Intralesional Curettage technique for Giant cell tumor of bone - current concepts and evidence

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Learning Points for this Article !!

Evidence based technique of intralesional surgery, Role of adjuvants and chosing between bone and cement for reconstructing the void after intralesional curettage.

Abstract

Intralesionalsurgery is the most favored kind of surgery for giant-cell tumors of the bone. A good surgical technique helps minimize the risk of local recurrence. A good exposure followed by meticulous curetting aided by a high-speed burr is the backbone of this surgery. The role of chemical and thermal adjuvants is discussed with the evidence. The best way to reconstruct the cavity after curettage has been hotly debated. This article discusses the role of bone, cement, as well as a combination "sandwich" technique.

Keywords: Intralesional surgery, curettage, giant-cell tumor, adjuvant, "sandwich" reconstruction.

Introduction

Giant-celltumor (GCT) is the most common surgically treated benign bone tumor. Due to the benign nature, intralesional surgery is preferred as a joint saving option. Although benign, GCTstreated with intralesional surgery have a tendency to recur. The rates of recurrence depend on the quality of surgery. Recurrence rates today have dropped to 8-12% compared to 30% reported by Campannaci or 43% by Goldenberg in the past [(1–4)1, 2, 3, 4, 5]. This article looks at the surgical technique of intralesional surgery. Goodintralesional surgery is called as an extended curettage to differentiate it from a simple curettage done in the past. The extended curettage refers to a better tumor clearance using additional methods or adjuvants. We discuss with evidence the benefit or absence of benefit with various adjuvants aimed at extending the margin of the curettage. At the end of curettage, the surgeon has to choose his method of reconstruction from cement, bone graft, or a combination. We also review the various methods of reconstruction after an intralesional curettage.

The Technique

Exposure

The technique begins with a good exposure. The initial part of the exposure involves getting to the bone and to the soft tissue mass outside the bone where present. This exposure should be as atraumatic as possible to minimize functional loss. In the distal femur, whether medial or lateral, the vastus muscle fibers are elevated away from the septum and bone (subvastus exposure) rather than cutting through the muscle which scars and denervates the muscle. Similarly in the proximal tibia, on the lateral side, the muscles are separated away from the bone and retracted posteriorly. This kind of an approach allows the surgeon to cover the construct with good vascularized tissue at thetime of closure.During this exposure, thetumor may be encountered in Grade 3 tumors where a soft tissue mass is present. Ward and Li advise using a cautery for this part of the exposure to improve the margin as cautery kills the tumor(5)[6]. The second part of exposure involves exposing the bone containing the tumor. If a soft tissue mass is present, it is exposed with a layer of tissue over it (Fig. 1). Once this is done, the area around is protectedusing hydrogen peroxide soaked mops. The aim is to isolate the bone opening and avoid any soft tissue contamination with the tumor(Fig. 2)as hydrogen peroxide kills GCT cells(6)[7]. Soft tissue seeding can cause soft tissue recurrences which can be multiple making subsequent surgery for recurrence challenging. Once isolation is done, an opening is made into the tumor-bearing bone. One has the choice of making a generous window keeping adequate margin from the soft tissue component. This allows entire soft tissue mass to be excised. The bone is then dealt with by curetting and burring. The other alternative preferred by the authors is to make a small window and debulking the tumor before excising the soft tissue cover. This allows a more controlled spillage. Irrespective of the method used, the final exposure should be generous and allow visualization of every part of the tumor cavity, a 360° view (Fig.3). The exposure should be a "door" rather than a window in the bone.

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Curetting and Burring

Sharp curettes

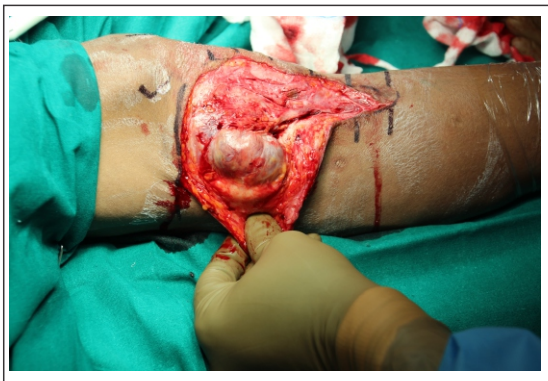

Figure 1: Intraoperative picture showing the exposure of the soft tissue component in a case of proximaltibial giant-cell tumor. The soft tissue component is exposed all around keeping a small layer of normal tissue on it.

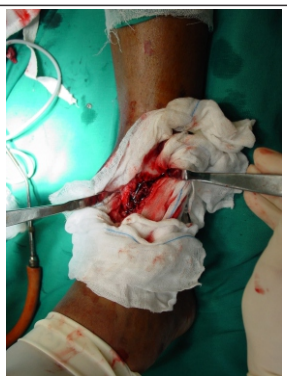

Figure 2: Intraoperative picture during surgery for distal tibia giant-cell tumor. Note that the areaof curettage is isolated all around with mops or gauze soaked in hydrogen peroxide in an attempt to avoid soft tissue contact of any spilledtumor during the curettage.

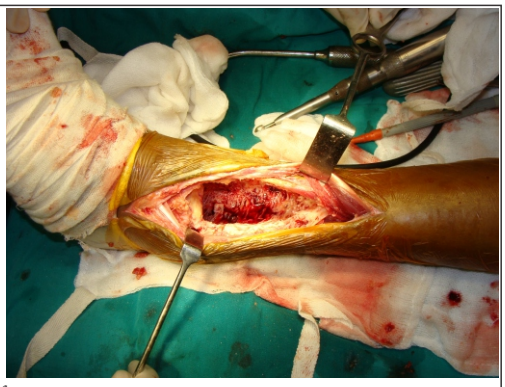

Figure 3: Intraoperative picture of a distal tibia giant-cell tumorshowing the generous window made into the bone. Note that the entire tumor cavity is visible through this window.

of various sizes should be available for a curettage. Loose parts of tumor are evacuated with a disc forceps. The walls are then curetted with the sharp edges of the curette. Good visualization is a key to the meticulous and complete curetting. The authors recommend the use of a surgical loupe and headlight as a part of adequate visualization (Fig.4). The headlamp allows good illumination within the depths of the tumor cavity which is very difficult with the regular ceiling mounted lights. A loupe allows magnification and helps see any tumor remaining on the walls. Tumor cavities often have overhanging bony ridges with tumor hidden behind them. A curette may not be useful to break these hard bony seams; a burr is best used for this. In addition to breaking the ridges, the high-speed burr helps in extending the curettage for a few millimeters beyond the grossly visible tumor margin. We recommend using a "C" arm to guide this extension of curettage. The radiographic visualization can prevent inadvertent joint penetration and also ensure that curettage has been extended all around the tumor cavity. A good practice is to start at say 12 O' clock positions and then systematically move all around the cavity and cover every part. Tumor stains the wall brown or yellow and burr is used till healthy white cortical bone is seen in the walls. Salai and Rahamimov recommend that methylene blue be poured into cavity for 2 min and then rinsed away (7)[8]. They have shown that the blue dye stains a 2mm area all around which can then be burred away to ensure a 2mm clearance. Irrigation is used during the burring as well as intermittently to aid visualization. A pulse lavage is useful in big cavities as the pressure jets delivered aids in mechanical cleansing of the tumor from the wall. Care is taken not to penetrate the articular cartilage usually visualized as a white structure distinct from the subchondral bone.

Adjuvants

In addition to the high-speed burr (considered as an essential part of the curettage and not as an adjuvant(8)[9]), various physical and chemical agents have been used to control the microscopic disease remaining in the walls after a good curettage. Liquid nitrogen, phenol, hydrogen peroxide, alcohol, electrocautery, bone cement, and the argon plasma cautery have been used as adjuvants.

Liquid Nitrogen

Liquid nitrogen by the cold-induced causes cell membrane disruption and protein denaturation of cells.Liquid nitrogenpoured into the cavity was shown to reduce local recurrence first by Marcove(9)[10]. The open pour technique required direct pouring of liquid nitrogen into cavity making it difficult to control the freezing. The second generation methods such as Mellers use a closed system where a probe place into a viscous gel within the tumor cavity causes lowering of temperature with thermocouples in the wall monitoring the temperature(10,11)()[11,12]. This allows freezing to be used in a more controlled way. Irrespective of method used, cryotherapy requires isolation of normal tissues and neurovascular bundles and insulation from the cold. Bone is rendered weak after the procedure and requires to be protected from weight-bearing or strengthened with

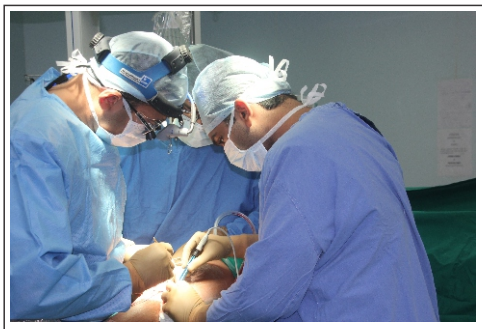

Figure 4: Intraoperative picture showing the surgeon using a loupe for magnification and a headlamp for illuminating the depth of the cavity. A good visualization is the key to an adequate curettage.

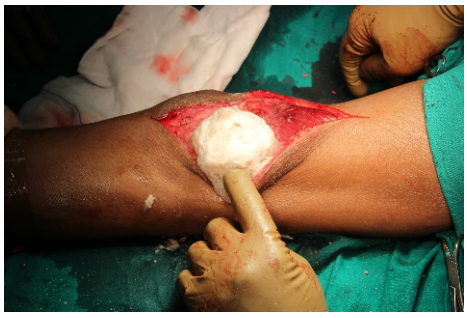

Figure 5: Intraoperative picture of a distal femur giant-cell tumorshowing hydrogen peroxide used as a chemical adjuvant with the characteristic bubbling.

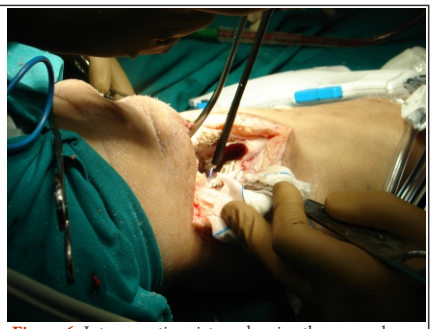

Figure 6: Intraoperative picture showing the argon plasma cautery being used to cauterize the cavity after a curettage of a proximal tibia giant-cell tumor. The argon plasma flame generated by the handpiece is visible.

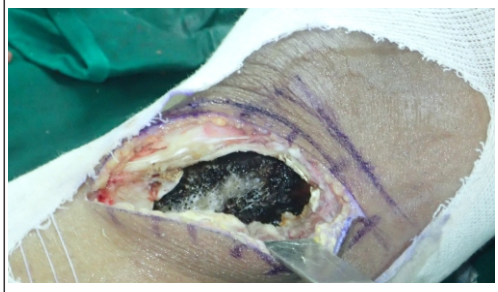

Figure 7: Cauterized walls after use of the argonplasma cautery in the proximal tibia after giant-cell tumorcurettage. The blackening seen is useful as a guide to ensure that the entire surface is cauterized.

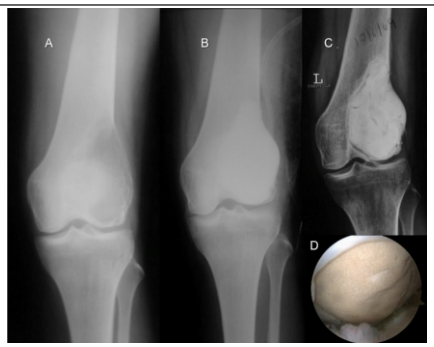

Figure 8: Giant-cell tumor of the distal femur treated with extended curettage and cementing. (a)The pre-operative X-ray showing the subchondral extent, (b) immediate post-operative X-ray showing the cement filling the entire cavity, (c) cement exposed in the joint within a year after surgery, (d) the exposed cement is visible at arthroscopy

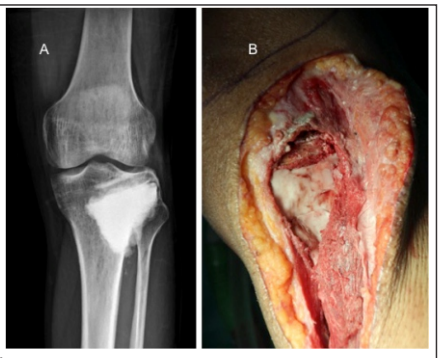

Figure 9: "Sandwich" reconstruction in the proximal tibia, X-ray (a) and intraoperative picture (b). Iliac crest block was used in the subchondral area and cement below it. Separation between the two layers with a gel foam is not necessary.

internal fixation or cement.Malawer and Dunham reported a 7.9% recurrence rate in 102 GCTs treated with cryotherapy(12)[13]. Fractures occurred only when internal fixation was not used, and the skin, soft tissue, and neurovascular bundle injury were prevented by mobilization and gel foam protection. The high rate of infection reported by Marcovewas not seen in Malawer's and Dunham series. Vethet al. more recently reported excellent oncological control and low complication rate with cryotherapy used for benign and low-grade malignant tumors(13) [14].

Phenol

Phenol causes protein coagulation, damages DNA and causes cell necrosis(14,15) [15,16]. Compared to liquid nitrogen, phenol has limited penetration into bone of <1–1.5mm(15,16)[16,17]. Phenol has been shown to kill GCT neoplastic cells when placed in contact of 80% solution in 6 min(17)[18]. Schiller et al. first showed that application of phenol to tumor cavity lowered the recurrence rate from 29.1% to 9.7% for benign tumors (18)[19]. There has been no consensus as to the concentration of phenol used; some using 5% poured into cavity while others used 90%solution painted with an applicator(3,19) [3,20]. Phenol is a causticchemical which needs to be handled with care. It can cause severe damage to normal tissues on contact. Even dilute solutions cause severe burns if exposure is prolonged. Inhalation by operating theaterpersonnel can cause irritation to respiratory mucous membranes and can cause systemic toxicity if chronic(20)[21]. Phenol can be absorbed from cancellous bone or exposed soft tissues if used for irrigation in the tumor cavity and can cause systemic toxicity resulting in damage to kidneys, heart, liver, and the nervous system(3,21) [3,22]. Phenol is inflammable and electrocautery is to be used with caution in it's presence. The potential for skin damage is increased when used with hydrogen peroxide(5) [6]. Lackmanet al. reported a local recurrence rate of 6.3% in their series of 63 patients and recommend the use of 90% phenol applied for 5 min along with burring and cementing in GCTs(19)[20].Saizet al. used 12.5% solution in glycerol painted on the bone cavity surface and reported local recurrence of 12.5% (22)[23]. The benefit of phenol has not been conclusively shown. Turcotteet al. could not demonstrate any significant benefit of phenol in the Canadian sarcoma group study (8)[9].Triebet al. in their small series could not show any benefit of phenol in reducing local recurrence (23)[24]. All in all, phenol use is potentially dangerous without demonstrable benefit in the presence of other adjuvants such as hydrogen peroxide, high-speed burr, and acrylic cement.

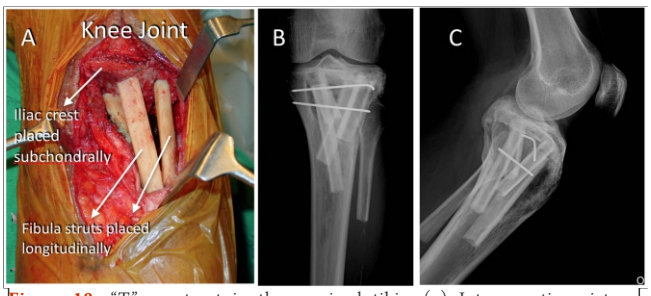

Figure 10: "T" construct in the proximal tibia. (a) Intraoperative picture, (bandc)Anteroposterior and lateral X-rays, respectively. Note the subchondral horizontally placed iliac crest block and vertically placed fibula struts. The cavity is not completely packed, a change from the traditional way.

Hydrogen Peroxide

Nicholson et al.(6)demonstrated that hydrogen peroxide in small concentrations causes' instant, substantial microscopically visible damage to the neoplastic cells of GCT. Balkeet al.(24)[25]concluded from their series that results with H2O2 lavage are comparable to that obtained with phenol. They could not demonstrate the beneficial effect of peroxide when used with high-speed burr and cement packing. Weighing all the evidence, hydrogen peroxide is safer than phenol and can be used in small concentrations to avoid damage to osteoblasts and soft tissues. The usual recommended concentration is 3% or 10 volumes. However, the medical grade peroxide solution available in our operating rooms is 20 volumes (equivalent to 6%). We have safely used this now over 10 years (Fig. 5).It is recommended that one thoroughly wash out the cavity after peroxide treatment, particularly when bone grafting is done as hydrogen peroxide also kills the osteoblast calls(6)[26].

Argon Plasma Cautery

The argon plasma cautery is a machine which uses argon gas to generate a coagulative beam like a flame which causes non-contact coagulative necrosis of the tissues. It has been used for endoscopic control of gastrointestinal bleeding and for controlling the bleed from the liver surface in hepatic injuries and surgery. This beam

causes instant desiccation, coagulation, and cauterization of tissue(25)[27]. Since the coagulativebeamis generated by a hand-heldpiece, it is easy to control and direct the flame (Fig.6) and therefore safer than methods such as cryotherapy and phenol. The cauterized area turns black (Fig.7) aiding the complete cauterization of the cavity surface under visual control. Lewis et al. reported a local recurrence rate of 10% in their series of 37 cases which is similar to that with other adjuvants(25)[27]. More importantly, no complications attributable to this technique were seen. Ofluogluet al. reported only one recurrence of 24 patients treated with argon beam along with phenol and cement(26) [28].Beneveniaet al. demonstrated equivalence between phenol and argon plasma cauterizationin terms of local control(27)[29]. The shortcomings of this method are that amount of treatment depends on the power setting and exposure time. The depth of penetration and long-term effects on bone strength and articular cartilage are still not known.

Do Adjuvants Make a Difference?

Several studies in literature cite the benefits of using a particular adjuvant in reducing local recurrence(12,13,18,19,27)[13,14,19,20,29]. However, most of these studies have not separated the use of high-speed burr from other chemical or thermal adjuvants. The high-speed burr perhaps is the most important means of extending the curettage and is considered now a must rather than an adjuvant. Balkeet al.(24)showed that recurrence rate decreases with use of more adjuvants but could not show any difference when burr was used indicating that the benefit happened with a burr. Blackleyet al.(3)[3] in their study of 59 patients showed a 12% recurrence rate with use of burr alone. This matches the recurrence rate after adjuvants, and they conclude that adequacy of tumor removal rather than theuse of adjuvants determines the local recurrence rate. Perhaps the strongest evidence of no benefit of any chemical or thermal adjuvant comes from the Canadian study by Algawahmedet al.(28)[33]. In their systematic review and meta-analysis spanning six studies and 387 patients, they found no benefit with chemical and thermal adjuvants over simple burr. In my experience, hydrogen peroxide has been safe to use even at 100% concentration. We would also use argon plasma cautery in an effort to keep the resultant defect contained as often there is only a thin shell of bone or periosteum which if burred would make the defect uncontained.

Reconstructing the Defect

After a good extended curettage, the surgeon is left with a defect which varies in volume and extent depending on the tumor size. Most defectsare contained except in the area of the window made for the curettage. On the side of the joint, one has cartilage only or cartilage with varying amounts of subchondral bone depending on the tumor extent. The choice of material to fill this defect is between bone (autograftand/or allograft) and cement (polymethyl methacrylate) or a combination of the two. Bone has the advantage of being a biological material and having an ability to remodel once incorporated. However, autograft quantity is limited and can cause donor site morbidity. Allografts are not easily available and also have higher risk of infection and delayed healing. Bone grafting also involves a significant period of protected weight-bearing till the graft incorporates. Cement, on the other hand, is easily available in any quantity, conforms to any irregular defect, and has immediate strength to compression allowing early weight-bearing. Cement also works as an adjuvant due to the heat released at polymerization. In addition, being radio-opaque, any recurrence is easily spotted as a radiolucent defect. Recurrence is sometimes difficult to appreciate after bone grafting unless large in size because the graft is generally not densely packed leaving numerous lytic and sclerotic areas. Cement is not the best material directly under the cartilage as it transmits large forces to the cartilage which can risk early degeneration of the joint. Does cement really affect the articular cartilage adversely? Lackmanet al.(19)[20] in 63 cases reported only one patient with osteoarthritis (OA). Besides, those with pre-existing OA did not have an accelerated cartilage wear on follow-up. It is difficult in a small clinical series to judge if the OA has developed due to cement or naturally as an effect of aging. Frassicaet al.studied the effect of subchondral cement on articular cartilage in dogs (29)[34]. They report that subchondral stiffness returned to normal in 12 weeks with bone graft and to 79% with bone cement. They could not demonstrate any adverse effect on the cartilage and conclude that subchondralcement is safe. Von Steyernet al.(30) [35] studied nine cases of GCTs around the knee treated with cement within 3.5mm of cartilage (average 1mm). They evaluated cartilage damage with delayed gadolinium-enhanced MRI of the cartilage(dGEMRIC) and with biochemical serum markers like cartilage oligomeric matrix protein(COMP). In one patient, there was frank irregularity of the medial condyle but no arthritic changes or functional compromise. In another, there was exposed cement for 15mm on the femoral condyle with an adjacent tibial cartilage lesion which remained stable for 10 years and did not compromise function. Although thedGEMRIC study showed some change indicating a glycosaminoglycan loss from cartilage, frank OA developed in only one patient.COMP values were higher, but again these did not correlate to any clinical or radiological evidence of OA.Although their series was small, they could not demonstrate any deleterious effect on joint even when little or no space existed between cartilage and cement. In contrast, Tejwaniet al.(31)[36] reported two cases of symptomatic full-thickness cartilage loss with cement exposure after treatment of GCT with cement. Both cases were treated with arthroscopic surgery. Fig. 8 shows a case where subchondralcement caused cartilage wear and cement exposure into the joint. Ward and Li recommend a customizedapproach to the reconstruction (5)[6]. Wherever more than 25% of the articular surface is undermined, he recommends subchondral bone grafting before cementing (Sandwich procedure) (Fig.9). Internal fixation was recommended if thecross-sectional area of cement exceeded 50% of bone. The biggest attraction for cement is it's role as an adjuvant in reducing local recurrence. Von Styernet al. concluded from their study of 294 cases from the Scandinavian sarcoma group study(30)[37] that cement is statistically significant in reducing the local

recurrence rates, but they too recommend subchondral bone to avoid cementing close to articular surface in an effort to prevent cartilage damage. However, in contrast, Blackleyet al.(3)[3] showed that rate of local recurrence did not depend on whether bone or cement was used for reconstruction but on how well the disease was cleared. They showed a 12% local recurrence using just a high-speed burr, a rate similar to that reported with cement reconstruction. Perhaps the amount of subchondral bone involved is more important than whether cement or bone graft was used. Chen et al.(32)[38]found that amount of subchondral bone involvement was directly related to the functional score. They considered <3mm subchondral remaining bone as subchondral bone involvement and found that for every 10% increase of subchondral bone involvement, there was a 3% reduction of Enneking score in a linear fashion. Reconstructing the entire cavity with bone can be challenging due to the volume of graft required. We would recommend a layer of autograft in the subchondral area and then allograft in the rest of the cavity. It is not necessary to fill the entire volume with bone. Fibular struts have been shown to be equally effective(33)[39]. We have used a combination of autograft iliac crest subchondral and fibular struts either allograft or autograft longitudinally in what we call as a "T" construct (Fig. 10).

Conclusions

Intralesional surgery should be done with a wide exposure. A high-speed burr is an essential part of the curettage. There is no conclusive evidence of benefit with any other adjuvant, but hydrogen peroxide is safe and cheap if an adjuvant is desired. Reconstruction with either bone or cement could be a surgeon's choice, but it looks like a good and logical option to build up a few millimeters of subchondral bone with autograft as it is easy to get without much donor site morbidity. Perhaps more time and attention should be paid to tumor clearance rather than reconstruction.

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