Okay, thank you for your attention today. Today we will be doing a CME course entitled Paradigm Shift for the Management of Extra-Articular Distal Humeral Fracture. My name is Ivan Tarkin, I’m an orthopedic traumatologist from the University of Pittsburgh Medical Center.

To introduce the topic of our discussion today I thought I’d present a very typical case. So this is the case of a very lovely 22 year old woman who presented to the University of Pittsburgh Medical Center after a horrific hang gliding accident. She had a closed injury of her upper extremity as depicted in her x-rays, she has a standard distal third humeral fracture, AO/OTA type 13A3 and she had preserved radial nerve function. And this injury involved her dominant arm unfortunately. So when treating a young, healthy person with this type of fracture there are certainly treatment controversies in 2013 and these are the topics that we’ll discuss today. So the question is does this young lady be best served in a functional brace, a Sarmiento type brace conservative care or in 2013 is open reconstruction a better option? And then if you choose surgery for your patient there are many controversies with regards to what type of surgery to offer the patient in terms of exposure of the fracture and also instrumentation of the fracture, meaning what type of internal fixation do you use?

The reason why this is a great topic and important to talk about is these fractures are not too uncommon. They comprise upwards of 3% of all fractures and trauma is the overwhelming ideologic factor in a majority of cases as previously seen in our young woman. They occur in everyone although there are spikes where these distal third humeral fractures occur. In a younger
population typically to higher energy mechanism and also in a older patient population where pathologic bone and osteoporosis are implicated.

The mechanism of these injuries are relative standard, in a younger higher end patient population usually they are due to higher energy trauma. Most of the fractures that we see here at UPMC are motor vehicle related, traffic related but certainly we see a fair amount of these fractures in our athletes. In fact in the recent few weeks we’ve seen a few of these cases from arm wrestling of all types of mechanisms. Falls and high energy falls, falls from heights are also common mechanisms.

So in talking about this problem I guess I have a personal philosophy that no matter what you do no one likes a crooked, stiff and painful elbow so as we are going through this talk we are going to try and think about pitfalls – excuse me, avoiding pitfalls in this occurring in our patients. In this case will serve I think as a very good example. So this again is another young lady who came to me, I believe she was about 25 years of age and when she walked in the room she sort of tried to hide her arm, she was a little bit shy about letting the world see her arm. In fact she would wear long sleeves even in the warmer months because she was concerned about the cosmesis of her crooked arm after treatment for a distal third humerus fracture. Also her elbow motion was severely compromised, perhaps she had a 30 degree arc of motion or so, and also her arm killed her all the time. It was a constant source of frustration for her, so this patient sought opinion after opinion after opinion and then she was kindly referred to my division for care. And she elected to go through non-union reconstruction, malunion reconstruction which we all know is quite an undertaking with significant risks. You could see the fluoroscopic views show her dramatic deformity in the sagittal plane and
then we could see the intraoperative correction of that and plate and bone graft methodologies for treatment.

Here is her – an early postoperative picture. You could see that her arm is straight and well fixed which is going to encourage function hopefully as well as cosmesis. And here she is at about 2 weeks postop and you could see that her arc of motion is dramatically improved, clearly at the time of her surgery I also incorporated a contracture release and I’ve gone on to follow this nice young woman for about a year or so and this person who was previously quite miserable is now thankfully a more happy human being.

So what are the goals of care after a distal third humeral fracture or distal extraarticular humeral fracture? Well I’d submit fracture union is a primary goal, but certainly restoring the mechanical alignment of the limb and certainly preserving adjacent joint motion and functionality is paramount to happiness and I think we could all agree on that. And the last point we certainly want to avoid long term pain but also it’s very critical especially with these distal third fractures to avoid neurologic a complication, and we’ll go into that in a little bit more depth.

So the radial nerve, radial nerve, radial nerve is infamous for injury preoperatively after distal third fracture. You could see in this intraoperative photo here that this bone spike was implicated in this particular person’s radial nerve palsy but certainly at the time of accident there could be a stretch injury to the nerve with displacement of the fracture as this nerve is in a very vulnerable location. We are all familiar with the devastating manifestations of radial nerve palsy whether it be transient
or permanent, this manifests in paralysis of the dorsal compartment and hand drop as well as sensory deficit. And talking about the radial nerve is specifically important when we are talking about humeral fractures of the distal third because as you could see in this study out of Sweden it occurs with the greatest frequency as compared to proximal third and middle third variants. And in fact it occurs one-fifth of the time, 20% of the time, which is a staggering statistic. But don’t forget about the ulnar nerve, the ulnar nerve is also at risk certainly by its relatively superficial location and close proximity to the elbow at the cubital tunnel, this nerve is at risk from the injury but certainly as we’ll talk about later a bit of foreshadowing, this nerve will become very important when we are discussing the potential for operative care of these types of injuries.

So what are management strategies that can promote wellness and good outcomes after distal third humeral fracture? No talk would be replete without talking about Sarmiento bracing or functional bracing as for a long period of time most orthopedic surgeons have considered functional bracing the standard of care for most humerus fractures including those fractures of the distal third. And we had good reason to believe that this was a optimal treatment modality. You could see that Sarmiento and his group report on 620 patients which is a huge series and they had an incredible union rate, almost 100% of these fractures healed. And you could see in this particular series 35% of these cases, of the 620 patients, were of the distal third.

And the story even gets better with functional bracing, not only do almost 100% of these fractures heal but also the elbow works. There was only a modest decrease in elbow range of motion after functional bracing. So potentially a great option, no surgery, you just wear and brace and your
elbow still works at the end of your treatment so certainly a very attractive option. However, Sarmiento went on to look specifically at functional bracing for the distal third and perhaps depending upon your perspective the results aren’t as grand.

So here is a study which was published in 1990 where Sarmiento looked at 72 patients, adult patients that is with distal third humeral fracture, which is still a very large series. The average age of his patients was somewhat young, 28, although it was a diverse study with regards to age, about an equal proportion of male and female with multiple mechanisms of injury and the patients wore his functional brace about an average of 12 days post-injury. As we alluded to before, many of these patients had radial nerve palsy from their injury. His study corroborates the earlier findings I discussed that 18% had radial nerve palsy from their injury. The good news is that there was about a 75% recovery rate with only conservative care and his union rate with these fractures again was high, 96, which is wonderful for any type of fracture intervention. And these patients wore the brace for approximately 3 months or so. However despite an incredible union rate, 96%, the story continues with functional bracing for distal third humeral, adjacent joint motion loss was significant. So for the shoulder 45% of the patients had a decrease in external rotation, greater than 15% of patients had a loss of shoulder abduction and when you look at the elbow about 25% of the people had deficits with regards to flexion and extension.

Now we talk about what about deformity with bracing with our distal third fractures with functional bracings? Still like our functional data the deformity was substantial, and as outlined in the second case I presented many people find this to be a tremendous problem. In the coronal plane 41% of
patients who are braced have a significant varus deformity, And in the sagittal plane like seen in our – a case I presented upwards of 30% have a significant deformity.

So concerning the functional limitations and potentially the inconvenience of the brace it just begs the question is open reconstruction, is open reduction, internal fixation a better option for these patients both young and old, high demand and low demand? Certainly although this is anecdotal but somewhat corroborated in the literature in 2013 patients don’t necessarily tolerate the brace as well as we think they should. They are in the brace for upwards of 3 months in the early going they feel gross motion of their fracture which is very uncomfortable, very painful especially in the summer months the brace is sweaty, causes skin irritation and there are some Americans that just do not have the body habitus where a brace is even a pragmatic consideration.

So is surgery a better option? Well maybe, maybe not. This slide is somewhat sobering if we look at a lot of studies smattered throughout the orthopedic trauma literature you see that there have been many complications somewhat unique to operation on these injuries which may make this modality a lot less appealing. I’ve already told us that the radial nerve is at risk but with operation there could be iatrogenic radial nerve palsies and you could see that the numbers are all over the board, anywhere from 3% to 16% of operative cases where the patient goes to sleep with a hand which is functioning and wakes up with a hand drop. So that clearly isn’t a positive surgery.

What about infection? Well upper extremity cases rarely get infected but it seems like in the distal humerus there is a substantial rate, upwards of 5% of cases. And then with operation trying to
secure the distal humerus which is a very short distal segment which is subjected to the lever arm of the entire form in the hand, gaining and maintaining adequate fixation to union can certainly be an issue, with issues in upwards of 5% of the time. And then cases going on to frank nonunion have been reported in some series upwards of 6%; and again we should take these details you know in comparison to Sarmiento bracing where there is no incision, no investment in surgery. And the numbers don’t look all that appealing. However I’ll make an argument. I’ll make an argument that if we optimize our surgical protocols and if we operate with meticulous execution then this has a distinct possibility to improve outcomes after distal third extraarticular humerus fracture.

So what is the gold standard at least as I see it with regards to open reconstruction of the distal humerus? Well there are two main considerations, one is going to be our operative exposure, how we get to the bone to reduce it and then the other one is going to be with regards to which part of the bone we manipulate an instrument, meaning what are our fixation strategies? So the standard technique as I see it is operating through a triceps split which is well known to a majority of trauma and nontrauma orthopedic surgeons, and considering that there is a short distal segment which we need robust fixation to promote early rehabilitation, dual column plating has appropriately served as the standard. But I’ll talk about in the upcoming slides problems with what I consider to be the standard exposure of triceps split and then we’ll move on to the fixation issue is dual column plating really appropriate or best care for these type of injuries? But we’ll start with exposure.

Now what are the problems with a triceps split? There is no true internervous or intermuscular plane. When we are splitting the triceps clearly there is going to be the opportunity for massive scar
formation and this could cause elbow contracture and certainly compromised motion. And then certainly as we are splitting through that muscle and we are retracting on that muscle there is the opportunity for significant muscle damage and denervation causing weakness primarily of elbow extension. And you’ll see I have a picture of another patient that was referred to my trauma clinic who had a triceps split for a distal humerus with very limited motion and this patient needed to undergo significant contracture release to have an elbow which was even reasonably functional.

I promised that I would go on to the fixation issue and what I perceive the big problems with bicolumnar plating, namely problems with putting a plate both on the lateral column and the medial column with emphasis on the medial column.

The advantage of dual column plating is obvious, more fixation into a short distal segment in multiple planes equals a more biomechanically robust construct. This has been proven both in the lab and also clinically. And most of us considered this at least previously to be the standard of care to optimize the biomechanics for early motion and to encourage uneventful fracture union. However there are some issues with it. When you are approaching the distal humerus to apply both a medial and a lateral plate there is a significant amount of soft tissue stripping and especially in the more comminuted distal third humerus fractures like the AO/OTA type 3 pattern with a butterfly fragment as I showed in that 22 year old girl at the beginning of this presentation, you could certainly have issues with devitalizing bone and the potential for encouraging a nonunion with a less than biologic exposure. But I think the main issue with bicolumnar plating is the prospect of putting medial column fixation in an area where there is a very tenuous soft tissue envelope which is quite
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diminutive, there is no substantial muscle coverage in that area at least distally as we head down towards the elbow. And to make that circumstance even worse you have the ulnar nerve sitting right there which needs to be displaced to do this surgery, the cubital tunnel typically needs to be released. And then you are having a surgical exposure where the nerve is being manipulated, you are having hardware right adjacent to the nerve, you are having a nerve which is looser than it was before with the potential for motion postop, and it’s not so surprising that in a – too significant portion of these cases that patients end up with either a temporary or a chronic ulnar nerve neuropathy or a dysfunction. It’s been reported in upwards of 50% of cases which I’d argue is unacceptable.

It’s been argued in the literature that the etiology of ulnar nerve problems is multifactorial, but I think the issues are quite obvious, handling of the nerve intraoperatively, postoperative scarring, this is an area which was already traumatized and then you are putting metal right next to a major peripheral nerve. Although the incidence of ulnar nerve injury during surgery is variable, anywhere from 2% to 50% as we described, it’s still too much and potentially avoidable. And also it’s probably underestimated. And palsy can mean a lot of things, it can mean chronic neuropathic pain, it can mean numbness, and it can be frank weakness in the hand. As this is a huge issue with distal humeral surgery, there have been some attempts to take on this problem technically with the prospect of transposing the nerve, although the literature is somewhat inadequate to know whether or not this is really solving a problem. My gestalt is that it doesn’t.

So now we’ll talk about potential alternatives in distal humeral fracture surgery in terms of the exposure and potentially the instrumentation to see if we could start to come up with a protocol
which is optimized so we can improve functional outcomes after distal humeral surgery as compared to the standard Sarmiento bracing. So why don’t we talk about the exposure first.

So I described that a triceps splitting approach was unattractive because there is no true plane, you are going right through a major muscle so what about if we don’t violate the muscle at all? What happens if we just go to the side of the muscle? If we go lateral to the triceps and just gently reflect the muscle off of the lateral intermuscular septum and the distal humerus, perhaps that’s a better way to treat the triceps. As I tell my residents, don’t be a triceps hater, be a triceps lover and just move the triceps to the side as opposed to split right down the middle.

Another potential advantage of this approach is that you can get wider exposure and decompression of the radial nerve. We talked about that abstract radial nerve palsy after these surgeries is very significant, well what happens if we are more mindful about how we handle the nerve and how we decompress the nerve? Perhaps those issues can resolve of the classic problems with distal humeral surgery.

So at the University of Pittsburgh Medical Center specifically and in my division we set off looking at this problem from – in numerous ways and we started with approach first. We posed the question is it triceps sparing, is a lateral para-tricipital approach really better than the traditional triceps split? And this was a study which we subsequently presented to our trauma colleagues at the OTA and then to the American Academy of Orthopedic Surgeons. So to look at this problem we recruited a lot of the patients we did distal humeral surgery on. Fortunately for me in our division we have surgeons
that like to split and surgeons that love to spare and so we had the patients to look at both cohorts of patients. And again it’s in the same fracture pattern, this AO/OTA 13A2 and 3 patterns and over the past 4 years we recruited these patients.

Two cohorts primarily based on what type of surgical exposure they had for their distal humerus and we looked at some objective measures. One was elbow range of motion, which we studied critically using a goniometer. And also we looked at triceps strength using a handheld monometer. Also for completeness we also used a validated questionnaire namely the DASH Score to see if there was a significant overall difference between patients treated with a triceps splitting exposure or a triceps Levy exposure or sparing exposure, the lateral para-tricipital approach.

So how did the patient cohorts do? Well I don’t think it’s too unexpected that when you respected the triceps and just encouraged it off to the side that patients did better with regards to their overall elbow flexion and extension, and this was a statistically significant finding. But further, if you don’t violate the triceps and you don’t cause iatrogenic muscle and/or nerve damage these patients also had improved strength. However though fracture union was the same in both cohorts and also our DASH Scores were remarkably similar between the groups. So we concluded from this study that a triceps sparing approach, the lateral para-tricipital approach was in fact an improvement over traditional triceps splitting approach for extraarticular distal humerus fractures as a greater elbow range of motion is seen and also triceps strength is significantly better.
So now we’ve talked about the exposure aspect of this but what about the reconstructive portion of this? Once we had the fracture exposed and reduced the fracture then how we instrument the fracture, or what plates and screws we use and where we put them and how many, would that make a difference? Well at the time I started my clinical practice a new technology was born and this was locking technology. And with this fixed angle technology came a whole host of precontoured plates. Well one of these precontoured plates was a small fragment type of implant with locking technology and it was ideally suited for the posterolateral aspect of the distal humerus. It wasn’t intentionally designed presumably to work alone but certainly it was contoured to this unique area. So we posed the question, if you use a single plate and you can get multiple points of fixed angle screws into a short distal segment is it safe and potentially is it efficacious for distal third fracture? And certainly this type of instrumentation can be done through a triceps sparing type approach, a lateral paratricipital approach. So we put the approach and now this new instrumentation theme together and we examined how the patients did in a critical way. And the good news at the same time that my unit was doing this here at the University of Pittsburgh Medical Center the University of Nebraska Medical Center where I previously trained one of my mentors was using the same approach. So the study hypothesis was that single column plating, posterolateral plating with a locked precontoured implant for extraarticular distal humeral fractures would work, and potentially lead to optimized outcomes.

We looked at a relatively large cohort of patients, 35 patients from two institutions over a few years. These were OTA, AO/OTA excuse me classification, 13A2s and selected A3 patterns. The patient ages were all over the board from young to old but most were in the younger age group, 37. These
patients were all fixated, put in a splint for a week or so and then an early aggressive motion protocol was instituted. We followed all of these patients clinically and radiographically at least to union and note any complications which may be unique to this different type of distal humeral surgery.

Well how did we do? Well here is a typical case, you could see that we have a triceps sparing approach here, a lateral para-tricipital approach. As I worked the triceps off the lateral intermuscular septum and the humerus I readily identified the radial nerve. I do a decompression of the nerve as it pierces the lateral intermuscular septum to give it a little more freedom from injury and also to accommodate hardware. I perform a neurolysis of the nerve deep into the spiral groove, isolate the nerve, do my anatomic fracture reduction that’s complemented with interfragmentary compression with lag screws and then I use my precontoured locking plate primarily as a neutralization device to an already anatomic or reduced fracture that has a bunch of lag screws.

Here is a standard example, you could see this fresh postoperative case, staples still in place where screws out of the plate are providing interfragmentary compression, the plate is serving as a fixed angle neutralization device. You could see in this short distal segment that we have 1, 2, 3, 4, 5 fixed angle screws and our alignment is the way it should be anatomic. And we got some very promising results, 97% union rate so that’s at least as good as bracing, but we had no malunions. All these fractures healed straight. There was no significant elbow stiffness. All of these patients regained their elbow function within acceptable limits. There was no case of any nerve injury. And then some anecdotal data, these patients are happy and many of them send Christmas cards.
However no technique is perfect, and we did have some issues. Out of our large cohort of patients we did have one patient who had a catastrophic failure. There is a patient who had a distal third fracture with some shaft extension. She was fixed in the manner that I described with multiple lag screws and then using the plate as a neutralization device. This patient however subsequently had sustained another high energy fall and you could see, I believe this was about at the 3 week mark, she had catastrophic failure with all of these screws breaking away at the head/neck junction and repeat fracture displacement. We are very critical of our failures and we try and learn from them and I would argue that in this case probably I had insufficient screw fixation of my shaft segment. There were only 3 locking screws. And also during this case potentially we weren’t as careful with not putting down all those screws on power pre-tensioning the head/neck junction. But this is one complication potentially associated with this technique. This patient was subsequently revised and went on to uneventful union and I gave her a more traditional fixation technique with orthogonal plating to improve the biomechanics, make the fracture fixation construct more sturdy to encourage uneventful union since we had that failure in this patient.

Another unexpected complication was a very late triceps rupture. This occurred at about a year, a very nice lady, she has diabetes but no other significant comorbidities and just from routine activities all of a sudden she starts to develop pain about her posterior elbow specifically on the olecranon process. When she came to my office her diagnosis was obvious that she had no meaningful triceps extension and she had a palpable defect about her olecranon. Her operative findings corroborated the fact that she did in fact have a triceps rupture. The etiology is somewhat unknown, I couldn’t decipher whether it was from hardware irritation or if it was from too aggressive of a previous
exposure, hard to know, but nonetheless this lady had a failure and I did a allograft repair of her triceps mechanisms as primary reconstruction wasn’t an option. She went on to do reasonably well although she still does have some chronic pain about her elbow and she is mildly stiff.

So what I concluded from our study with just looking at single column lock plating is that it’s both safe and efficacious and certainly after these devastating injuries it promotes wellness. Many of these patients get their elbow motion back, they don’t complain of chronic pain and they have preserved strength of their triceps.

So now hot off the press with all of this sort of momentum for a single column posterolateral lock plating through a lateral para-tricipital approach we wanted to compare this more modern approach to the standard approach and I’ve already described it. It was primarily a triceps splitting type exposure and a dual column plating. So I had one of our better residents audit our practices over the last 10 years or so and also we combined our data again with our friends from Nebraska and we looked to see whether or not there would be any true differences if we changed operative techniques with regards to wellness after distal third humeral fracture with either single column plating through a more modern approach or the standard triceps splitting approach with dual column plating.

The title of our study which is coincident with the title of this talk is A Paradigm Shift in the Surgical Reconstruction of Extraarticular Distal Humeral Fractures: Single Column Plating. As described this was a multicenter study, patients included were at our Level I trauma center here at Presby, also our friends at Mercy contributed patients and then the trauma centers in Nebraska also
contributed patients. And we examined outcomes in both cohorts, namely fracture union, alignment, elbow functionality and certainly complications between the two with the same types of patients and fracture patterns.

We had a pretty good group of patients, 105 patients in all, and the good news is if you looked at the two different cohorts there really wasn’t any significant difference in the patient demographics, so there were similar patients, similar injuries. And the good news is that with both techniques union is reliable, 100% in Group 1 and 98% in Group 2 which wasn’t statistically different between the dual column plating and the single column plating. But in the single column plating group we did have one malunion, this happened to be a patient of mine, a bigger muscular gentleman who had uncomplicated surgery. He took a fall I think at about the three week mark and you could see he bent his plate. We recognized it and subsequently since the plate was stable we didn’t do any additional work as it was only 11 degrees off from the sagittal plane and as you can see on the right of the screen he uneventfully healed with full elbow motion, no pain and happiness.

But we did find some significant differences between the two groups. In terms of elbow functionality which I told you is a major issue with distal humeral fractures we want our patients to have great range of motion, normal range of motion and if you look at the dual column plating primarily through a triceps splitting exposure and if you look at the single column plating through a lateral para-tricipital approach we do better with a more modern approach. The mean elbow flexion and extension was statistically better for the more modern approach.
What about complications? This tells a real story here. So in the dual plating group out of 48 patients which could be included there were 15 complications, and I’ll call your attention to some of them: implant irritation which we thought would be a big one because of the medial plate and its vicinity to the ulnar nerve and a soft tissue envelope which is somewhat diminutive; also elbow stiffness or excuse me very significant elbow stiffness that required intervention and also what was very surprising iatrogenic surgeon created radial nerve injury was dramatically higher in the dual column group versus the single plated group, through a lateral para-tricipital approach we had none.

So let’s look at this in a little bit more detail. As alluded throughout this talk there are concerns, many concerns about putting hardware medially and the main concern is local irritation and as you could see in this slide the ulnar nerve usually doesn’t like intimate contact with metal, so it isn’t so surprising that the rate of implant related complication in terms of irritation, ulnar nerve neuritis was dramatically higher in the cohort with a dual column strategy. But also what was a surprising finding but a very interesting and telling finding is this issue of iatrogenic radial nerve palsy. In the middle of the talk I described how distal humeral surgery potentially got a bad name because of this and with our newer strategies and more innovative exposure, lateral para-tricipital approach this doesn’t occur at least in the hands of you know people who do this routinely. And although it’s conjecture we came up with a few thoughts why this happens. One is you don’t have 2 plates creating a lot of bulk on the distal humerus, so the chronic or acute or chronic tension on the radial nerve isn’t there. Secondarily with the lateral para-tricipital approach you get this grand view of the radial nerve, and you are able to do a decompression of the radial nerve especially as it starts to wind into the lateral intermuscular septum. This allows the nerve some freedom and it allows you to
manipulate the nerve potentially with more safety and also it allows for hardware to reside underneath the nerve perhaps in a more safe fashion.

So I’ll conclude this study we just finished and our talk with the following thoughts. One is that I feel open reconstruction should be the standard of care in a vast majority of distal humeral fractures as with a modern approach outcomes are more reliable than with functional bracing. And our research would suggest that the new standard of care should be a triceps sparing approach with a lateral para-tricipital approach and radial nerve decompression and posterolateral plating for fractures patterns which are amenable to direct reduction and interfragmentary lag screws using this plate as a neutralization device. We’ve shown with the last few studies that this technique has an optimal union rate, the fractures heal straight and that a wellness in terms of elbow functionality while limiting complications is optimal.

I thank you very much for your time and I’ll entertain any questions.