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SURGICAL BUR, SURGICAL SYSTEM, AND METHOD FOR OPERATING THE SURGICAL SYSTEM

Abstract

A surgical bur includes a bar-shaped shaft and a cutting part provided at one axial end of the shaft, which rotates around the axis of the shaft. The shaft is formed on the outer peripheral surface on the cutting part side in the axial direction and includes a liquid flow generation part having at least one of a convex part projecting outward in the radial direction or a concave part recessed inward in the radial direction.

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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates to a surgical bur, a surgical system, and a method for operating the surgical system.

BACKGROUND ART

[0002] Conventionally, one of the medical instruments used in surgery, known as surgical burs, is used with bone surgery instruments. Exemplary surgical burs are disclosed in related art documents such as JP 2013-502943 A, JP 2016-527003 A and JP 2019-531140 A. A surgical bur has a shaft and a cutting part provided at the tip of the shaft. The cutting part has blades that cut tissues such as bones. The shaft is fixed to the drive shaft of a handpiece or similar device.

[0003] During surgery, by operating the drive shaft to rotate the surgical bur and pressing the cutting part against the tissue to be removed (target tissue), it is removed by the rotating blades. Around the area to be removed, the surrounding area is filled with perfusion fluid (disinfected water, saline solution, irrigation, etc.) supplied externally, and the surgical bur rotates in the perfusion fluid to remove the target tissue.

[0004] Such surgical burs are used in various surgeries such as orthopedic surgery, neurosurgery, spinal surgery, and ENT surgery, or in procedures for selectively removing parts of tissues.

SUMMARY OF INVENTION

[0005] However, in the surgical burs disclosed in the documents listed above, there is an issue where cut tissue from the target removal position floats around, obstructing the surgeon's view during the cutting operation. Although a certain amount of perfusion fluid is continuously supplied around the removal target position, it may be insufficient to improve the view of the surgeon at the removal target position.

[0006] The present disclosure aims to solve the above problem by ensuring the surgeon's view around the removal target position during the tissue removal work using a surgical bur, thereby improving the safety, accuracy, and speed of the work.

[0007] The present disclosure provides at least the following configuration:

[0008] (1) A surgical bur including a bar-shaped shaft and a cutting part provided at one axial end of the shaft, which rotates around the axis of the shaft, [0009] wherein the shaft is formed on the outer peripheral surface on the cutting part side in the axial direction and includes a liquid flow generation part having at least one of a convex part projecting outward in the radial direction or a concave part recessed inward in the radial direction.

[0010] (2) A surgical system including: [0011] the surgical bur described in (1); [0012] a handpiece having a long tubular support that exposes the cutting part and the liquid flow generation part at the tip and rotationally supports the shaft; [0013] a rotation control device that rotationally drives the shaft of the surgical bur supported by the tubular support; and [0014] a perfusion fluid device that supplies perfusion fluid towards the cutting part and the liquid flow generation part of the surgical bur.

[0015] (3) A method for operating the surgical system described in (2), [0016] wherein the tip of the tubular support of the handpiece supporting the surgical bur is inserted into the affected area, and the perfusion fluid device supplies perfusion fluid to the cutting area by the surgical bur, and [0017] wherein while the cutting part and the liquid flow generation part are placed in the liquid perfusion fluid accumulated in the affected area, the rotation control device rotationally drives the surgical bur, generating a flow of the perfusion fluid by the liquid flow generation part.

[0018] According to the present disclosure, it is possible to ensure the surgeon's view around the removal target position during the tissue removal work using the surgical bur, thereby improving the safety, accuracy, and speed of the work.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0019] FIG. **1** is a schematic diagram showing the main configuration of a surgical system.

[0020] FIG. **2** is an overall configuration diagram of the surgical bur according to a first embodiment.

[0021] FIG. **3** is a partially enlarged view showing the tip of the surgical bur attached to the handpiece attachment.

[0022] FIG. **4** is an explanatory diagram schematically showing the flow of perfusion fluid due to the rotation of the surgical bur.

[0023] FIG. **5** is an explanatory diagram schematically showing the flow of perfusion fluid when the surgical bur is rotated in the opposite direction to that shown in FIG. **4**.

[0024] FIG. **6** is an explanatory diagram schematically showing the state of the surgery using the surgical bur.

[0025] FIG. **7** is a partially enlarged view showing the tip of the surgical bur according to a second embodiment attached to the handpiece attachment.

[0026] FIG. **8** is a front view of the cutting part seen from the tip of the surgical bur.

[0027] FIG. **9** is a partial cross-sectional view cut along the axial direction of the liquid flow generation part.

[0028] FIG. **10** is a partial cross-sectional view cut along the axial direction of the liquid flow generation part serving as a cutting blade.

[0029] FIG. **11** is a perspective view showing the tip of the surgical bur according to a first modification of the liquid flow generation part.

[0030] FIG. **12** is a perspective view showing the tip of the surgical bur according to a second modification of the liquid flow generation part.

[0031] FIG. **13** is a cross-sectional view taken along the line XIII-XIII shown in FIG. **12**.

[0032] FIG. **14** is a perspective view showing the tip of the surgical bur according to a third modification of the liquid flow generation part.

DESCRIPTION OF EMBODIMENTS

[0033] Hereinafter, the surgical bur and surgical system in which the surgical bur is used according to the present disclosure will be described in detail with reference to the drawings. The surgical system exemplified here is configured for use in spinal surgery, but the application of the present disclosure is not limited thereto.

[0034] FIG. **1** is a schematic diagram showing the main configuration of a surgical system **100**. The surgical system **100** includes a controller **101**, a handpiece **103**, a connection cable **105** connecting the handpiece **103** to the controller **101**, and a foot switch **107**.

[0035] The handpiece **103** includes an attachment **103***a* and a grip **103***b*. The attachment **103***a* at the tip of the handpiece **103** is a long tubular support that supports the surgical bur **10** detachably. The grip **103***b* of the handpiece **103** is provided with a power source M such as an air motor or electric motor (electric motor) that rotationally drives the surgical bur **10**. The power source M is rotationally controlled by the foot switch **107** connected to the controller **101**. The controller **101** controls various operations such as the rotational speed and direction of the surgical bur **10** by the handpiece **103**. This driving control is realized by the operation of a computer that includes a processor, memory, and storage. The power source M and the controller **101** described above function as a rotation control device that rotationally drives the shaft **11** of the surgical bur **10** supported by the attachment **103***a*.

[0036] FIG. **2** is an overall configuration diagram of the surgical bur **10** according to a first embodiment. The surgical bur **10** includes a bar-shaped shaft **11** that extends along the rotation axis Lc and a ball-shaped cutting part **13** provided at one end of the shaft **11**. Diamond abrasive grains or the like (not shown) are electrodeposited on the surface of the cutting part **13**. Alternatively, a cutting blade may be formed instead of the abrasive grains mentioned above. The “ball shape” herein means that when the surgical bur **10** is rotated around the rotation axis Lc, the surface shape formed by enveloping the abrasive grains or cutting edge formed on the cutting part **13** is a sphere or a rotational ellipsoid centered on the rotation axis Lc.

[0037] The shaft **11** includes a liquid flow generation part **15** formed on the outer peripheral surface on the cutting part **13** side in the axial direction. The liquid flow generation part **15** of this configuration is a spiral protrusion **17** formed spirally around the outer circumference of the shaft **11**, centering on the rotation axis Lc (hereinafter also simply referred to as the axis), and protruding in the radial direction. The spiral protrusion **17** shown here is a single protrusion with a pair of wall surfaces **17***a* extending circumferentially on both sides in the axial direction. The position of the liquid flow generation part **15** on the shaft **11** is set according to the size and application of the surgical bur **10**. For example, the distance S from the base end **13***a* of the cutting part **13** to the axial end of the liquid flow generation part **15** may be set within the range of ±20% of the maximum outer diameter dimension Dp of the cutting part **13**.

[0038] The surgical bur **10** is formed of a hard material such as stainless steel or a hard alloy (tungsten carbide). The base end on the side opposite to the cutting part **13** of the shaft **11** has a connecting part **19** fixed to the drive shaft (not shown) of the power source M of the handpiece **103**.

[0039] FIG. **3** is a partially enlarged view showing the tip of the surgical bur **10** attached to the attachment **103***a* of the handpiece **103**. The surgical bur **10** exposes the cutting part **13** and the liquid flow generation part **15** from the tip of the attachment (tubular support) **103***a*, and the shaft **11** is rotationally supported by the handpiece **103**. The surgical bur **10** fixed to the rotation shaft is rotated around the rotation axis Lc by the rotational driving from the handpiece **103**.

[0040] In this surgical system **100**, the surgeon operates the foot switch **107** while holding the handpiece **103** shown in FIG. **1** to rotate the surgical bur **10** at high speed. Then, when the surgeon moves the handpiece **103** while pressing the cutting part **13** of the surgical bur **10** against the desired part, the rotating cutting part **13** can cut that part. During surgery, perfusion fluid W such as saline or sterilized water is supplied to the cutting area (also referred to as the affected area), and the liquid flow generation part **15** generates a flow in the perfusion fluid W present around the affected area due to the rotation of the surgical bur **10**. This flow of perfusion fluid W improves the surgeon's view of the affected area.

[0041] FIG. **4** is an explanatory diagram schematically showing the flow of perfusion fluid due to the rotation of the surgical bur **10**. As shown in FIG. **4**, the surgical bur **10** rotates around the rotation axis Lc in the direction Rc (clockwise when viewed from above the rotation axis Lc). Since the spiral protrusion **17** of the liquid flow generation part **15** is a right-handed spiral (same as right-hand threads), the wall surface **17***a* of the spiral protrusion **17** advances from the cutting part **13** side to the handpiece **103** side along the shaft **11**, producing a feed motion. This feed motion of the spiral protrusion **17** generates a flow indicated by arrow FL**1** in the perfusion fluid W around the spiral protrusion **17**. The perfusion fluid W, flowing in the direction of arrow FL**1**, eliminates the perfusion fluid W containing tissue fragments P cut by the cutting part **13** from the vicinity of the cutting part **13**. Consequently, new perfusion fluid W with high transparency that does not contain tissue fragments P flows into the vicinity of the cutting part **13**, maintaining a good view of the vicinity of the cutting part **13**. In other words, the view around the cutting area during the cutting operation is kept clear, improving the surgeon's workability.

[0042] FIG. **5** is an explanatory diagram schematically showing the flow of perfusion fluid W when the surgical bur **10** is rotated in the opposite direction to that shown in FIG. **4**. As shown in FIG. **5**, the surgical bur **10** rotates around the rotation axis Lc in the direction Ruc (counterclockwise when viewed from above the rotation axis Lc). The wall surface **17***a* of the spiral protrusion **17** of the liquid flow generation part **15** advances from the handpiece **103** side to the cutting part **13** side along the shaft **11**, producing a feed motion. This feed motion of the spiral protrusion **17** generates a flow indicated by arrow FL**2** in the perfusion fluid W around the spiral protrusion **17**, eliminating the perfusion fluid W containing tissue fragments P cut by the cutting part **13** from the vicinity of the cutting part **13**.

[0043] The direction of the perfusion fluid W flow can be in either directions shown by arrows FL**1** and FL**2**, but when a circulation path is formed for the perfusion fluid W, it is preferable to direct the perfusion fluid W towards the discharge direction. The rotation direction of the surgical bur **10** can be set by the controller **101** shown in FIG. **1** and can be appropriately changed by the surgeon according to the situation. The flow rate of the perfusion fluid W can be easily adjusted by increasing or decreasing the rotational speed of the surgical bur **10** using the controller **101**.

[0044] Additionally, by changing the spiral protrusion **17** from a right-handed spiral to a left-handed spiral, the direction of the perfusion fluid W flow can be reversed. When the outer diameter of the shaft **11** is 1.5 mm, the preferred pitch (the axial advancement per rotation) of the spiral protrusion **17** is, for example, preferably 0.3 mm to 2.5 mm, more preferably 0.5 mm to 1.5 mm. The spiral protrusion **17** is not limited to a single protrusion and may comprise multiple protrusions. The axial length of the liquid flow generation part **15** is preferably 2 mm to 10 mm, more preferably 3 mm to 5 mm.

[0045] As shown in FIG. **3**, it is preferable that the spiral protrusion **17** has a tapered shape, with the protrusion height in the radial direction being lower closer to the cutting part **13**. In other words, the enveloping line Lh of the outer edge of the spiral protrusion **17** becomes shorter in distance from the rotation axis Lc as it approaches the cutting part **13**. By making the protrusion height lower closer to the cutting part **13**, the view near the cutting part **13** of the surgeon during surgery is less obstructed by the spiral protrusion **17**, making it easier to maintain a wider field of view.

[0046] Moreover, it is preferable that the maximum outer diameter dimension Dp of the spiral protrusion **17** is smaller than the maximum outer diameter dimension Dc of the cutting part **13**. This prevents the surgeon's view from being obstructed by the spiral protrusion **17** during surgery and makes it easier to secure the view near the cutting part **13**. Additionally, because the protrusion height of the spiral protrusion **17** is lower than that of the cutting part **13**, unnecessary tissue is less likely to be inadvertently damaged by the spiral protrusion **17**.

[0047] FIG. **6** is an explanatory diagram schematically showing the state of a surgery using the surgical bur **10**. The surgical system used includes the previously described components shown in FIG. **1** as well as an additional tubular sheath **21**, an endoscopic device **23** (percutaneous spinal endoscope), and a perfusion fluid device **25**. Here, an example of cutting a patient's bone **27** is described.

[0048] The perfusion fluid device **25** includes a fluid supply unit **25**A that delivers perfusion fluid W to the affected area and a fluid recovery unit **25**B that sucks and discharges the perfusion fluid W from the affected area. The fluid supply unit **25**A and the fluid recovery unit **25**B are provided with pumps (not shown) that deliver or recover the perfusion fluid W. In this configuration, the fluid supply unit **25**A supplies the perfusion fluid W to the affected area through the endoscopic device **23** inserted inside the sheath **21**, and the fluid recovery unit **25**B sucks and discharges the perfusion fluid W around the affected area through the inside of the sheath **21**.

[0049] The endoscopic device **23** has a cylindrical insertion part **33** that is inserted into the affected area, an observation optical system **35** that sends illumination light from the tip of the insertion part **33**, illuminates the area around the cutting part **13**, and acquires an observation image, a working lumen **37** into which various instruments are inserted, and a supply path **39** that supplies perfusion fluid W to the working lumen **37**. The endoscopic device **23** outputs the imaging information of the observation image obtained from the observation optical system **35**, as well as various information such as the imaging conditions and imaging position. The configuration may also allow the surgeon to observe the observation image visually obtained from the observation optical system **35**. When the configuration outputs imaging information, an image display device such as a monitor connected to the endoscopic device **23** displays the imaging information, enabling the surgeon to

easily view the imaging information.
[0050] The sheath **21** is provided with a discharge path **41** for discharging the perfusion fluid W inside the sheath **21**. The supply path **39** connects to the fluid supply unit **25**A of the perfusion fluid device **25**, and the discharge path **41** connects to the fluid recovery unit **25**B.
[0051] First, the patient's skin **29** and muscles **31** are incised, and the sheath **21** is inserted close to the bone **27** planned for cutting. Then, the insertion part **33** of the endoscopic device **23** is inserted inside the sheath **21**. After inserting the insertion part **33** of the endoscopic device **23** into the body cavity, the fluid supply unit **25**A of the perfusion fluid device **25** supplies the perfusion fluid W to the working lumen **37** through the supply path **39**. This supplies perfusion fluid W from the working lumen **37** to the affected area, and the cutting part **13** and the liquid flow generation part **15** are positioned in the liquid perfusion fluid W accumulated in the affected area. Furthermore, the perfusion fluid W around the affected area is sucked and discharged by the fluid recovery unit **25**B through the discharge path **41**, ensuring that the perfusion fluid W around the affected area is sequentially replaced without stagnation.
[0052] Then, the attachment **103***a* of the handpiece **103**, with the surgical bur **10** attached to its tip, is inserted into the working lumen **37** of the endoscopic device **23**. The inserted attachment **103***a* is rotationally driven by the rotation control device consisting of the power source M and the controller **101**, enabling bone cutting by the rotating cutting part **13**. The condition of the cutting by the cutting part **13** can be visually confirmed by looking at the observation image obtained by illuminating the affected area around the cutting part **13** with illumination light from the observation optical system **35**, or by displaying the imaging image on a monitor or other image display device.
[0053] As described above, the surgeon can operate the handpiece **103** and perform on-off control of the rotation of the surgical bur **10** using the foot switch **107** shown in FIG. **1** while visually confirming the observation image obtained from the observation optical system **35**, cutting the bone with the surgical bur **10**.
[0054] When cutting the bone, tissue fragments generated during cutting mix with the perfusion fluid, causing the perfusion fluid W to become suspended, making it difficult to see the cutting state in the observation image. However, since the liquid flow generation part **15** provided in the surgical bur **10** generates a flow in the perfusion fluid W due to the rotational drive, the suspended perfusion fluid W near the cutting part is carried away to another area by the flow, being replaced with new perfusion fluid W. As a result, the area around the cutting part **13** is always filled with new perfusion fluid W, making it possible to obtain a clear observation image of the vicinity of the cutting part **13**.
[0055] The flow of the perfusion fluid W generated by the liquid flow generation part **15** flows towards the base end side opposite to the cutting part **13**, as shown in FIG. **4**. In this way, when the liquid flow generation part **15** generates a flow of perfusion fluid W along the shaft **11** towards the liquid flow generation part **15**, the suspended perfusion fluid W around the cutting part **13** is carried away by the flow and smoothly discharged from the working lumen **37** by suction from the fluid recovery unit **25**B.
[0056] Additionally, when the flow of the perfusion fluid W is directed towards the cutting part **13**, as shown in FIG. **5**, new perfusion fluid W supplied by the fluid supply unit **25**A can be provided to the cutting part **13**. In other words, the liquid flow generation part **15** generates a flow of the perfusion fluid W around the cutting part **13** towards the opposite side of the shaft **11**. This ensures that the area around the cutting part **13** is always filled with new perfusion fluid W, allowing for a clear observation image to be obtained.
[0057] No matter the direction of the flow of the perfusion fluid W, the perfusion fluid W will not stagnate, quickly cooling the cutting part **13** and the affected area cut by the cutting part **13**, suppressing the rise in temperature. Therefore, bone damage caused by heat generated during bone cutting is less likely to occur. Consequently, during the cutting operation of the target tissue, it is

possible to stably ensure the surgeon's field of view around the cutting position. Thus, the safety, accuracy, and speed of the work can be improved.

[0058] In the above-described surgery, the sheath **21** and the endoscopic device **23** are used, but it may also be possible to supply the perfusion fluid W to the incised affected area and perform the cutting with the surgical bur **10** by rotating the surgical bur **10** while operating the handpiece **103**. In that case, as well, rotating the cutting part **13** and the liquid flow generation part **15** of the surgical bur **10** in the perfusion fluid W allows the condition of the cutting operation to be clearly visible.

[0059] FIG. **7** is a partially enlarged view showing the tip of the surgical bur **10** of a second embodiment attached to the attachment **103***a* of the handpiece **103**. In this configuration, the cutting part **13**A of the surgical bur **10** extends from the axial tip to the axial base and includes multiple rows of cutting blades **43** formed in rotationally symmetrical positions around the rotation axis Lc. Between the multiple rows of cutting blades **43**, there are rake faces **45** and relief faces **47** of the cutting blades **43** adjacent circumferentially, with recessed grooves **49** provided therebetween.

[0060] FIG. **8** is a front view of the cutting part **13**A seen from the tip of the surgical bur **10**. The cutting part **13**A of this configuration has four cutting blades **43**, with cutting blades **43** and grooves **49** alternately arranged circumferentially around the cutting part **13**A. As shown in FIG. **7**, the multiple rows of cutting blades **43** are formed spirally along the axial direction, and consequently, the grooves **49** are also formed spirally. Therefore, with the rotation Rc of the surgical bur **10**, the perfusion fluid W in the grooves **49** generates a spiral flow indicated by arrow FL**3**.

[0061] The flow FL**3** of the perfusion fluid W from the cutting part **13**A is in the same direction as the flow FL**1** caused by the spiral protrusion **17** in the liquid flow generation part **15**, promoting flow FL**1**. As a result, the perfusion fluid W containing tissue fragments P cut by the cutting part **13**A is efficiently removed from the vicinity of the cutting part **13**A, and new transparent perfusion fluid W without tissue fragments P flows into the vicinity of the cutting part **13**A. Consequently, the view around the cutting part **13**A becomes more favorable, ensuring a good view of the removal position during the cutting operation.

[0062] FIG. **9** is a partial cross-sectional view cut along the axial direction of the liquid flow generation part **15**. The spiral protrusion **17** of the liquid flow generation part **15** is formed with a flat top surface **17***b* with a lower radial height at the protruding tip, removing sharp pointed sections. By removing pointed sections from the top surface **17***b* of the spiral protrusion **17**, contact with tissue during the surgery can prevent damaging the contacted tissue.

[0063] On the other hand, the shape of the top of the spiral protrusion **17** can be made sharp, allowing the spiral protrusion **17** to function as a cutting blade.

[0064] FIG. **10** is a partial cross-sectional view cut along the axial direction of the liquid flow generation part **15**A serving as a cutting blade. The spiral protrusion **17**A formed in the liquid flow generation part **15**A has a sharply pointed tip **17***c*. The pointed tip **17***c* can contribute to cutting tissues. Therefore, by pressing both the cutting part **13** and the pointed tip **17***c* of the spiral protrusion **17**A against the tissue to be cut during surgery, a wide range of tissues can be efficiently removed.

[0065] Next, modifications of the liquid flow generation part will be described. The liquid flow generation part **15** is not limited to the above-described spiral protrusion **17** and can have any shape that can create a flow of perfusion fluid. For example, a shape that has an effect of stirring the perfusion fluid may be used. Each modification of the liquid flow generation part shown below is simplified in shape, but can include parts of the shapes and configurations exemplified in the liquid flow generation part.

[0066] FIG. **11** is a perspective view showing the tip of the surgical bur **10** according to a first modification of the liquid flow generation part **15**B. This liquid flow generation part **15**B includes a flat plate **51** as a convex part protruding outward in the radial direction from the outer peripheral surface of the shaft **11** and extending along the rotation axis Lc, and a continuous wall surface **51***a*. At least one flat plate **51** is provided circumferentially on the shaft **11**, preferably multiple ones in rotation symmetric positions. With this configuration, as the surgical bur **10** rotates, the wall surface **51***a* of the flat plate **51** stirs the surrounding perfusion fluid, generating a flow in the perfusion fluid.

[0067] Although not shown, the entire flat plate **51** or a part of it may be inclined from the rotation axis Lc to one side in the circumferential direction of the shaft **11**. This means that the wall surface **51***a* of the flat plate **51** may be inclined at a predetermined angle in the same direction like a screw. In this case, as the surgical bur **10** rotates, a flow will be generated along the shaft **11** in the perfusion fluid W. The flat plate **51** does not have to be inclined entirely; for example, only a part of the axial direction of the flat plate **51** may be inclined.

[0068] FIG. **12** is a perspective view showing the tip of the surgical bur **10** according to a second modification of the liquid flow generation part **15**C. FIG. **13** is a cross-sectional view along the line XIII-XIII shown in FIG. **12**. This liquid flow generation part **15**C includes a recessed groove **53** recessed inward in the radial direction from the outer peripheral surface of the shaft **11**. The recessed groove **53** is provided in at least one place in the circumferential direction of the shaft **11**, preferably multiple places in rotation symmetric positions. The recessed groove **53** has an inner wall surface **53***a* along the shaft **11**. As the surgical bur **10** rotates, the inner wall surface **53***a* stirs the perfusion fluid W, generating a flow in the perfusion fluid W.

[0069] Although not shown, the entire recessed groove **53** or a part of it may be inclined from the rotation axis Lc to one side in the circumferential direction of the shaft **11**. In other words, the inner wall surface **53***a* of the recessed groove **53** may be inclined helically from the rotation axis Lc at a predetermined angle. In this case, as the surgical bur **10** rotates, a flow along the shaft **11** will be generated in the perfusion fluid W.

[0070] As in the liquid flow generation parts **15**, **15**A, **15**B, and **15**C described above, the liquid flow generation part can create a flow in the perfusion fluid W with any protrusion or recess on the shaft **11** in the radial direction, and any shape that can generate a flow in the perfusion fluid W is acceptable.

[0071] FIG. **14** is a perspective view showing the tip of the surgical bur **10** according to a third modification of the liquid flow generation part **15**D. This liquid flow generation part **15**D includes multiple rod-shaped bodies **55** protruding outward in the radial direction from the outer peripheral surface of the shaft **11**. The rod-shaped bodies **55** include multiple tip-side rod-shaped bodies **57** with a longer protruding length, positioned closer to the cutting part **13**, and multiple base-side rod-shaped bodies **59** with a shorter protruding length, positioned away from the cutting part **13**. The rod-shaped bodies **55** are arranged at arbitrary positions along the circumference and preferably at multiple rotation symmetric positions centered on the rotation axis Lc. Additional rod-shaped bodies may be provided between the tip-side rod-shaped bodies **57** and the base-side rod-shaped bodies **59**. As the surgical bur **10** rotates, the rod-shaped bodies **55** stir the perfusion fluid W, generating a flow in the perfusion fluid W.

[0072] The configurations related to the present disclosure is not limited to the embodiments described above and can be appropriately modified and improved. Other configurations such as materials, shapes, dimensions, numbers, forms, locations, etc., of the components described in the above embodiments are optional as long as the invention can be achieved and are not limited.

[0073] As described above, the present disclosure includes the following configurations:

[0074] (1) A surgical bur including a bar-shaped shaft and a cutting part provided at one axial end of the shaft, which rotates around the axis of the shaft, [0075] wherein the shaft is formed on the outer peripheral surface on the cutting part side in the axial direction and includes a liquid flow generation part having at least one of a convex part projecting outward in the radial direction or a concave part recessed inward in the radial direction.

[0076] This surgical bur causes the liquid flow generated by the convex or concave liquid flow generation part formed on the shaft during surgery to remove perfusion fluid containing tissue fragments generated around the cutting part from the vicinity of the cutting position, thereby stabilizing the surgeon's field of view around the cutting position.
[0077] (2) The surgical bur according to (1) wherein the flow generation part including a spiral protrusion formed spirally around the outer circumference of the shaft centering on the axis, protruding outward from the outer peripheral surface of the shaft, [0078] wherein the surgical bur generates a flow in the perfusion fluid around the spiral protrusion by the feed motion of the spiral protrusion generated by rotating the shaft.
[0079] (3) The surgical bur according to (2), wherein the spiral protrusion has a lower protruding height in the radial direction closer to the cutting part.
[0080] This surgical bur suppresses the obstruction of the surgeon's view near the cutting part by the spiral protrusion during surgery, making it easier to secure a wider field of view.
[0081] (4) The surgical bur according to (2), wherein the maximum outer diameter dimension of the spiral protrusion is smaller than the maximum outer diameter dimension of the cutting part.
[0082] This surgical bur suppresses the obstruction of the surgeon's view by the spiral protrusion during surgery, making it easier for the surgeon to secure the view near the cutting part. Additionally, because the protrusion height of the spiral protrusion is lower than that of the cutting part, unnecessary tissue is less likely to be inadvertently damaged by the spiral protrusion.
[0083] (5) A surgical system including: [0084] the surgical bur described in any one of (1) to (4); [0085] a handpiece having a long tubular support that exposes the cutting part and the liquid flow generation part at the tip and rotationally supports the shaft; [0086] a rotation control device that rotationally drives the shaft of the surgical bur supported by the tubular support; and [0087] a perfusion fluid device that supplies perfusion fluid towards the cutting part and the liquid flow generation part of the surgical bur.
[0088] This surgical system can ensure a good view of the condition during the cutting operation by rotating the cutting part and the liquid flow generation part in the liquid perfusion fluid at the affected area.
[0089] (6) The surgical system according to (5), further including: [0090] a sheath with a cylindrical tip inserted into the affected area, a tubular support of the handpiece inserted into the sheath; and [0091] an observation optical system obtaining an observational image of the affected area around the cutting part of the surgical bur.
[0092] This surgical system allows cutting with the surgical bur through the sheath inserted into the affected area, and the observation optical system within the sheath can acquire the cutting condition.
[0093] (7) The surgical system according to (6), wherein the perfusion fluid device suctions and discharges the perfusion fluid in the sheath's cylinder.
[0094] This surgical system can remove the perfusion fluid accumulating around the affected area by suctioning it in the sheath's cylinder.
[0095] (8) The surgical system according to (6), wherein the observation optical system includes an endoscopic device obtaining the observational image from the tip inserted into the affected area.
[0096] This surgical system allows the surgeon to easily observe the cutting condition by the cutting part using the endoscopic device.
[0097] (9) A method for operating the surgical system described in (5), including: [0098] inserting the tip of the tubular support of the handpiece supporting the surgical bur into the affected area, supplying the perfusion fluid towards the cutting area by the surgical bur using the perfusion fluid device; and [0099] rotationally driving the surgical bur with the rotation control device while the cutting part and the liquid flow generation part are placed in the liquid perfusion fluid accumulated in the affected area, generating a flow of the perfusion fluid by the liquid flow generation part.
[0100] This method for operating the surgical system allows suspended perfusion fluid near the

cutting part to be replaced with new perfusion fluid, maintaining good visibility of the observation image around the cutting part.
[0101] (10) The method for operating the surgical system described in (9), wherein the liquid flow generation part generates a liquid flow along the shaft towards the liquid flow generation part with the rotation control device rotating the surgical bur, directing the perfusion fluid around the cutting part.
[0102] This method for operating the surgical system removes the perfusion fluid containing tissue fragments cut by the cutting part from the vicinity of the cutting part by flowing along the shaft towards the liquid flow generation part, constantly filling the area around the cutting part with new perfusion fluid.
[0103] (11) The method for operating the surgical system described in (9), wherein the liquid flow generation part generates a liquid flow towards the opposite side of the shaft with the rotation control device rotating the surgical bur, directing the perfusion fluid around the cutting part.
[0104] This method for operating the surgical system supplies new perfusion fluid to the cutting part, replacing the perfusion fluid containing tissue fragments cut by the cutting part from the vicinity of the cutting part, constantly filling the area around the cutting part with new perfusion fluid.

Claims

1. A surgical bur comprising: a shaft extending along an axis; a cutting part provided on the shaft at one end in an axial direction of the shaft; and a liquid flow generation part formed on an outer peripheral surface of the shaft at a position close to the cutting part, the liquid flow generation part having at least one of a convex part projecting outward in a radial direction of the shaft or a concave part recessed inward in the radial direction of the shaft and being configured to generate liquid flow when the shaft is rotated around the axis.
2. The surgical bur according to claim 1, wherein the liquid flow generation part includes a spiral protrusion formed spirally around the outer peripheral surface of the shaft centering on the axis, and protruding outward from the outer peripheral surface of the shaft.
3. The surgical bur according to claim 2, wherein the spiral protrusion has a lower protruding height in the radial direction toward a position closer to the cutting part.
4. The surgical bur according to claim 2, wherein a maximum outer diameter dimension of the spiral protrusion is smaller than a maximum outer diameter dimension of the cutting part.
5. A surgical system comprising: the surgical bur according to claim 1, a handpiece having a longitudinal tubular support that exposes the cutting part and the liquid flow generation part at the tip and rotationally supports the shaft; a rotation control device that rotationally drives the shaft of the surgical bur supported by the tubular support; and a perfusion fluid device that supplies perfusion fluid towards the cutting part and the liquid flow generation part of the surgical bur.
6. The surgical system according to claim 5, further comprising: a sheath having a cylindrical shape to be inserted into an affected area and through which the longitudinal tubular support of the handpiece is inserted into; and an observation optical system that allows a user to view an observational image of the affected area around the cutting part of the surgical bur.
7. The surgical system according to claim 6, wherein the perfusion fluid device suctions and discharges the perfusion fluid in the sheath.
8. The surgical system according to claim 6, wherein the observation optical system includes an endoscopic device that obtains the observational image from a tip end thereof inserted into the affected area.
9. A method for operating the surgical system according to claim 5, the method comprising: supplying the perfusion fluid towards the cutting area by the surgical bur using the perfusion fluid device while inserting the tip of the longitudinal tubular support of the handpiece supporting the

surgical bur into the affected area; and rotationally driving the surgical bur with the rotation control device while the cutting part and the liquid flow generation part are placed in the liquid perfusion fluid accumulated in the affected area, generating a flow of the perfusion fluid by the liquid flow generation part.

10. The method according to claim 9, wherein the liquid flow generation part generates a liquid flow directing the perfusion fluid around the cutting part along the shaft towards the liquid flow generation part with the rotation control device rotating the surgical bur.

11. The method according to claim 9, wherein the liquid flow generation part generates a liquid flow directing the perfusion fluid around the cutting part towards a side further to the shaft with the rotation control device rotating the surgical bur.