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REVIEW ARTICLE

Thoraco lumbar spine metastasis
Current concepts and an update on surgical management

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Spinal metastases are causing a treatment dilemma worldwide. As current medicine evolves, treatment of primary tumours is improving, leading to increased survival and hence later presentation of metastases. Spine is one of the main locations for metastases with thoracolumbar regions being most commonly affected. Currently treatment options are mainly for palliation and include chemotherapy, radiotherapy and surgery. A review of literature was carried to look into the current practices and evidence for the management of thoracolumbar spinal metastases. As surgical techniques are becoming more minimally invasive, a similar trend is occuring in treatment of metastatic disease. This is resulting in fewer morbidities and complications, which has a knock-on effect of increasing survival in certain patient groups. However, there are still concerns regarding the appropriate surgical approaches for thoracolumbar metastases and whether these newer minimally invasive techniques have the same oncological benefits as the standard open procedures. Future research should focus on comparing outcomes and survival rate of minimally invasive versus open surgery.

Keywords : Thoracic spine ; lumbar spine ; management ; metastases ; surgical management.

INTRODUCTION

Metastatic spread of tumours is a common occurrence in practice today. The skeleton is one of the main sites of distant metastasis or secondary cancer *(41)*. Specifically related to the spine, it is forty times more common to have a metastatic disease process, than a primary tumour of the spine. The most common primary sites are breast, prostate and lung with involvement of 39.3%, 23.5% and 19.9% respectively *(18)*. Vertebral bone metastases are one of the more common sites of spread, usually via haematogenous or direct route. Up to 70% of people with malignant tumours have metastatic spread to the spine, with nearly 14% presenting with symptomatic disease and approximately 10% having cord compression *(37)*. The thoracic spine is the main site of involvement followed by the lumbar spine *(13,18,37,41)*. Consensus on treatment of thoracolumbar metastases is still not clear. With the improvement in treatment of primary tumours

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and thus increased survival rates, the potential of developing metastatic disease still looms. The treatment options for metastatic spine disease are constantly evolving including the trend towards minimally invasive surgery, however large volumes of cases are still palliative in nature. Despite advances in minimally invasive surgery, it is clear that the importance of updating, reviewing current practice and literature to ensure improvement in the treatment for metastatic spine disease is necessary *(18)*.

Presentation

Often the presentation of vertebral metastatic involvement is a late feature, with 90% of patients presenting with back pain. Subsequent imaging often shows vertebral collapse and pathological fractures. Neurological sequelae are frequently present, but usually develop after the pain *(3)*. Depending on the location of the tumour, radiculopathy and neural compression can result from extension into the epidural space. Myelopathy and cord compression or cauda equina syndrome can result from fractures and could be the initial presentation. Majority present with subtle neurological deficits but few people present initially with quadriplegia or paraplegia. These are often recorded according to the American Spinal Injury Association impairment scale (ASIA) or the Frankel scale *(3,17)*. In people with metastatic spine lesions the median score on the Frankel scale is D, implying a decreased sensory function but useful motor function *(3,17)*. Compression fractures are common in patients with metastatic spinal disease, however within the thoracic and lumbar spine, patients rarely present with frankly displaced fractures unlike in the cervical spine *(37)*.

When presented with thoracolumbar metastases, the treatment strategy is often difficult to determine and therefore primary tumour site and overall prognosis must be taken into consideration. The aims of intervention in spinal metastatic disease is to improve the quality of life for patients, by reducing pain, preserving mobility, preventing incontinence and prolonging survival *(37)*.

Classification

The treatment options for spinal metastases are chemotherapy, steroid therapy, radiotherapy, percutaneous intervention and surgery. The decision process in determining the best treatment approach is multidisciplinary. Classification of metastatic lesion within the spine is often complex and can aid treatment planning. Lesions can involve the bone, paravertebral soft tissues and epidural space. These lesions can then be solitary or multiple.

Most classification systems are based on neurological function such as the modified Frankel *(17,40)*. An alternative classification system is the Harrington classification system, which includes bone destruction and neurological compromise in its formula *(20,40)*. Depending on the classification assigned, inference for treatment can be made. Class I and II are often treated non-operatively with chemotherapy, hormonal treatment with an adjunct of radiation. Class III can be treated with either medical or surgical intervention, while class IV and V would usually undergo surgical intervention. Conclusions on treatment are never solely based on classification systems, as the primary tumour type often dictates whether or not surgical treatment is warranted. Primary lesions such as renal cell tumours require surgical intervention irrespective of Harrington classification, as they are not chemo or radiosensitive *(40)*.

Prognosis and Survival

Much of the surgical interventions in spinal metastases are palliative in nature. Balancing the risk of surgery and improvement in quality of life offered by surgical intervention is a constant clinical dilemma. Assessment of patient including use of predictive scores is now commonplace in clinical practice with scoring systems including the revised Tokuhashi, Tomita and modified Bauer scores. These aids the decision process on the best treatment options for the patient. Studies have looked at the predictive values of these scores. Ultimately complications can occur in up to 25% of people undergoing spinal surgery, most commonly post-operative infection. As life expectancy is actually determined by overall extent of metastatic

disease, taking the risks of surgery into account, the main reason to proceed is to improve the quality of life *(40)*.

The Tomita score uses three significant prognostic factors in its calculation, namely ; grade of malignancy, visceral metastatic disease and bone metastases *(44)*. They recommend that a prognostic score of 2-3 should undergo wide excision, intermediate scores (4-5) should undergo marginal or intralesional excision and a score of 6-7 should undergo palliative surgery. A score of 8-10 should be offered non-surgical care *(44)*. On review of this scoring system from 1993-1996, 83% who were treated surgically had local control for 80% of survival time *(40,44)*.

The Tokuhashi score was updated in 2005 *(40)*. They recommended excisional surgery where a good prognostic score (12-15) was obtained on their 15-point scale. Palliative intervention was recommended for intermediate scores (9-11) and conservative management recommended for poor prognostic scores (<8). This group proved a good consistency rate of 87% between the prognostic scores and actual survival in 118 patients reviewed *(7)*. Thus, highlighting the score is beneficial in suggesting the need for excision or palliative intervention and can be used as an adjunct when deciding on intervention.

The spinal instability neoplastic score was established in 2010 as another way to quantify tumour related spinal instability. This 18-point scale evaluates multiple factors including location, presence of pain, and degree of collapse *(14)*.

Ibrahim *et al (23)* showed an improvement in quality of life after surgery for spinal metastases. Approximately 80% of patients interviewed post operatively was satisfied or very satisfied with their clinical improvement *(23,45)*. This highlights the potential benefits of surgical intervention in these cases *(12)*. However, for best outcomes it is important to consider using multiple prognostic scales to aid in selecting a surgical plan. These scales as mentioned, should however be used in the context of patient variables, including age, stage of tumour, and general health.

Balain *et al. (4)* described Oswestry spinal risk index in order to aid in the treatment of metastatic disease in the spine. The Oswestry spinal risk index is a simple summation of two elements : primary tumour pathology (PTP) and general condition (GC) : OSRI = PTP + (2 - GC). Revised Tokuhashi, Tomita and modified Bauer scores are all equally good in predicting prognosis. Most predictive variable from all three score were used to develop Oswestry spinal risk index. This simple score most accurately predicts life expectancy in patients presenting with spinal metastasis. Life expectancy predictability of Oswestry spinal risk index has been externally validated by Fleming *et al. (15)* in their study.

Imaging

Plain radiographs

Imaging is critical for assessment, operative planning and follow-up of patients with metastatic spinal tumours. Initial assessment is with plain radiographs. This modality, however, does not detect early metastatic processes, as they require between 50% to 75% destruction of cancellous bone. A lesion cannot be detected on lateral radiographs until greater than 30%-50% of trabecular bone is destroyed. However, they are the first imaging modality used and do help identify pathological fractures, lytic or sclerotic lesions, pediculolysis, masses and deformities and are recommended to be completed *(10,37)*.

Computed Tomography (CT)

Computed Tomography is a useful imaging modality in assessing bone structure. It is commonly used to distinguish between lytic and blastic lesions. When used in conjunction with myelography it is useful in assessing the degree of neural compromise. Two and three-dimensional reconstructions are useful for assessing bone structure and have taken over from plain radiographs in some institutions. In cases where the tumour is suspected to be highly vascular, CT angiography is useful in illustrating blood flow. CT is particularly useful in those presenting after previous surgery when compared to magnetic resonance imaging (MRI), as it avoids

artefact distortion and is commonly used to assess hardware placement *(47)*.

Magnetic Resonance Imaging (MRI)

MRI is the gold standard imaging modality in spinal tumours. Published literature has shown superior sensitivity, specificity and accuracy when compared to radiographs, CT and nuclear medicine scans *(6,39)*. MRI is a superior modality for assessing soft tissue structures of spine. This allows MRI to be utilised for determining the extent of tumour infiltration, cord compression and nerve root entrapment. The use of T1, T2 weighted and STIR images facilitate full assessment of the spine *(26)*. As recommended by Rose *et al. (37)*, a full spine MRI should be completed, as nearly 15% of patients will have lesions at non-contiguous sites. Figure 1 is a MRI T2 weighted sagittal image of cervical and upper thoracic spine showing T1 vertebral body metastases with epidural extension causing compression of spinal cord.

Fig. 1. — MRI T2 weighted sagittal image of cervical and upper thoracic spine showing T1 vertebral body metastases with epidural extension causing compression of spinal cord.

Nuclear medicine imaging

Bone scans are utilised in asymptomatic patients, where metastatic disease is suspected. They provide the benefit of early detection of metastases with sensitivity to 2mm *(47)*. These scans, however, are not high resolution and hence can lead to confusion. Fracture sites, infection and inflammation can all appear as regions of possible metastases. Hence follow up imaging with CT or MRI is usually necessary *(47)*. Single photon emission tomography (SPECT) is a more advanced imaging modality compared to bone scanning. This allows three-dimensional cross-sectional imaging of specific lesions. It is very useful in differentiating between metastatic and benign lesions *(11,26)*.

Nonetheless it is positron emission tomography (PET) in combination with CT, (PET CT) which has become the most widely used imaging modality. This is due to its superior detection of lesions when compared to bone scans, SPECT and PET scanning on its own. Unfortunately, the radiation exposure with PET CT was high, therefore it has been recommended to be used only in cases where sufficient information has not been obtained from MRI and radiographs *(47)*.

Treatment Options

Medical therapy

Chemotherapy is often only used as an adjuvant treatment. However, in cases where the primary tumour is highly chemosensitive, such as in lymphoma or seminoma, chemotherapy can be used as a primary agent *(37)*.

Corticosteroids have been used in treatment of spinal metastases as they reduce vasogenic oedema and thus reduce local inflammation. In some tumours such as multiple myeloma, corticosteroids have a direct tumour lysis effect. The published evidence in the use of steroids is lacking and neurological benefit is usually only seen in the first 10-14 days of treatment, hence their use is not widespread *(42)*.

Radiation therapy

Radiation therapy is a popular treatment for spinal metastases for years. It provides good

analgesic effect, with local control of tumour and minimal side effects. Neurological improvement after radiotherapy intervention has been reported in up to 70% of those treated where the primary tumour is highly radiosensitive *(28,46)*.

However, radiotherapy as a stand-alone treatment has flaws. Pain relief can be a delayed effect, and the stability of the spine is not altered or corrected. Studies have shown that almost half of all patients undergoing radiotherapy have vertebral body compression fractures subsequently *(30,35)*. Rose *et al. (37)* again highlighted that results from radiotherapy were highly dependent on histology. If histology was unfavourable, then rapid failure could be expected. The ideal radiotherapy protocol for thoracolumbar metastases is not clearly defined but a review from the American Academy of Orthopaedic Surgeons does suggest 30Gy in 10 fractures as a common approach *(37)*.

Numerous randomised controlled trails have looked at radiotherapy alone or in combination with surgery. Patchell et al. *(34)* in 2005 published a landmark paper in turning the tide back in favour of surgery for metastases with cord compression. They concluded that direct decompressive surgery followed by radiotherapy was superior to radiotherapy alone in terms of mobility and return to ambulation as well as less analgesic requirements and corticosteroid use.

Stereotactic radiosurgery and intensity-modulated radiotherapy are the newest developments, allowing for focused beam radiation as it minimised the radiation exposure to surrounding tissues and spinal cord. Ryu *et al. (38)* investigated CT guided intensity modulated radiosurgery for spinal metastasis. 10 patients were recruited, 8 of these had spinal metastases between T6 and L2 with or without cord compression. The results from this trial were favourable, with most patients having good analgesic effect and partial recovery of motor function within two to four weeks. The maximum dose of radiation to the spinal cord was 50% of that prescribed and there was no detectable toxicity.

CyberKnife technology is also being utilised for the treatment of spinal metastases. A review of 125 patients who were treated with CyberKnife technology included 66 patients with thoracic or lumbar lesions. Considering strict inclusion and exclusion criteria employed, the results showed no acute radiation toxicity or new neurological deficit in a 30-month follow up period *(19)*. Currently however these radiotherapy techniques are recommended in poor surgical candidates with recurrent disease, if patient is deemed inoperable or as an adjunct to surgery.

Surgical Intervention

The decision to manage a patient surgically is a complex decision process and a multidisciplinary discussion is undertaken. Several issues and selection criteria are assessed with regards to suitability of patient for operative intervention. The primary aims when undertaking surgical intervention is to decrease or relieve pain, reverse or prevent neurological compromise as well as improving quality of life *(1,2)*. The objective for surgical intervention is to decompress nerve root impingement and to stabilise and reconstruct anatomic spinal column.

Various surgical techniques are in wide stream use, including tumour debulking, anterior, posterior

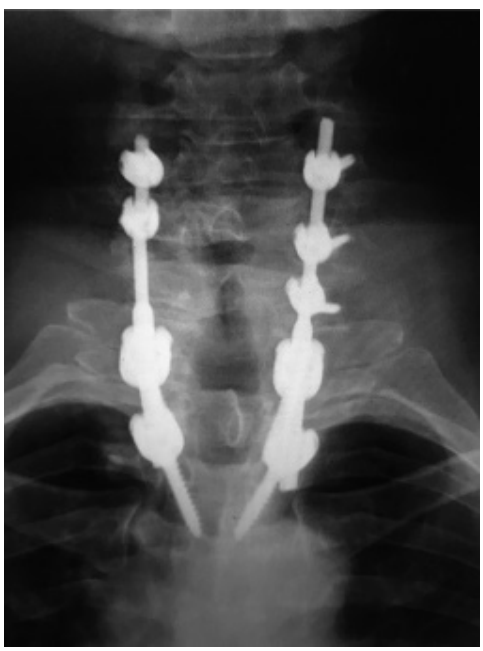

Fig. 2a. — Post-operative radiographs of antero-posterior view of thoraco-cervical junction showing posterior decompression and stabilisation.

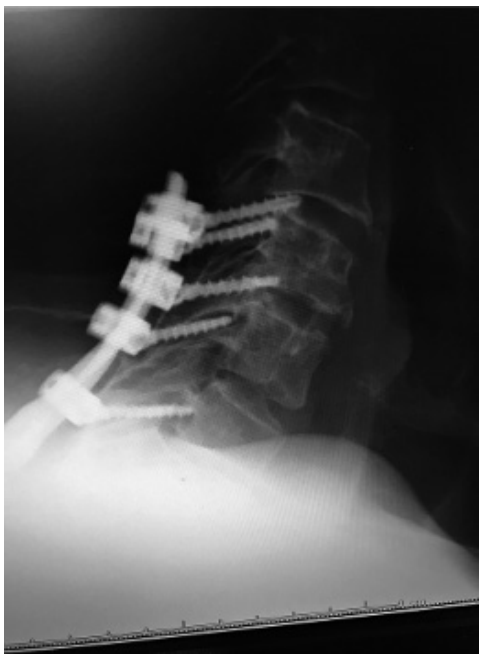

Fig. 2b. — Post-operative radiographs of lateral view of thoraco-cervical junction showing posterior decompression and stabilisation.

or combined approaches for marginal or wide excision. Piecemeal removal or curettage can also be included. The surgical approach depends on a number of factors including location, presence of spinal instability and presence of neural compression or deficit *(37,40)*. Figures 2a and 2b shows post-operative radiographs of antero-posterior and lateral views of thoraco-cervical junction showing posterior decompression and stabilisation.

Circumferential decompression and reconstruction is the main surgical treatment of choice in patients with thoracic metastases who are good operative candidates. Malhotra *et al. (27)* investigated the quality of life improvements between anterior and posterior approaches for thoracic spine metastasis. They concluded that there was no difference in the quality of life improvement between both groups and that the choice of approach should be made with respect to patient and tumour factors.

Fourney and Gokaslan *(16)* developed key considerations to help determine the best surgical approach for thoracolumbar metastases as shown in Table 1.

Table I. — Summary of key considerations in determining the surgical approach in thoracolumbar metastases

MAPS [32]	
Method of resection	En bloc spondylectomy, piecemeal excision, palliative decompression
Anatomy of spinal disease	Tumour location and levels / surgical staging
Patient fitness	Medical comorbidity, previous irradiation
Stabilisation procedure	Anterior, posterior, or both

Surgery for thoracolumbar spinal metastases may be performed by anterior, anterolateral, posterior or posterolateral or by combination approach. Using these considerations, the optimal surgical approach can be determined as follows :

1. Methods of resection *:*

En bloc resection removes whole tumour in one piece with a healthy layer of tissue. Spondylectomy is removal of whole vertebra, while corpectomy removes only the vertebral body. En bloc resection is indicated in solitary spinal metastasis or oligo metastatic spinal lesions with no or fully treated visceral metastases. It should also be considered if there is a favourable histological type and if it is feasible to perform the operation. It is important to consider tumour staging and patient's medical fitness *(2)*.

2. Anatomy of spinal disease :

Tumour location is an important factor in determining the approach. Due to the vascularity and relative size, the vertebral body is the main site of metastases. The anterior approach gives best access to the vertebral body but however it must be noted that many publications recommend a posterolateral approach in palliative decompression cases *(5)*.

3. Patient fitness :

This is another factor that is taken into account when deciding on approach *(16)*.

4. Spinal stabilisation and instability :

Stabilisation and instability must be considered with planning surgery. Bone mineral density and biomechanics of spine all contribute to instability. After posterior or posterolateral resection for thoracic or lumbar metastases, supplemental stabilisation is often required due to large resection of the vertebral

body, facet joints or pedicles. Considering this instability, the need for two stage procedure must be balanced with increased morbidity associated with it *(16)*.

Some papers do suggest that metastases in T5-T10 should be approached by a right sided thoracotomy, whereas, T11-L1, at the thoracolumbar junction, is usually approached using a combined thoracotomy and retroperitoneal approach. Published literature from 2013 by Yurter *(47)*, looked at 2098 patients undergoing laminectomy with or without radiotherapy. This showed that 46% had improved neurological function but 14% reported a decline. 1164 patients undergoing laminectomy with radiotherapy and posterior stabilisation had good analgesic effect with 84% reporting decrease in pain and 62% reporting improved motor function.

Chong *et al. (8)* carried out a study looking at outcomes for patients who had single stage posterior decompression and stabilization for metastases of the thoracic spine. This study showed improvement of functional status including pain scores and Frankel grades. Improvement in pain scores was particularly noted in the group with more rigid fixation using titanium mesh cages in keeping with previously published literature *(8,43)*.

Jansson *et al (24)* in 2006 reported on survival and complications on 282 patients who were operated for neurological deficit due to thoracic or lumbar spine metastases. This study found that the majority underwent posterior decompression and stabilisation. Those who had radical excision of the tumour and rigid fixation had longer post-operative survival. This study emphasized important improvement in function that can be achieved by surgery. However, complications were recorded at a rate of 20% and mortality of 27% within 2 months of surgery due to their disease.

In certain cohorts of patients' complete removal of the metastases is preferable if the prognosis is good. This is often achieved through corpectomy in which cases reconstruction and stabilisation of the anterior column is required. Bone graft or titanium mesh or implants can be used, but often grafting is not ideal in metastatic disease processes due to poor fusion rates. Expandable cages are another alternative for stabilisation. A review of long-term outcomes with use of expandable cages in single or multi-level corpectomies for spinal metastases. 68% of cages were placed in the thoracic or lumbar spine. Primarily a posterior stabilisation approach was taken. Post operatively ; the outcomes were favourable, with the Frankel score improving significantly, the segment height also increased. However, complications did arise with hardware failure resulting in re-operation in three cases. Of note, only one of these failures was within the lumbar spine. The high complication rates seen in this study would urge careful patient selection and promotion for bony fusion with adequate posterior stabilisation *(9)*.

Minimally invasive surgery (MIS)

MIS is another area of growth over the past number of years. Techniques including video-assisted thoracoscopic surgery, mini open decompression, minimal access spine surgery and percutaneous pedicle screw fixation all offer benefits over the traditional open operation, in the correctly chosen patient group. They have reduced morbidity rates, by reducing soft tissue trauma by smaller incisions, less blood loss, earlier mobilisation. The benefits of minimally invasive surgery in the context of metastatic spinal disease, is that it can facilitate adjuvant therapies commencing sooner post operatively *(25)*.

Endoscopic video-assisted thoracoscopic surgery (VATS) has been reviewed in the literature *(32,33)*. There have been retrospective reviews and case reports detailing the outcomes after using VAT in the setting of spinal metastases *(32)*. Overall, they showed improvement in neurological function and good analgesic control post operatively and at follow up. Due to the steep learning curve, blood loss, complications, increased operating time and cost, VATS have not become common practice to date. Endoscopy assisted posterior decompression is another option reported in the literature. Case series and case reports make the bulk of evidence surrounding its use in the setting of metastatic spinal disease. The results from Mobb *et al. (32)* and McLain *et al. (31)* showed good improvement in neurological function in those with impairment

pre-operatively and good analgesic effect post operatively. Again, these reports are of small cohorts of patients to date.

Minimal access spine surgery (MASS) was first described in 1997 for anterior lumbar fusions. This has become more widely used than VATS, as it is easier to learn and allows a fast decompression of the spinal canal. It also allows direct, three-dimensional vision for easier reconstruction of anterior column. Now through different approaches, it can be used from T2 to S1 *(31,32)*. Six studies reviewing 76 patients treated by MASS, showed improvement in neurological function as well as pain control. Huang *et al (21)* showed substantially less time spent in intensive care if the patient underwent MASS compared to a standard thoracotomy approach.

Vertebroplasty and Kyphoplasty

Other surgical options to be considered include percutaneous vertebroplasty and kyphoplasty. These are minimally invasive techniques and give good analgesic effect in pathological fractures causing vertebral body collapse. It is important to note that these minimally invasive techniques are contraindicated when tumour is involving the spinal canal, if the patient is asymptomatic or if there is local or generalised infection. In percutaneous vertebroplasty, polymethylmethacrylate (PMMA) bone cement is inserted under fluoroscopic guided needles into the vertebral body. This solidifies at the fracture site thus improving stability *(47)*.

Kyphoplasty is a similar procedure, but a balloon like device is inserted initially to create a potential space for cement to be injected. This allows the vertebral height to be restored. The analgesic effect of both these procedures was similar but kyphoplasty had a reduced rate of cement leakage, but this was negligible overall *(22,47)*. Markmiller *(29)* reported a prospective study in 115 patients who underwent percutaneous balloon kyphoplasty. This study showed significant improvement in pain scores and in Karnofsky performance status results. Also 23% had increase in vertebral height post operatively and 97.4% had no complications reported at time of publication.

Skyphoplasty is a newer alternative to regular kyphoplasty ; this uses a stiff plastic tube passed over a cannula, which is then expanded to create the cavity. This is an alternative to balloon technique, with benefits of better directional control during expansion of the device. No substantial evidence has yet been published with regards to its use in the context of metastatic spine disease *(36)*.

Recurrent Metastatic Disease

The risk of recurrence increases if wide or marginal excision was not obtained at the time of primary surgery. This is also true if radiation was given pre operatively. In cases of revision surgery, the risk of associated complications also increases substantially. This is due to poor tissues secondary to chemotherapy and radiotherapy exposure, and an overall poorer health status of the patient. The choice of revision surgery is complex. When deciding on the best intervention it is imperative that the potential for long-term survival, further recurrence, tumour growth and complications be considered. Intervention should address symptomatic non-healed fusions and hardware failures, for example *(40)*.

DISCUSSION

Unfortunately, spinal metastases in those with malignant disease are a common finding. The thoracolumbar spine is the most common site of spinal metastases and with up to 14% of people presenting with symptomatic disease, prompt diagnosis, work-up and treatment options need to be considered. As radiological imaging techniques advance, pre-operative planning has improved. This has led to improvements in resectability and hence improved minimally invasive techniques including percutaneous interventions. MRI is the gold standard imaging modality and is recommended, as we have discussed, due to its sensitivity and specificity. Currently, the mainstay of treatment of metastatic spine disease including thoracolumbar metastases is mainly palliative. The treatment strategies combine a multidisciplinary approach, involving radiotherapy, chemotherapy and surgery. As discussed, the classification systems in use for prognosis and survival are useful in aiding treatment

decisions ; however, as the treatments evolved similar advances with the classification systems have not occurred.

New advances in radiotherapy techniques have played a major part in management of thoracolumbar metastases over the past number of years. Since 2005 and landmark paper by Patchell *et al. (34)*, radiotherapy is now commonly used in combination with surgery. With more focused delivery of radiation therapy available including stereotactic and CyberKnife technology, treatment options for people with advanced and palliative disease are improving. The traditional surgical management of en bloc resection of spinal metastases is now being replaced by more minimally invasive surgical techniques. These techniques are coming to the fore, due to the advantages of lower morbidities and complications associated with them compared to the traditional open techniques. Video assisted, mini open and minimal accesses as well as percutaneous procedures have all been published in the literature in use for thoracolumbar metastases. However, advantages of minimally invasive surgery against open surgery for spinal metastasis needs further clarifications.

As discussed in the paper, percutaneous vertebroplasty and kyphoplasty are now widely used techniques with good patient outcomes. However, as the treatment of cancer develops, and patient survival increases, this brings new challenges to the management of metastases, especially within the spine. As life expectancy increases, the late complications and hardware failures will come to light in future studies. We will see a shift from palliative procedures to curative procedures with a focus on increased survival and quality of life benefits.

CONCLUSION

It is clear that the treatment options for metastatic spinal disease are numerous. Deciding on the appropriate treatment plan is the area of difficulty. Although the prognosis for patients with spinal metastases is guarded, surgical intervention can greatly improve the quality of life and in some cases, increases survival. Careful assessment and review of prognostic indicators should be taken into consideration when planning intervention. However, it is vital not to treat all tumours the same, as treatment and hence outcome is very much dependent on the individual and their disease. Research in future must focus on comparisons between treatment modalities, for example comparing minimally invasive and open surgery. Determining the optimal factors to improve outcomes, and prolonging survival will aid in treatment choices for patients to ensure optimal management plan is initiated.

REFERENCES

1. **Abrahm JL**. Assessment and treatment of patients with malignant spinal cord compression. *J Support Oncol* 2004 ; 2 : 377-388.
2. **Aebi M**. Spinal metastasis in the elderly. *Eur Spine J* 2003 ; 12 Suppl 2 : S202-213.
3. **American Spinal Injury Association** : Available from: http://www.asiaspinalinjury.org/publications/2006_Classif_worksheet.pdf. Accessed March 30, 2015.
4. **Balain B, Jaiswal A, Trivedi JM, Eisenstein SM, Kuiper JH, Jaffray DC**. The Oswestry Risk Index: an aid in the treatment of metastatic disease of the spine. *Bone Joint J* ; 95 : 210-216.
5. **Bilsky MH, Boland P, Lis E, Raizer JJ, Healey JH**. Single-stage posterolateral transpedicle approach for spondylectomy, epidural decompression, and circumferential fusion of spinal metastases. *Spine* 2000 ; 25 : 2240-2249.
6. **Buhmann Kirchhoff S, Becker C, Duerr HR, Reiser M, Baur-Melnyk A.** Detection of osseous metastases of the spine: comparison of high resolution multi-detector-CT with MRI. *Eur J Radiol* 2009 ; 69 : 567-573.
7. **Choi D, Crockard A, Bunger C *et al.*** Review of metastatic spine tumour classification and indications for surgery: the consensus statement of the Global Spine Tumour Study Group. *Eur Spine J* 2010 ; 19 : 215-222.
8. **Chong S, Shin S, Yoo H *et al.*** Single stage posterior decompression and stabilization for metastasis of the thoracic spine: prognostic factors for functional outcome and patients' survival. *Spine J* 2012 ; 12: 1083-1092.
9. **de Ruiter GC, Lobatto DJ, Wolfs JF, Peul WC, Arts MP**. Reconstruction with expandable cages after single- and multilevel corpectomies for spinal metastases: a prospective case series of 60 patients. *Spine J* 2014 ; 14 : 2085-2093.
10. **Edelstyn GA, Gillespie PJ, Grebbell FS**. The radiological demonstration of osseous metastases. Experimental observations. *Clin Radiol* 1967 ; 18 : 158-162.
11. **Even-Sapir E, Martin RH, Barnes DC, Pringle CR, Iles SE, Mitchell MJ**. Role of SPECT in differentiating malig-

nant from benign lesions in the lower thoracic and lumbar vertebrae. *Radiology* 1993 ; 187 : 193-198.

12. **Falicov A, Fisher CG, Sparkes J, Boyd MC, Wing PC, Dvorak MF**. Impact of surgical intervention on quality of life in patients with spinal metastases. *Spine* 2006 ; 31 : 2849-2856.
13. **Finkelstein JA, Zaveri G, Wai E, Vidmar M, Kreder H, Chow E**. A population-based study of surgery for spinal metastases. Survival rates and complications. *J Bone Joint Surg Br* 2003 ; 85 : 1045-1050.
14. **Fisher C, DiPaola CP, Ryken TC *et al.*** A novel classification system for spinal instability in neoplastic disease: an evidence-based approach and expert consensus from the Spine Oncology Study Group. Spine 2010 ; 35 : E1221-1229.
15. **Fleming C, Baker JF, O'Neill SC, Rowan FE, Byrne DP, Synnott K**. The Oswestry Spinal Risk Index (OSRI): an external validation study. *Eur Spine J* ; 25 : 252-256.
16. **Fourney DR, Gokaslan ZL.** Use of "MAPS" for determining the optimal surgical approach to metastatic disease of the thoracolumbar spine: anterior, posterior, or combined. Invited submission from the Joint Section Meeting on Disorders of the Spine and Peripheral Nerves, March 2004. *J Neurosurg Spine* 2005 ; 2 : 40-49.
17. **Frankel HL, Hancock DO, Hyslop G *et al.*** The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. *Paraplegia* 1969 ; 7 : 179-192.
18. **Galasko CS, Norris HE, Crank S**. Spinal instability secondary to metastatic cancer. *J Bone Joint Surg Am* 2000 ; 82 : 570-594.
19. **Gerszten PC, Ozhasoglu C, Burton SA *et al.*** CyberKnife frameless stereotactic radiosurgery for spinal lesions: clinical experience in 125 cases. *Neurosurgery* 2004 ; 55 : 89-98.
20. **Harrington KD**. Metastatic disease of the spine. *J Bone Joint Surg Am* 1986 ; 68 : 1110-1115.
21. **Huang TJ, Hsu RW, Li YY, Cheng CC**. Minimal access spinal surgery (MASS) in treating thoracic spine metastasis. *Spine* 2006 ; 31 : 1860-1863.
22. **Hulme PA, Krebs J, Ferguson SJ, Berlemann U**. Vertebroplasty and kyphoplasty: a systematic review of 69 clinical studies. *Spine* 2006 ; 31 : 1983-2001.
23. **Ibrahim A, Crockard A, Antonietti P *et al.*** Does spinal surgery improve the quality of life for those with extradural (spinal) osseous metastases? An international multicenter prospective observational study of 223 patients. Invited submission from the Joint Section Meeting on Disorders of the Spine and Peripheral Nerves, March 2007. *J Neurosurg Spine* 2008 ; 8 : 271-278.
24. **Jansson KA, Bauer HCF**. Survival, complications and outcome in 282 patients operated for neurological deficit due to thoracic or lumbar spinal metastases. *Eur Spine J* 2006 ; 15 : 196-202.
25. **Laufer I, Madera M, Bydon A *et al.*** Minimally invasive surgery in the treatment of thoracolumbar metastatic tumors. *ArgoSpine News & Journal* 2011 ; 23 : 134-138.
26. **Laufer I, Sciubba DM, Madera M *et al.*** Surgical management of metastatic spinal tumors. *Cancer Control* 2012 ; 19 : 122-128.
27. **Malhotra NR, Kosty J, Sanborn M *et al.*** Optimal approach to circumferential decompression and reconstruction for thoracic spine metastatic disease. *Ann Surg Oncol* 2014 ; 21 : 2864-2872.
28. **Maranzano E, Latini P**. Effectiveness of radiation therapy without surgery in metastatic spinal cord compression : final results from a prospective trial. *Int J Radiat Oncol Biol Phys* 1995 ; 32 : 959-967.
29. **Markmiller M**. Percutaneous balloon kyphoplasty of malignant lesions of the spine: a prospective consecutive study in 115 patients. *Eur Spine J* 2015 ; 24 : 2165-2172.
30. **Matsubayashi T, Koga H, Nishiyama Y**. The reparative process of metastatic bone lesions after radiotherapy. *Japan J Clin Oncol* 1981 ; 41 : 1039-1047.
31. **McLain RF**. Spinal cord decompression: an endoscopically assisted approach for metastatic tumors. *Spinal Cord* 2001 ; 39 : 482-487.
32. **Mobbs RJ, Nakaji P, Szkandera BJ, Teo C**. Endoscopic assisted posterior decompression for spinal neoplasms. *J Clin Neurosci* 2002 ; 9 : 437-439.
33. **Molina CA, Gokaslan ZL, Sciubba DM**. A systematic review of the current role of minimally invasive spine surgery in the management of metastatic spine disease. *Int J Surg Oncol* 2011 ; doi : 10.1155/2011/598148.
34. **Patchell RA, Tibbs PA, Regine WF *et al.*** Direct decompressive surgical resection in the treatment of spinal cord compression caused by metastatic cancer: a randomised trial. *Lancet* 2005 ; 366 : 643-648.
35. **Patel B, DeGroot H** 3rd. Evaluation of the risk of pathologic fractures secondary to metastatic bone disease. *Orthopedics* 2001 ; 24 : 612-617.
36. **Rashid R, Munk PL, Heran M, Malfair D, Chiu O**. Skyphoplasty. *Can Assoc Radiol J* 2009 ; 60 : 273-278.
37. **Rose PS, Buchowski JM**. Metastatic Disease in the Thoracic and Lumbar Spine: Evaluation and Management. *J Am Acad Orthop Surg* 2011 ; 19 : 37-48.
38. **Ryu S, Fang Yin F, Rock J *et al.*** Image-guided and intensity-modulated radiosurgery for patients with spinal metastasis. *Cancer* 2003 ; 97 : 2013-2018.
39. **Sciubba DM, Petteys RJ, Dekutoski MB *et al.*** Diagnosis and management of metastatic spine disease. A review.' *J Neurosurg Spine* 2010 ; 13 : 94-108.
40. **Singh K, Samartzis D, Vaccaro AR, Andersson GBJ, An HS, Heller JG**. Current concepts in the management of metastatic spinal disease. The role of minimally-invasive approaches. *J Bone Joint Surg Br* 2006 ; 88 : 434-442.
41. **Solomon S, Warwick D, Nayagam S.** *Apley's System of Orthopaedics and Fractures.* 9th edition. CRC Press, Taylor & Francis Group LLC 2010.
42. **Sørensen S, Helweg-Larsen S, Mouridsen H, Hansen HH**. Effect of high-dose dexamethasone in carcinomatous

metastatic spinal cord compression treated with radiotherapy : a randomised trial. *Eur J Cancer* 1994 ; 30A : 22-27.

43. Tokuhashi Y, Ajiro Y, Umezawa N. Outcome of treatment for spinal metastases using scoring system for preoperative evaluation of prognosis. *Spine* 2009 ; 34 : 69-73.

44. Tomita K, Kawahara N, Kobayashi T, Yoshida A, Murakami H, Akamaru T. Surgical strategy for spinal metastases. *Spine* 2001 ; 26 : 298-306.

45. Wai EK, Finkelstein JA, Tangente RP *et al.* Quality of life in surgical treatment of metastatic spine disease. *Spine* 2003 ; 28 : 508-512.

46. Wu AS, Fourney DR. Evolution of treatment for metastatic spine disease. *Neurosurg Clin N Am* 2004 ; 15 : 401-411.

47. Yurter A, Ju DG, Sciubba DM. Management of Metastatic Spine Disease. *JSM Neurosurg Spine* 2014 ; 2 : 1020.