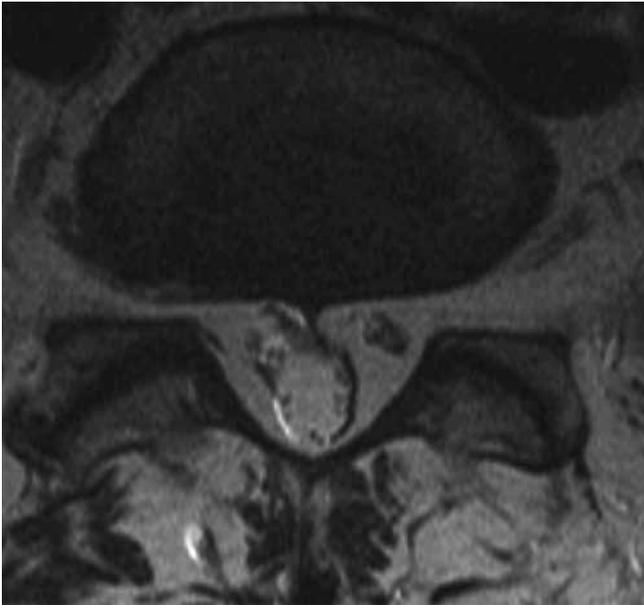


Fig. 1. — On CT, the conjoined nerve root anomaly may be mistaken for foraminal mass or disc herniation. The MRI is the modality of choice to confirm this anomaly.

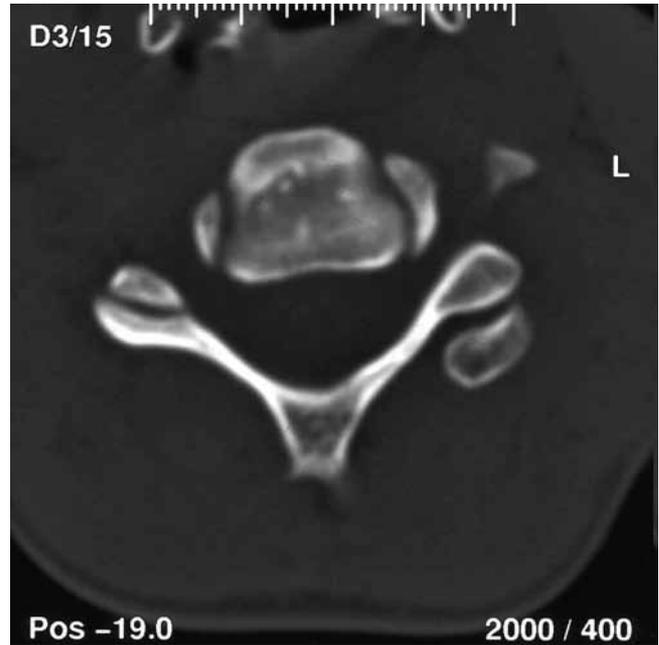


Fig. 2. — The absent cervical pedicle syndrome is frequently misdiagnosed as post-traumatic interapofyseal luxation what may result in inappropriate therapy including aggressive traction or surgery.

The bulging disks, annular enhancing tears and protrusions are frequently found in asymptomatic population and the relation to the symptoms is frequently questionable. In the contrary, the extrusions are only exceptionally found in normal population and generally there's a good correlation with the lumbar pain and/or sciatica.

In the setting of spinal stenosis the bony measurements are of little value and the significant stenosis should be considered in case of disappearance of CSF signal and tortuosities of the compressed nerve roots.

The foraminal impingement may be considered only in case of fat disappearance and congruent clinical findings.

In case of protrusion only clear mechanical compression/displacement of the nerve root should be

correlated with congruent symptoms.

If not, periferal nerve involvement should be considered and additional imaging may be necessary in order to exclude peripheral neuropathy, tumour or impingement.

Conclusion: The radiologist should be able to conclude which findings may be related to the clinical complaints if any and suggest additional imaging protocol if necessary.

This implies the knowledge of normal variants, which may simulate disease, and of abnormal imaging findings, which are without clear association with the clinical symptoms.

The normal variants or congenital anomaly may occasionally simulate disease. The wrong diagnosis may result in inappropriate therapy and serious medico-legal actions.

The bulging disks, annular enhancing tears and protrusions are frequently found in asymptomatic population and the relation to the symptoms is questionable.

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